PHOTO: Thomas Mangelsen

# Honoring, Protecting, and Restoring Yellowstone Bison in the Wild

## Buffalo Field Campaign's findings on factors jeopardizing the unique and Distinct Population Segment of Yellowstone bison

BUFFALO
FIELD CAMPAIGN
Protecting Wild Bison Since 1997

June 1, 2023

Public Comments Processing
Attn: FWS-R6-ES-2022-0028
U.S. Fish and Wildlife Service
MS: PRB/3W
5275 Leesburg Pike
Falls Church, VA 22041-3803

P.O. Box 957
West Yellowstone, MT 59758
(406) 646-0070
info@buffalofieldcampaign.org
BuffaloFieldCampaign.org

BUFFALO FIELD CAMPAIGN
Protecting Wild Bison Since 1997

Re: U.S. Fish & Wildlife Service's 12-month status review of the distinct population segment of Yellowstone bison (Docket No. FWS-R6-ES-2022-0028)

Dear Director Martha Williams,

Buffalo Field Campaign has carefully considered the best available science and evidence in developing the information and findings provided herein to inform the Secretary's determination of the biological status of wild Yellowstone bison pursuant to the Endangered Species Act.

The best available science and evidence indicates Yellowstone bison meet the criteria of a threatened or endangered Distinct Population Segment justifying Endangered Species Act listing, protection, and recovery.

In our examination of the best available science, Buffalo Field Campaign also found substantial evidence indicating the subspecies of plains bison remaining in the wild is at risk of extinction throughout all or a significant portion of their indigenous range.

As an organization and on behalf of our members, Buffalo Field Campaign recommends you consider and select qualified Indigenous reviewers to serve on the panel of scientists convened to independently review the biological status of Yellowstone bison.

Buffalo Field Campaign also recommends the U.S. Fish & Wildlife Service procure the services of tribal scientists, wildlife biologists, and traditionalists with ecological knowledge from tribes with treaty rights and ancestral ties to Yellowstone bison in developing plans, establishing criteria, carrying out conservation measures, and effectively monitoring actions that honor, protect, and restore wild Yellowstone bison in the ecosystem and bioregion they depend on for survival.

The inclusion of Indigenous leadership and inter-governmental cooperation with Indigenous tribes in developing and implementing recovery plans is an indispensable part to restoring wild Yellowstone bison in the ecosystem and bioregion where the migratory species is now extinct as a consequence of State and federal government actions and inadequate regulatory mechanisms.

The future of the country's only representative population of migratory bison persisting in the wild since prehistoric times must be secured through the Endangered Species Act's provisions for protecting and recovering Yellowstone bison's imperiled herds.

Sincerely,

James L. Holt, Sr.
Executive Director

Justine Sanchez
President

**Recommendations in providing for fair and independent representation on the panel of scientists convened to review the biological status of Yellowstone bison.**

As part of the U.S. Fish & Wildlife Service's 12-month review of the biological status of Yellowstone bison, an independent panel of scientists is selected and convened to provide peer review on the Secretary of the Interior's determination of whether the distinct population segment is "so depleted in numbers that they are in danger of or threatened with extinction." 16 U.S.C. § 1531(a)(2).

The legitimacy of the Secretary's determination rests, in part, on the panel's representation and independence and ability to critically examine and interpret the best available science and evidence in a publicly transparent process.

These essential attributes enable the Secretary to properly and reliably discharge her statutory duties using the best available information and data while seeking to conserve threatened and endangered species and the ecosystems on which they depend for survival. 16 U.S.C. § 1531(b).

The Secretary of the Interior and the U.S. Fish & Wildlife Service would be remiss in failing to consider and select qualified Indigenous reviewers with the requisite skill, expertise, and experience, preferably and additionally supported by traditional ecological knowledge, to serve on and fully participate in the deliberations of the panel of scientists convened to impartially and independently review the biological status of Yellowstone bison.

PHOTO: Sandra Lee Zelasko

# Honoring, Protecting, and Restoring Yellowstone Bison in the Wild

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**1.A. Common name (and other common names) for Bison.**

North America's Indigenous peoples identified the wildlife species in their own languages thousands of years before European Americans arrived on the continent. Below is a sample of published translations:

> Mashkode-bizhiki – Ojibwe.
> Iinii na – Blackfoot.
> Ayání – Dineh, Dine.
> Hii3einoon – Northern Arapaho, herd of buffalo.
> ᐸᐢᑳᐏ ᒧᐢᑐᐢ Paskwâwi-mostos – Cree.
> Q'ʷey Q'ʷay (pronounced kwi-kway) – Salish.
> Kamqu'qukul 'iyamu (pronounced kam koo koo kool ee ya moo) – Kootenai.
> Bishee – Crow.
> Yanasi ᏯᎾᏌ – Cherokee.

Ojibwe People's Dictionary; Blackfoot Dictionary; Dictionary of the Northern Arapaho Language (The Arapaho Language Project , Colorado.edu); Plains Cree Dictionary; Smith, Salish-Pend d'Oreille Culture Committee 2011 at 1; U.S. Fish & Wildlife Service 2013; Hubbard 2016 at 14; Cherokee Nation Language Department (language.cherokee.org).

What is a common name?

> I end this report with the Lakota name "*Tatanka*" for our bison brother because this is my people's term for this animal. To me, the *Lakota* name *Tatanka*, and the animal the term represents, has more depth than just the designation of a species of animal; it describes behavior, character, demeanor, social standing, and *Tatanka* is the representative of all buffalo in form, grace, and beauty. The term "*Tatanka*" is also one that is used to describe that majestic buffalo bull that is obviously in charge of the whole herd and will take on all challengers to his authority.

Garrett 2007 at 8.

Buffalo, a French derived term, has been popularly used to identify the wildlife species since the 17th century. J. Albert Rorabacher, *The American buffalo in transition: a historical and economic survey of the bison in America*, (North Star Press 1970).

The common English name for the wildlife species is North American bison.

PHOTO: Rick Harney

**1.B. Scientific name for *Bison*.**

The scientific name for plains bison is *Bison bison bison*. U.S. Fish & Wildlife Service, 77 Fed. Reg. 26191, 26192 (May 3, 2012).

The scientific name for wood bison is *Bison bison athabascae*. U.S. Fish & Wildlife Service, 77 Fed. Reg. 26191, 26192 (May 3, 2012).

The scientific name for European bison or wisent is *Bison bonasus*. Olech, IUCN SSC Bison Specialist Group (2008).

Plains Bison
PHOTO: Thia Martin

European Wisent
PHOTO: Goodshield Aguilar

### 1.C. Controversial or unsettled taxonomic issues for *Bison*.

After decades of debate there is no scientific consensus on whether *Bison* belong in their own genus.

"In 1758, Linneaus placed bison in the genus *Bos (Bos Bison*), but bison were subsequently moved to a sister genus (*Bison*)" in the 19th century. Douglas et al. 2011 at 167 (citing Wilson & Reeder 1993).

Two extant species are recognized within the *Bison* genus: European wisent (*Bison bonasus*) and North American bison (*Bison bison*). Douglas et al. 2011 at 167 (citing McDonald 1981).

There is also contentious scientific debate on subspecies separation of North American bison. Douglas et al. 2011 at 167.

Two subspecies are recognized in North America: plains bison and wood bison. Cronin et al. 2013 at 500.

Designation of subspecies of bison is based on historical physical separation and quantifiable behavioral, phenological, and morphological differences in the skull, horn, body proportions and size, and hair patterns. U.S. Fish & Wildlife Service 77 Fed. Reg. 26191, 26192 (May 3, 2012).

Genetic studies to date do not support subspecies designation of bison. The lack of genetic evidence may be an artifact of anthropogenic intervention and the introduction of plains bison into wood bison breeding territories in Canada. Cronin et al. 2013 at 500 (citing Geist 1991; Wilson & Strobeck 1999).

> A mitochondrial clade of southern bison, including the two present-day bison subspecies in North America, the plains bison (*B. bison bison*) and wood bison (*B. b. athabascae*), shares a common ancestor dating to the period of glacial coalescence ~15,000–22,000 cal y BP.
>
> . . .
>
> Our recovered genealogy is similar to previously published mitochondrial genealogies for bison, in which the most striking feature of the tree is the clustering of all present-day bison into clade 1a, with a maternal common ancestor that postdates the LGM [Last Glacial Maximum] (Fig. 2A).

Heintzmann et al. 2016 at 8059, 8060 (endnotes omitted).

**2. Physical description, characteristics, and life history of Bison.**

Bison are North America's largest terrestrial mammal.

Bison are sexually dimorphic: males are larger than females. Meagher 1986 at 1.

> In bison, sexual dimorphism appears to be the product of local adaptations specific to each sex since males and females are segregated for most of the year (Berger and Cunningham 1994; McHugh 1958; Meagher 1973; Roe 1951). Sexual segregation thus drives differences in the selective pressures on males and females because the sexes occupy different habitats for most of the year.

Dalmas 2020 at 8–9.

PHOTO: Thomas Mangelsen

In adults, the sex of bison can be distinguished by head and horn size. Meagher 1986 at 3 (see Figure 3).

Males can weigh from 1,014 to 2,000 pounds (460 to 907 kilograms). Females can weigh from 794 to 1,200 pounds (360 to 544 kilograms). Smithsonian 2018.

From hoof to shoulder, bison stand from 5 to 6.5 feet (1.5 to 2 meters) tall.

Bison's distinct shoulder hump is a mass of muscle connected by long vertebrae supporting a large head. Bison use their large heads to move snow from vegetation in a swinging, side to side motion. Meagher 1986 at 4.

Bison's large size and coordinated group movements in single file suggests they "can break trail for considerable distances through deep snow (> 1 m)." Knowledge of destination is an important condition for bison movements and migrations to seasonal ranges. Gates et al. 2005 at ix.

Bison horns are curved upward and inward, tapering to a sharp point. Meagher 1986 at 1. Horns are used in defense against predators.

Bison use their horns to score and scrape trees, a behavior that eventually kills trees and prevents forest encroachment into grasslands.

"Bison are highly insulated" by layers of fur, thick skin, and subcutaneous layers of fat. Martin & Barboza 2020 at 6.

Bison have two layers of fur: an underlayer of soft, woolly fine hair, and an outer layer of thick, shaggy coat of fur, a long and heavy mane, a black beard under the chin (a pronounced feature in mature bulls), a cape, and black tail ending in a tuft of stiff hair. Hindquarter fur is short, tan to brown. Forequarter fur is darker, brown to black. Meagher 1986 at 3; Lederman Science Education Center 2001.

Bison's "forequarters and head are draped in a dense coat of long guard hairs that is not shed seasonally and limits thermal exchange." Martin & Barboza 2020 at 6.

Bison develop thick, woolly coats of fur to survive winter. Bison's outer layer of fur helps shed moisture and snow, while the underlayer of fur prevents heat loss and provides insulating warmth against extreme temperatures. U.S. National Park Service Dec. 1, 2021 at 2.

Pelage molt begins in late winter and early spring. Patches of fur slough off and cling to the forequarters into August. A new winter coat of fur is grown by fall. Meagher 1986 at 3.

Bison fur is used to line nests and provides nesting material for several species of birds. Banff National Park 2019 at 4, 9, 84.

Bison's skin thickens in response to cold temperatures, and fatty deposits provide insulation. U.S. National Park Service Dec. 1, 2021 at 2.

PHOTO: Thomas Mangelsen

Bison's thick skin, underfur, long guard hairs, and layers of fur and fat insulate them from cold and wind and provide warmth to temperatures far below zero degrees Fahrenheit. Meagher 1986 at 4.

"Bison also have the ability to use their large head and massive neck and shoulder muscles as snow plows to forage in snow as deep as four feet." U.S. National Park Service Dec. 1, 2021 at 2.

Bison have "adapted to efficiently find nourishment from low quality forage that allows them to battle blizzards, –40 degree temperatures, and 50 mph winds. Under cold stress, bison have developed the adaptation to minimize nutritional needs and slow their metabolism to conserve energy." U.S. National Park Service Dec. 1, 2021 at 2.

"Bison also have the ability to generate internal body heat through digestion." U.S. National Park Service Dec. 1, 2021 at 2.

"Forage is retained longer in their gut — due to the increase of indigestible plant material found in the winter — which allows them to eat less but still receive the nutrition they require." U.S. National Park Service Dec. 1, 2021 at 2.

Despite their size and weight, bison can quickly pivot and spurt-run up to 35 miles per hour (56 kilometers per hour). U.S. National Park Service 2018 at 3.

"Bison are bulk feeders able to digest large amounts of low quality fibrous forage in voluminous rumens (Houston 1982, Hudson and Frank 1987, Hanley 1982)." Gates et al. 2005 at 26.

Bison's large size, sharp horns, quick agile movements, and group defense strategy are used to ward off approaches and fend off attacks by predators. U.S. National Park Service 2018 at 4; Auttelet et al. 2015 at 5.

Bison can jump over objects 6 feet tall (1.8 meters). Auttelet et al. 2015 at 2.

Bison are strong, powerful swimmers. Meagher 1986 at 6 (citing Fuller 1960 who noted bison regularly swam rivers 1 kilometer wide with currents of 3 to 6 kilometers per hour).

PHOTO: Mike Burdic

"I observed a lone cow swimming strongly from the mainland to an island . . . a distance of about a mile and a half. . . I followed her in a canoe and noted that she showed no undue signs of fatigue on landing." Fuller 1960 at 5.

Bison have excellent hearing, vision, and sense of smell. Auttelet et al. 2015 at 2 (citing Meagher 1973, Lott 2002).

Bison's hearing is acute. "They react to small noises such as the accidental cracking of a branch underfoot at distances of 100 to 200 yards." Fuller 1960 at 4.

Bison's acute sense of smell is important in detecting danger. Meagher 1986 at 6 (citing Fuller 1960, McHugh 1958).

Bison's "sense of smell is highly developed and appears to be of prime importance in detecting danger." Fuller 1960 at 4.

> On one occasion, after watching a herd from a place of concealment for nearly an hour, a sudden shift in the wind, which carried my scent to the bison, precipitated an immediate stampede. I have no quantitative data on the maximum distance at which bison can detect human scent, but it is at least several hundred yards.

Fuller 1960 at 4.

Bison are capable of producing a number of sounds. Vocalizations include the roaring "bellow" of bulls during the rut, snorts, and coughs from forced inhalations and exhalations. Fuller 1960 at 6. The "distinctive roar or bellow of rutting bulls may carry nearly" 5 kilometers (> 3 miles). Meagher 1986 at 6 (citing McHugh 1958).

> Bellowing is a conspicuous breeding-season characteristic (Lott, 1974), described nearly 150 years ago as "the long continued roll of a hundred drums" (Audubon, 1843, cited in Cates, 1986). Bellows are short (mean = 2.05 s), guttural, low-frequency (mean = 230 Hz) exhalations (Gunderson and Mahan, 1980) that occur when males are alone, in mixed-sex groups, and, most often, with females.

. . .

> With respect to Darwin's idea that vocalizations serve as a male display to females, (1) males bellowed neither before nor after copulating when rivals were absent but (2) they bellowed both before and after copulating when rivals were present. Overall, these results suggest that bison bellows do not serve as advertisements to females but function as intrasexual displays.

Berger & Cunningham 1991 at 2, 1.

Bison wallowing and tree rubbing are scent-marking behaviors. Bowyer et al. 1998 at 1049.

> [M]ale urination while wallowing advertises the animal's physical condition and primes females for oestrus. . . . [R]eproductive effort increases with age and large males mate more often than small males… [W]allowing of females may leave behind olfactory signals for males . . . [T]ree rubbing occurs most commonly among females and, as above, may relate to advertising the reproductive status of the animal.

PHOTO: Jackson Doyel

Peck 2001 at 73 (citations omitted).

"Wallowing is a behavior of bison that is important for grooming, insect repulsion, sun protection, and social interactions (McHugh 1958, Reinhardt 1985, McMillan et al. 2000). This behavior involves an animal repeatedly rolling on the ground, after which additional animals wallow in the same area." Nickell et al. 2018 at 2.

Flehmen (lip curl), commonly observed in mature bulls during the rut, may facilitate identification of a female in estrus. Meagher 1986 at 6 (citing Lott 1981).

**Bison reproduction.**

Bison mating behavior is polygynous or polygamous, i.e., dominant male bulls produce a majority of the offspring. Lott 2002 at 193–196.

Bison's highly competitive mating system in large herds contributes to evolved social and dominance relations, natural selection of wild traits, and fitness, in good times and bad. Bailey 2013 at 179–198, 133–149.

"A polygamous mating system can reduce or eliminate the genetic contribution of many males and thereby increase VMRS [Variance in Male Reproductive Success] which in turn can rapidly reduce genetic variation in a population (e.g. Kaeuffer et al., 2004)." Pérez-Figueroa et al. 2012 at 164.

Variance in male reproductive success changes in any given year based on the number of sexually mature females nutritionally fit to reproduce, and dominant males fit to contest for mates in the rut.

The variance for the reproductive success of dominant males in Yellowstone bison is uncertain. Pérez-Figueroa et al. 2012 at 164.

Male variance or contribution to reproductive success is unknown.

In Badlands National Park, South Dakota, USA (40°50' N, 102°20' W), "the most successful males in a given year copulating with up to 14 females (Berger J, in preparation), . . . traveling up to 33 km a day in search of females, even though more than 85% of the mature males may actually spend less than 2 weeks in habitats where females occur during the 6-week rut (Berger, 1989)." Berger & Cunningham 1990 at 2.

Most estimates are based on observation and not DNA-based paternity analysis. Pérez-Figueroa et al. 2012 at 161.

> [The Yellowstone bison] population is geographically isolated and likely has moderate or high variance in reproductive success, as in many ungulates (Hogg et al. 2006; Ortego et al. 2011) due to a polygamous mating system and a dominance hierarchy in which a limited proportion of males breed most of the females and which could lead to relatively rapid loss of genetic variation.

Pérez-Figueroa et al. 2012 at 160.

> In our simulations, VMRS [Variance in Male Reproductive Success] was the factor with the strongest influence on *Ne* and the loss of variation, when VMRS was high to extreme. Thus, future research could improve understanding of loss of variation by providing estimates of VMRS through paternity analyses in bison populations. We did not consider high variance in female reproductive success or heritability of fitness, both of which could increase the rate of loss of variation (heterozygosity) by perhaps 10–20% (Ryman et al. 1981).

Pérez-Figueroa et al. 2012 at 165 (*Ne* is the effective population size).

Observed mating is a poor predictor of actual reproductive success for individual male bison, and can be misleading. Mooring & Penedo 2014 at 922.

> To summarize, 44% of observed matings did not result in the birth of offspring, and 60% of the copulations that did produce a calf did not accurately predict the sire bull. Thus, what appeared to be a good herd-wide association between behavioral and genetic measures was highly misleading regarding the fitness of individual bison.

Mooring & Penedo 2014 at 920.

> Bison females are seasonally polyestrous and may experience 2 or 3 estrous cycles, mating with different males during each estrous period (Vervaecke and Schwarzenberger 2006). Previous studies reported that 9–15% of breeding females engaged in multiple copulations during different estrous periods (Berger and Cunningham 1994; Wolff 1998), whereas we observed that around 15% of breeding-age cows at Fort Niobrara (range 7.6–23.5% per year) bred 2 or more times during successive estrous periods. In addition, some cows may

> not conceive because of failure by the bull to fertilize, which also would overestimate behavioral estimates of reproductive success.

Mooring & Penedo 2014 at 921.

Gathering behavioral and genetic data on the variance in male reproductive success is important to a species of conservation concern because it is one reliable measure of fitness, and estimating effective population sizes to avoid loss of genetic variation and to ward off genetic inbreeding. Mooring & Penedo 2014 at 914, 922.

> The occurrence of large groups of bison in the Delta Junction herd in 1996 compared with 1997 did not significantly alter timing of mating. This outcome indicates that more than just social facilitation (sensu Asher et al. 1996) associated with large groups affected these reproductive activities, at least for the sizes of groups that we observed. We hypothesize that the presence of large males was an important factor in timing of mating behavior. Indeed, females in groups with large males were far more likely to copulate than those in groups with smaller males. This outcome indicates that females prefer to mate with large males, even when these individuals are rare.

Bowyer et al. 2007 at 1056.

Females sexually mature at age 2. Low levels of breeding by yearling female bison (1 of 21) were recorded in a study of Central herd. Gogan et al. 2013 at 1275.

"Female American bison of both subspecies more commonly breed for the first time between 2 and 4 years (Fuller 1962, Haugen 1974, Wolfe et al. 1999)." Gogan et al. 2013 at 1275.

> Our estimated overall pregnancy rate of 65% for central Yellowstone bison ≥2 years old (95% CI = 0.56–0.72) was greater than the range of annual pregnancy rates of 37–45% for ≥2-year-olds reported previously for this subpopulation (Kirkpatrick et al. 1996) and approximates the lowest annual pregnancy rates of 67–87% among ≥2–year-old plains bison elsewhere (McHugh 1958, Wolfe and Kimball 1989), and 72–85% for ≥2-year-old wood bison (Fuller 1962, Joly and Messier 2005). This pattern provides further evidence of temporal and spatial variation in bison pregnancy rates that likely reflect differences in population densities and environmental conditions (Coulson et al. 2000, Bonenfant et al. 2009, Gaillard et al. 2009).
>
> Our detection of peaks and troughs in pregnancy rates among bison ≥2 years old indicates that a high proportion do not breed successfully in sequential years (Fig. 4), and is consistent with reports of 70–85% of pregnancies occurring in ≥3-year-old non-lactating central Yellowstone bison (Kirkpatrick et al. 1996). Alternate year reproduction was detected via observations of sequential calving success in brucellosis-free plains bison with calving peaks at 3, 5, and 7 years and troughs at 4, 6, and 8 years old (Halloran 1968).

. . .

> [A]nnual variation in pregnancy rates is possibly attributable to the need for females to achieve a critical body weight by the breeding season. Lactating females lose more weight post-calving than do barren females (Green and Rothstein 1991, Wolff 1998) and may not be able to achieve a threshold body mass prior to the next breeding season. Reproductive pauses provide an explanation of the current low reproductive rate in central Yellowstone bison relative to other bison populations.
>
> Body condition during the reproductive season is a key factor in determining the probability of pregnancy in a number of ungulate species (Parker et al. 2009, Tollefson et al. 2010). Age and weight were highly correlated in our study, and for bison ≥2 years old, age was a better predictor of pregnancy rates than was weight. Our parameter estimates for the effects of age on pregnancy rates for bison ≥2 years old (0.21) are similar to 3 of the 4 estimates reported previously (Geremia et al. 2009: Table 14.6). However, we found weight to be an influential factor in determining pregnancy rates of central Yellowstone bison <2 years old. Elsewhere, plains bison calving successfully as 2-year-olds weighed more as yearlings than did females that calved for the first time at age 3 or 4 years (Green and Rothstein 1991).

Gogan et al. 2013 at 1276 (also finding older, heavier Central bison were more likely to be pregnant but no relationship was found "between pregnancy rates and serological status for brucellosis across a range of ages.").

A recent study found "12– 26% of pregnant cows lost their calf during gestation (Borgreen 2010). Our finding that 44% of copulations failed to produce offspring supports a role for spontaneous abortions." Mooring & Penedo 2014 at 921.

PHOTO: Jackson Doyel

Older males (≥7 years) participate in most of the breeding of offspring. Mooring et al. 2006 at 369 ("Dominance rank was positively correlated with copulatory success and age, and dominant bulls were more likely to tend (guard) cows as they approached estrus" with dominant bison bulls paying "a significant physiological price for high social status and the opportunity to mate.").

Rutting begins in late July and runs through August.

> [I]f males have access to a large number of females and copulate often, the most prolific males can experience sperm depletion (Preston et al. 2001). However, physiological studies indicate that bison bulls produce adequate sperm for breeding throughout the year (Helbig et al. 2007), and bulls at Fort Niobrara were rarely observed to copulate more than 20 times in a season.
>
> . . .
>
> It is unlikely that sperm competition plays a role in the reproductive success of male bison as it does for bighorn sheep (*Ovis canadensis*—Hogg 1988), because cows rarely mate with a 2nd male during the same estrous period.

Mooring & Penedo 2014 at 921.

Bulls display their dominance through posturing, bellowing, scent urinating, wallowing, and fighting other bulls. Interaction among mature bulls is intense and much of the behavior is displays of threat and signals of submission. Fights often end without injury but occasional fatalities occur. Meagher 1986 at 6; Mooring et al. 2006 at 738.

PHOTO: Jackson Doyel

> Dominant males temporarily consort with cows prior to or during estrus and attempt to keep all other bulls away by engaging in vocalizations, threat displays, and fights.
>
> The most conspicuous and frequent vocalizations made by bison bulls during the rut are bellows. Bellows function to intimidate rival males (Berger & Cunningham, 1991; Berger & Cunningham, 1994), while bellow amplitude has been linked to male body condition (Wyman et al., 2008). Importantly, amplitude and bellow quality are directly tied to mating success (Wyman et al., 2008).

Sarno et al. 2017 at 3.

> Behavioral measures may not accurately predict paternity for other reasons. For instance, when males practice alternative mating strategies that are less likely to be observed than the dominant strategy, measures of reproductive success based on copulations could be underestimated. Depending on their competitive ability, bulls use different mating strategies to gain access to mates and maximize their reproductive success (Wolff 1998). High-quality bulls defeat rivals and tend as many females as possible (dominant strategy), whereas less-competitive bulls may become "perpetual challengers" that follow tending pairs and opportunistically mate when the dominant bull is distracted (sneaky challenger strategy). There are indications that cows may practice mate selection for sneaky males (Wolff 1998).

Mooring & Penedo 2014 at 921.

> Although factors such as predation risk clearly influenced group size in bison, benefits from the presence of large males also played a strong role in mating activities. The presence of large males may be critical to the dynamics of some ungulate populations (Mysterud et al. 2002; Rankin & Kokko 2007). We hypothesize that large groups of bison offer a reduced risk from predation and an added benefit related to timing of mating for individual females that occur with large males.

Bowyer et al. 2007 at 1056.

Weakened bulls and fatalities from the rut benefit grizzly bears as a late summer and early fall food source. U.S. Fish & Wildlife Service 82 Fed. Reg. 30503, 30536 (June 30, 2017).

Scent marking trees by females in locations around the rut suggest the signaling or advertising of estrus. Peck 2001 at 37 (citing Bowyer et al. 1998 and Coppedge & Shaw 1996).

> [T]he significance of scent marking trees is related to the expectation that the rut occurred in locations geographically around the periphery of the plains near to outcrops of trees which provide females places to advertise their receptiveness. That is to say, the model presented here predicts that bison rut in an arc around the periphery of the plains next to the parkland, thus in a position for females to use the nearby trees for scent marking.

Peck 2001 at 38.

"Wallowing and rubbing of trees by American bison may have additional functions, but these behaviors clearly are used for scent marking by large males during rut (Bowyer et al. 1998a)." Bowyer et al. 2007 at 1055.

Female bison "advertise oestrus" by rubbing and scent marking trees "much more frequently than other bison during the rut (see also, Coppedge and Shaw 1996). . . . to aid males searching for a mate. . . .the male urination in wallows may form a return signal to the females." Peck 2001 at 37–38 (citing Bowyer et al 1998.).

> Several aspects of our study are unique and provide general insights into the behavior of bison. Because large males were exceptionally scarce, we were able to clearly document that females preferred to mate with large compared with smaller males, although males likely sought out groups of females rather than vise versa. Moreover, large males played an important role to the degree of sociality exhibited by bison – groups with large males were larger than those without them. Scent-marking behavior by large males was more frequent than for smaller males (Bowyer et al. 1998a), and occurred primarily in a male–female context. Timing of scent marking was concordant with highly synchronous mating activities by bison, which supports the hypothesis that scent marking triggers ovulation in females.

Bowyer et al. 2007 at 1056–1057.

Wallowing is also a display behavior.

> Whatever protection from biting flies the mud gives the bull's near-naked rear-half, wallowing was primarily a social ritual among the bison bulls. If one bull started to wallow, the most dominant bull was sure to come and displace him. In essence, wallowing before a rival or females is a method of "display". Hence, a dominant bull leaving his wallow was followed by another bull, and another, until the whole herd had used the same wallow [see also, Bowyer et al. 1998: 83–84; Catlin 1995: 281–282; Grinnell 1892: 273]. The wallow was enlarged and deepened as each bull carried mud in its coat, and wallows became prominent features of the landscape that outlived the expiration of bison by decades.

Peck 2001 at 38 (quoting zoologist Valerius Geist 1996).

The herd wallow, "a circular excavation of fifteen to twenty feet in diameter, and two feet in depth … left for the water to run into, which soon fills it to the level of the ground," repeated millions of times over, had profound effects on aquatic species and hydrology. Peck 2001 at 41 (quoting Catlin 1995).

PHOTO: Jackson Doyel

Butler characterized bison as a geomorphic agent capable of widespread landscape change.

"Individual bison wallows, that numbered in the range of 100 million wallows, each displaced up to 23 $m^3$ of sediment." Butler 2006 at 448.

The combined bison wallows influence on "surface hydrology and runoff can only be considered to have been regionally substantial and locally enormous." Butler 2006 at 452.

"In the case of native animals, human impacts have reduced geographic ranges and population numbers of an extensive list of geomorphically significant animals, whereas introduced animals have created widespread and often deleterious geomorphic activity in the removal of vegetation and corresponding direct and indirect erosional responses." Butler 2006 at 448.

> Bison grazing and trampling that accompanied grazing have been credited with holding back aspen expansion in the northern plains (Campbell et al., 1994), maintaining shortgrass prairie in areas where mid-grass prairie would have otherwise become established (England and DeVos 1969), and mobilizing sand dune fields in the Great Plains during periods of protracted drought (Forman et al., 2001). Each of these grazing- and/or trampling-induced results has obvious ramifications on soil infiltration, surface runoff, and erosion. Bison trampling and slope loading along stream channels also led to the creation of well-established trails on the plains that led to stream crossings (Butler, 1995). Bison further altered stream habitats by locally increasing the silt fraction of the streambed and widening stream channels at crossing points (Fritz et al., 1999)(Fig. 3).
>
> Bison grazing in the Great Plains had an additional zoogeomorphic impact of great import: mixed-grass prairie vegetation was kept sufficiently short so that prairie dogs could colonize the area (Hygnstrom and Virchow, 2002). Prairie dogs are herbivorous, colonial rodents that create large burrow systems (Fig. 4)(Whicker and Detling 1988). Prairie dog burrowing and grazing in turn positively interacts with, and, therefore, encourages additional bison grazing (Whicker and Detling 1988), resulting in a feedback of additional bison trampling and wallowing.

Butler 2006 at 452.

Natural selection has favored large size and fighting ability in bison bulls. Lott et al. 2002 at 5–22.

A bull that has found a female who is close to estrus will stay by her side (courting) until she is ready to mate. A bull will tend or guard her in close proximity until he is permitted to copulate with her or is displaced by a rival bull. Once mated, the bull moves on to court another female. U.S. National Park Service 2018 at 3.

Following copulation, a female arches her back, secretes a portion of vaginal fluids and bull semen from her vulva, and erects her tail. The copulated female's 'tail-up' held high response is maintained for 1–2 days. Mooring et al. 2006 at 370 (citing Lott 1981; Berger 1989; Berger & Cunningham 1991; Komers et al. 1992b; Wolff 1998).

Bison may live 20 years or more in the wild. Meagher 1986 at 5.

The survival and reproduction of older bison "is an important component of natural selection. A bison's gene-based advantages for surviving, reproducing and leaving abundant genes in succeeding generations will not be fully realized if the animal dies at an early age due to some random catastrophe or to artificial culling. In contrast, the advantages of the fittest bison will accumulate as the animal lives longer. Thus, having many old bison, at least 12-15 years or age, in a bison herd is an important contribution to natural selection." Bailey 2013 at 84–85.

**Bison birthing synchrony and variation.**

Females give birth to one calf after 9 to 9 1/2 months gestation in late April and May. Twin calves are rare. Calves are bright red to tan. Calves can stand and nurse 10 to 30 minutes from birth, may try to graze 5 days and drink water 1 week from birth. Females nurse their calves for at least 7 to 8 months and are typically weaned after 1 year. Meagher 1986 at 4, 5.

PHOTO: Cindy Goeddel

Calves can keep up with the herd 2 to 3 hours after they are born. U.S. National Park Service 2021.

Females give birth in isolation from the herd.

Yellowstone's Northern and Central bison herds exhibit differential synchrony of parturition coincident with the onset of spring plant growth in each range.

"Data on timing of mating revealed a high degree of synchrony, with little between-year variation. Berger & Cunningham (1994) likewise observed little among-year variation in timing of births for bison, but Green & Rothstein (1993a) noted more interannual variability." Bowyer et al. 2007 at 1055.

There is evidence of temporal and spatial variation in Yellowstone bison pregnancy rates. Annual variation in pregnancy rates may be attributable to females achieving critical body weight by the breeding season. Female reproductive pauses observed in the Central bison herd may be a result of post-calving weight loss and the inability to achieve sufficient body mass by the breeding season. Gogan et al. 2013 at 1276.

"Reproductive pauses provide an explanation of the current low reproductive rate in central Yellowstone bison relative to other bison populations." Gogan et al. 2013 at 1276 ("the lowest annual pregnancy rates" of bison populations studied by McHugh 1958, Wolfe & Kimball 1989, Fuller 1962, Joly & Messier 2005).

"[A]vailability of spring forage is a major factor in the timing of parturition in temperate climate ungulates (Bunnell 1982, Rutberg 1987, Bowyer et al. 1998)." There is a strong correlation between latitude and the timing and synchrony of parturition in the Central and Northern bison herds. Gogan et al. 2005 at 1726.

> The distribution of parturition dates in Yellowstone bison is generally right-skewed with a majority of births in April and May and few births in the following months. Predicted timing of parturition was consistently earlier for bison of Yellowstone's northern herd than central herd. The predicted media parturition date for northern herd bison in the historical period was 3 to 12 days earlier than for 2 years in the contemporary period, respectively. Median predicted birth rates and birthing synchrony differed within herds and years in the contemporary period. For a single year of paired data, the predicted median birth rate for northern herd bison was 14 days earlier than for central herd bison. This difference is coincident with an earlier onset of spring plant growth on the northern range.

Gogan et al. 2005 at 1716.

> Among ungulates, timing and synchrony of parturition may enhance offspring survival, maternal survival, and future reproductive success. Rutberg (1987) hypothesized that timing and synchrony of births served as adaptations to weather, resource availability, or predation (predator saturation, confusion, and group defense). Parturition may occur when food resources are plentiful or of high quality (Bunnell 1980, 1982; Bowyer et al. 1998; Linnell and Anderson 1998; Sinclair et al. 2000), coincident with the high energetic demands of lactation (Millar 1977, Loudon 1985). Parturition and lactation at a period of high nutrient quality or availability may enhance the female's responses to the energetic demands of lactation and improve her physiological condition when she enters the next period of resource limitation or breeding season (Murray 1982). Thus, selection of parturition timing may act against birthing when the probability of high nutrient forage for the postpartum period is low (Ozoga and Verme 1982). Similarly, offspring born at the onset of a period of high nutrient abundance or quality may enter the next period of resource limitation with a larger body size and consequently greater probability of survival as calves and yearlings (Clutton-Brock et al. 1987) compared to late-born calves that are unable to gain sufficient body mass to survive the following period of nutritional deprivation (Thorne et al. 1976, Guinness et al. 1978, Clutton-Brock et al. 1987, Festa-Bianchet 1988, Rachlow and Bowyer 1991, Smith and Anderson 1998).
>
> Ungulate species in seasonal environments commonly exhibit pulse or restricted birthing seasons (Bunnell 1982, Rutberg 1987, Sinclair et al. 2000). Such synchronized parturition may be achieved by reduced variability in timing of conception and length of gestation. The nutritional plane of breeding females as determined by weather conditions or population density may affect timing of conception and gestation length (Parr et al. 1982, Clutton-Brock et al. 1988, Schwartz and Hundertmark 1993), thereby affecting the level of birthing synchrony as well (Adams and Dale 1998). Synchronous parturition in some ungulate populations may be an antipredator strategy enhancing neonate survival by predator swamping (Watson 1969, Estes 1976, Estes and Estes 1979). Other ungulate populations

> may exhibit asynchronous birthing as a means of avoiding predation on neonates (Sinclair et al. 2000).
>
> High and low levels of parturition synchrony have been reported in North American bison. Highly synchronized parturition is characterized by 50% of births occurring within 13 to 27 days and 80% of cumulative births within 23 to 60 days (Rutberg 1984, Green and Berger 1990, Berger 1992, Berger and Cunningham 1994, Berger and Cain 1999). Low parturition synchrony is characterized by 50% of births occurring within >90 days (Wolfe and Kimball 1989, Wolfe et al. 1999) and 80% of cumulative births within 60 to 70 days (Berger 1992, Green and Rothstein 1993*a*). Bison at Badlands National Park (BNP), South Dakota, achieved high synchrony in calving by synchronizing conception or a post-conception shortening of the gestation period by late-breeding females in adequate nutritional condition (Berger 1992). In contrast, bison in poor nutritional condition showed low synchrony in birthing (Berger 1992). However, no relationship was found between parturition date and maternal condition in bison at Wind Cave National Park (WCNP), South Dakota, except that the oldest females gave birth to their last calves "unusually late" (Green and Rothstein 1993*b*). Late birth dates for female calves increased the probability of reproductive failure as an adult; females born early in the calving season were more fecund than those born later for up to 9 years of life (Green and Rothstein 1993*b*). In addition, synchrony and timing of births in bison may be impacted by the presence of diseases (Berger and Cain 1999).

Gogan et al. 2005 at 1716–1717.

> Based on data collected since 1970, population rate of increase was significantly inversely related to population density for Central Range bison (population growth decreased with increasing population size), but not for the Northern Range population. Northern Range bison may be unresponsive until now because of the dominant effect of forage competition by a large elk population.

Gates et al. 2005 at vii.

**Bison calf survival.**

Late-born calves may not achieve an adequate body size needed to survive the harsh Yellowstone winter. Gogan et al. 2005 at 1726.

> The effects of climatic variability on large ungulates are most pronounced on neonatal survival because conception and gestation require less energy than lactation, and nutritionally stressed females may produce offspring that will not survive the first 2 weeks of life, thus avoiding the costs of lactation (Clutton-Brock et al. 1989, Gaillard et al. 2000). Adult female survival was high (0.92—0.96) and constant in bison from YNP, Wood Buffalo National Park (Larter et al. 2000), and the Henry Mountains (Van Vuren and Bray 1986). Thus, the differences in growth rates among these populations likely reflect differences in calf survival, which was highest in the Henry Mountains (0.94), lower in Yellowstone (0.76; Kirkpatrick et al. 1996), and lowest in Wood Buffalo National Park (0.49–0.63).

Fuller et al. 2007 at 2371.

> Bison in Yellowstone attempt to compensate for declining per capita food resources by range expansion, thus maintaining a relatively stable instantaneous density. However, compensation is not exact; population growth rate declines with density because high quality foraging patches are limited in overall area, are patchily distributed, and depleted first, forcing bison to shift to poorer quality patches as density increases. The likely demographic responses are decreased fecundity and increased juvenile mortality.

Gates et al. 2005 at vii.

"In recent decades, birth rates have been higher in northern Yellowstone (0.78; 95 percent Bayesian credible interval [CI] = 0.72 to 0.84) than in central Yellowstone (0.63; CI = 0.56 to 0.69)." Auttelet et al. 2015 at 86.

PHOTO: Robert Hughes

Birth rates for bison decline following winters with deep or hard snow pack, e.g., snow crusting events. Auttelet et al. 2015 at 86.

"Neonate survival has been 0.75 (standard deviation = 0.06) during the first month of life and 0.87 (standard deviation = 0.05) during the remainder of the first year (Geremia et al. 2014b)." Auttelet et al. 2015 at 90.

> Gestation lengths in bison are variable (Berger 1992). Factors such as nutritional status and the presence of disease may affect timing of births (Berger & Cain 1999; Keech et al. 2000) – timing and synchrony of mating clearly have a strong influence on when neonates are born. Consequently, mating and its effects on timing of parturition are critical components in the fitness of individual northern ungulates (Green & Rothstein 1993b; Keech et al. 2000; Côte´ & Festa-Bianchet 2001). Bison births may occur over >1 mo (Green & Rothstein 1993a; Berger & Cunningham 1994). Nonetheless, data on survivorship of these young are sparse, especially for populations where predation still is an important component in mortality of young bison. The timing of mating we observed in August likely indicates an adaptive advantage to such synchronous mating.

Bowyer et al. 2007 at 1055.

**Bison predators.**

Bison are dangerous prey.

Calves and other herd members rely in part on bison social structure to defend themselves against native predators including grizzly bears, wolves, and coyotes. In social groups, bison confront rather than flee predators.

PHOTO: Kim Kaiser

> Yellowstone bison employ a predator defense strategy whereby bison in a group cooperate to defend themselves and their young (Smith et al. 2000; MacNulty et al. 2007; Becker et al. 2009a). When threatened by predators such as wolves (*Canis lupus*), bison often gather together around young animals. Older males and females may challenge the predator(s), with their heads down and horns ready to hook their opponents. If one bison becomes vulnerable or is attacked, other bison may engage the predator(s) from a different direction. Bison usually prevail against one or a few predators when they employ this group defense strategy (MacNulty et al. 2007).

Auttelet et al. 2015 at 5.

The success of wolf hunting is limited to "a narrow set of conditions larger packs (>11 wolves) chasing smaller herds (10–20 bison) with calves." Tallian et al. 2017 at 1418.

> Historically, wolves and bison coexisted over vast areas of North America, but populations of both were drastically reduced because of predator control and market hunting (Lopez 1978). Wood Buffalo National Park and the adjacent Slave River Lowlands in Canada is 1 of the few areas where a wolf–bison system has been preserved and where wolves regularly prey on bison (Carbyn et al. 1993; Van Camp 1987). Bison there are the main prey of wolves, so questions of learning and selectivity are not pertinent. In the Mackenzie Bison Sanctuary in Canada, wolves avoid bison and kill moose, even though bison are more abundant (Larter et al. 1994).

Smith et al. 2000 at 1128–1129.

Bison are wolves' most formidable prey to kill. Smith et al. 2000 at 1129.

> From April 1995 through March 1999, field personnel observed 44 independent wolf–bison encounters, resulting in 57 total interactions (13 interactions involved the same bison and wolves), and saw 4 bison (7%) being killed; remains of 10 other wolf-killed bison were found (Table 2).

Smith et al. 2000 at 1131.

> During that same period, we observed 372 separate wolf–elk interactions, during which wolves killed 77 elk (21%). Hence, wolves were more successful killing elk than killing bison when they encountered them ($X^2 = 5.18$, $d.f. = 1$, $P = 0.03$). We documented 589 other wolf-killed elk during that period. Although there were more elk in YNP than bison (Table 1; elk outnumbered bison 5.6:1), the ratio of elk : bison killed by wolves was much higher (47.6:1).

> The 5-year average for the elk and bison population over the study period showed that elk comprised 83% (14,540) and bison 17% (3,027) of the available prey base. Based on our wolf–prey encounter rates of 372 (87%) for elk and 57 (13%) for bison, we found that wolves did not approach elk more often than they approached bison ($X^2 = 2.08$, $d.f. = 1$, $P = 0.15$).

Smith et al. 2000 at 1131–1132.

> As with other large prey, wolves killed primarily calves and older adults in poor condition (Mech 1970; Mech et al. 1998). The 1 bull they killed had a broken leg. We also found that bison kills increased from 1997 through 1999, indicating that with experience wolves were more successful killing bison.

Smith et al. 2000 at 1133.

> Currently, predation by wolves on bison does not limit bison subpopulations in YNP (D. Smith, Wolf Biologist, YNP, pers. comm.). . . . However, predation rates on bison vary in the park and are higher in central YNP compared to the northern range because elk are much less abundant in central YNP, particularly during the winter (Smith et al. 2000, D. Smith, Wolf Biologist, YNP, pers. comm.). In central YNP, because of the small and likely decreasing population of elk (Garrott et al. 2002), wolves are taking an increasing number of bison (D. Smith, Wolf Biologist, YNP, pers. comm.). Therefore, there is potential for this predator prey system to evolve to a state similar to that reported in Wood Buffalo National Park where bison are the main prey and other ungulates occur at low densities (Carbyn et al. 1993). Bison carcasses also provide an important food source for scavengers, particularly grizzly bears (Green et al. 1997, Mattson 1997).


PHOTO: Peter Dettling

Gates et al. 2005 at 51–52.

Grizzly bears rarely prey on bison. Mattson 2017 at 3; Wyman 2002 (female grizzly bear attacked a lone male bull); Varley & Gunther 2002 (female grizzly bear killed a calf with a lone female defending her young).

Natural winter kill, females dying from birthing complications, and males dying in the rut fulfills an important ecological role in providing carrion for grizzly bears. Mattson 2017 at 5.

> Of the foods, grizzly bear range was most strongly positively associated with ranges of oak-dominated vegetation types and bison.
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> . . .
>
> Grizzly bears apparently occupied the prairies and grasslands only where there were bison (Fig. 3) or humans not engaged in maize cultivation.

. . .

> Availability of oaks and bison also positively affected the location of core grizzly bear range in 1850. This is consistent with the current importance of acorns to black bears (*U. americanus*) in places such as southern Colorado (Beck 1991) and central Arizona (LeCount et al. 1984) and of bison to grizzly bears in the Yellowstone region, especially where other high-quality foods are scarce (Green et al. 1997; Mattson 1997*a*).

. . .

> Although piñon pine seeds and bison carcasses might have been spatially more dispersed than salmon, bison carcasses were often abundant along riparian areas (Burroughs 1961; Haines 1970), and piñon pines were abundant at lower elevations nearer where Europeans settled and were active (Brown 1994). Compounding this, bison, perhaps one of the most important foods of grizzly bears on the Great Plains, were nearly extirpated from 1850 to 1920.

. . .

> The presence of bison and extensive communities of oaks such as *Quercus gambelii* or *Q. turbinella* would also enhance prospects for restoration by providing high quality bear food. The identification of such areas, if they exist, is a necessary next step toward ensuring the long-term survival of grizzly bears in the contiguous United States.

Mattson & Merrill 2002 at 1128, 1131, 1133, 1135.

"Wolf use of bison carrion increased during 1999–2015 . . . [and] evidence that high levels of bison scavenging depressed bison attack and kill frequencies." Tallian et al. 2017 at 1424.

> During 1993 through 2010, biologists from Montana State University found 656 bison carcasses in central Yellowstone during winter and spring and the apparent causes of death were 225 wolf predations, 181 winter-kills, 153 due to unknown causes, 46 grizzly bear predations, 20 thermal/mud entrapments, 10 vehicle strikes, 7 accidents/injuries, 7 birth/pregnancy complications, 6 due to unknown predators, and 1 coyote predation (R. A. Garrott, Montana State University, unpublished data).

Auttelet et al. 2015 at 91.

> [B]ehavioral observations of bison in environments with a complete complement of natural predators are uncommon. In this predator-rich ecosystem, the group size of bison was directly related to distance to the forest edge, ostensibly a response to predation risk. This relationship likely plays an important role in the evolution of sociality for this gregarious large mammal.

Bowyer et al. 2007 at 1057.

**Factors influencing bison's winter survival.**

> Summer drought can reduce forage production and thus forage quality and quantity available to ungulates during the subsequent winter (Merrill and Boyce 1991).
>
> . . .
>
> Summer precipitation was highest in West Yellowstone (11.05 cm), followed by Mary Mountain (10.9 cm), Pelican Valley (9.8 cm), Lamar Valley (9.7 cm), and Gardiner basin (6.3 cm), which had the least precipitation (Table 3.6). On average, summers were drier on the northern range than central YNP.

Gates et al. 2005 at 48, 49.

> Important winter habitat for bison included shrub-grasslands consisting of Idaho fescue, bearded wheatgrass, bluebunch wheatgrass, sandberg's bluegrass, shrubby cinquefoil (*Dasiphora floribunda*), richardson's needlegrass, tufted hairgrass (*Deschampsia cespitosa*), big sagebrush and silver sagebrush (*Artemesia cana*). Wet meadows consisting of willows (*Salix* spp.) and sedges (*Carex* spp.) and vegetation associated with thermal areas (hotsprings vegetation) were also identified as important bison forage during the winter (Table 3.5).

Gates et al. 2005 at 50.

> If migration by bison into Montana is constrained by hazing animals back into the park, then bison numbers will be ultimately determined by food availability within the park. As a result, substantial winterkill could occur after bison reach high densities (Coughenour 2005; Plumb et al. 2009; White et al. 2013b).

Auttelet et al. 2015 at 78.

Winter severity, increasing levels of snow pack, the frequency of freeze-thaw conditions and snow crusting events, are conditions that increase the energetic costs of locomotion and foraging, drive deficiencies in dietary energy, and depletion of body protein and fat reserves for Yellowstone bison. DelGiudice et al. 1994 at 32.

> Snow conditions (e.g. depth and density) can have a significant impact on ungulate foraging, movements and survival. In YNP, snow may influence forage availability, energy expenditure during movements and foraging, ability to travel, vulnerability to predators and nutritional status of ungulates, including bison (Meagher 1973, Turner et al. 1994, Mech et al. 2001, Delgiudice et al. 2001, Meagher et al. 2002). The effect of deep snow on reducing forage availability to ungulates, prompting migratory movements to lower elevations, was noted in YNP as early as 1937-38 (Grimm 1939). This is a critical concern in the current management challenge of minimizing contact between bison and cattle as they disperse northward and westward across park boundaries during harsh winters.

Gates et al. 2005 at 45.

PHOTO: Peter Dettling

DelGiudice speculated "that deeper snow cover on the middle-upper Northern Range, as early as December, had a more compromising effect on the nutritional status of bison wintering there than of bison wintering on the lower portion of this range." DelGiudice et al. 1994 at 30 (peak snow depth was 5 times greater on the middle-upper elevations than lower elevations).

Nutritional deprivation, as reflected in net catabolism of protein, was found in bison wintering in the Pelican Valley, with bison in the Madison-Firehole experiencing the greatest nutritional deprivation. DelGiudice et al. 1994 at 31, 32 (relying on chemistry profiles of urinary potassium : creatinine ratios of bison sampled on 3 winter ranges).

"[H]eavy mortality during exceptionally severe winters appeared most important in Yellowstone as a whole." Meagher 1973 at 111.

> Pregnant female bison lose a substantial amount of body mass over the winter. Pregnant bison will mobilize fat reserves during late gestation periods to meet increasing nutritional demands. Often this is a tradeoff and immune functioning decreases. If reproductive demands are prioritized over immune defense, then nutritional resources are allocated to fetal growth, making female bison more susceptible to diseases and extreme weight loss during the winter.

U.S. National Park Service Dec. 1, 2021 at 3.

> The relationship between numbers of animals, available forage, and mortality did not appear to be direct; forage quantity, although affected by snow depth and distribution, exerted effects in combination with the physical stress imposed by snow depth and storm conditions at low temperatures.
>
> . . .
>
> The survival factor for bison in parts of Yellowstone may be the existence of thermal areas.

Meagher 1973 at 113.

> Geothermal features generate heat that can dramatically reduce snow cover and lengthen the growing season, both at geothermal basins and along the banks of streams and rivers influenced by warm water (Meagher 1973, Despain 1990), thus improving forage availability at these sites (Bjornlie and Garrott 2001). Geothermal sites and geothermally influenced shorelines may therefore be key refugia for bison during severe winters (Despain 1990, Meagher et al. 2002).
>
> . . .

> Mary Mountain bison (21.9 $km^2$; 14.4%) had the greatest total area and percentage of area geothermal features, with many of them occurring in the Firehole. Pelican Valley (2.7 $km^2$; 4.8%) also had a relatively high amount of geothermally influenced habitat, although notably less than Mary Mountain. Lamar Valley and Gardiner basin had insignificant geothermal influence on bison habitat (< 1%). West Yellowstone had no geothermal influence based on spatial data provided by the Spatial Analysis Center, Yellowstone National Park.

Gates et al. 2005 at 48.

Key informants identified snow crusts as an important constraint to forage availability for bison, making it difficult or impossible for bison to crater and forcing them to move in search of forage. Gates et al. 2005 at 247.

PHOTO: Thomas Mangelsen

The annual probability of snow crusting events varies across Yellowstone bison's winter ranges. *See* Gates et al. 2005 at 57 (Table 3.4).

Snow crusting events make forage inaccessible due to the buildup of ice and snowpack. In response to snow crusting events, bison must continue migrating to find accessible forage or die in the attempt.

While unpredictable, snow crusting events acting together with management imposed boundaries are a significant source of mortality and threat to the population as evidenced in a major crusting event in 1996–1997 resulting in the government slaughtering 1,084 bison migrating into Montana. Gates et al. 2005 at 47; Cromley 2002 at 135.

> West Yellowstone (0.29) had the second lowest probability of a crusting event. The central interior bison winter ranges (0.42) had the same probability of crusting events because the same climate data was used. The probability of crusting was highest in the Lamar Valley (0.56). Based on information provided by key informants, crusting events occur more often in Lamar Valley than central bison ranges.

Gates et al. 2005 at 48.

"Mean snow depth in central YNP was approximately 100 cm. The maximum was approximately 160 cm, close to the maximum at which bison may cease foraging (Turner et al. 1994)." Gates et al. 2005 at 46.

The effects of winter road grooming in facilitating bison's movements may have contributed to changes in "a delicately balanced demography." Gates et al. 2005 at 118 (quoting Meagher et al. 2002).

"Human use of YNP in winter (Figure 3.13) has grown simultaneously with the bison population (Chapter 5), providing opportunity for confusing causes and effect." Gates et al. 2005 at 54, 101, 125 (road grooming first began in 1967 with the opening of the Old Faithful snow lodge, but the first permit for a snowcoach was granted in 1955).

**Bison diet.**

Bison are herbivores. Diet consists of a variety of grasses and sedges with some browsing of forbs.

"The N [nitrogen] content of aboveground biomass is known to vary among species, functional groups (cool-season or $C_3$ plants are more nutritious than warm-season or $C_4$ plants), management (higher following burning of areas that have not recently burned), and season (Mattson, 1980; Hooper and Vitousek, 1997; Ranglack and du Toit, 2015)." Willand & Baer 2019 at 196.

PHOTO: Jackson Doyel

"Bison are bulk feeders able to digest large amounts of low quality fibrous forage in voluminous rumens (Houston 1982, Hudson and Frank 1987, Hanley 1982)." Gates et al. 2005 at 26.

Male and female diet and feeding behavior differs significantly, and between bison subpopulations.

> Specifically, we found that mean diet composition of male and female bison during the mating season differs significantly, with females having higher quality diets and males having greater dietary breadth (hypothesis 1). Further, while mean diet composition for male and female bison throughout multiple years is statistically indistinguishable, females have higher quality diets and males have greater dietary breadth (hypothesis 2). Additionally, diet segregation for bison in the Central Range was more pronounced during the mating season than across the multi-year period; while females had higher quality diets than males during this time, there was no difference in dietary breadth (hypothesis 3). Finally, diet segregation in the Northern Range was more pronounced across the multi-year period than during the mating season; while males had greater dietary breadth during this time, there was no difference in diet quality (hypothesis 4).

Birini & Badgley 2017 at 6–7.

Birini's & Badgley's results suggest that diet segregation of bison in the Yellowstone ecosystem "is associated with sex-specific nutritional demands and density-dependent influences associated with meeting these demands. . . . Collectively, these results suggest that females exhibit more selective feeding behavior throughout the majority of the year compared to males." Birini & Badgley 2017 at 7.

> Despite the fact that the two bison populations studied are separated by only tens of kilometers, we found evidence of opposing responses of sex-specific diet segregation in the two ranges. In the Central Range, diet segregation in bison was apparent during the mating

> season but not during the multi-year period, whereas in the Northern Range, diet segregation was apparent during the multi-year period but not during the mating season. In the Central Range, although males and females obtained a majority of their forage from different plants or plant parts during the mating season, with females ingesting higher quality forage, there was no difference in dietary breadth. Over the multi-year period, males and females from the Northern Range obtained a majority of their forage from different plants or different plant parts. While there was no sex-specific difference in dietary quality for Northern Range bison during this time, males consumed a greater diversity of dietary items compared to females. Opposing responses of diet segregation in each range may result from differences in the abundance and distribution of high-quality forage and the varying degree of competition for this forage across different ranges and different time periods.
>
> . . .
>
> Although competition for forage peaks during the mating season for bison in both the Northern and Central ranges, range-specific differences in the availability of high-quality forage may help explain the differences in diet segregation.

Birini & Badgley 2017 at 7.

> Ecological theory suggests that smaller-bodied, female bison should displace males from high-quality foraging habitats, since females forage in large groups and deplete resources more rapidly than do males. Based on our results, female bison in YNP have higher quality diets than males do, suggesting that diet segregation is associated with sex-specific nutritional demands. Additionally, range-specific differences in the abundance and distribution of high-quality forage, in conjunction with seasonal variation in population density of bison and elk, may influence spatial and temporal differences in diet segregation. Altogether, our results highlight the importance of accounting for spatiotemporal heterogeneity when conducting dietary studies on wild ungulates.

Birini & Badgley 2017 at 8 (endnotes omitted).

Sexual segregation may have affected the evolution of population diversity and could account for the extended periods with limited gene flow observed in *Bison* species.

Grange and colleagues found multiple lines of supporting evidence for "sex-specific differences in the direction of the gene flow, where females are preserving the distinct identities of each population, whereas males are ensuring gene flow between these distinct populations." Grange et al. 2018 at 21 (endnote omitted) ("[S]exual segregation enables males and females to use different strategies to maximize their fitness.").

**Bison grazing behavior.**

Bison behavior and distribution is driven in part by site fidelity.

> Most bison show fidelity to seasonal ranges that are more than 50 square kilometers (19

> square miles) in size and dominated by grassland and shrub steppe habitats. Individual bison do not segregate into territories, but tend to aggregate into dynamic groups that form, merge, and break-up as individuals feed, rest, and move across the landscape. Group movements are correlated, with associations of groups making back-and-forth movements across and between seasonal ranges over a span of days.

Auttelet et al. 2015 at 68 (footnote omitted).

> Field evidence suggests that the rate of digestion is sometimes the predominant factor limiting the daily intake rate by large herbivores (Mould and Robbins 1982, Wilmshurst et al. 1995), and can influence the optimal choice of diet (Verlinden and Wiley 1989, but see Hirakawa 1997).
>
> . . .
>
> The need to spend time in other activities or to maintain thermal balance can also constrain feeding time, setting an upper limit on the daily food intake (Arnold 1985, Belovsky and Slade 1986).

Fortin, Fryxell & Pilote 2002 at 970.

"[C]onsidering the average species height measured during each of the sampling periods (Table 1), we determined that, on average, bison consumed less than half of the aboveground biomass during any period of the year (Table 1)." Fortin, Fryxell & Pilote 2002 at 975.

> In late spring (period 3, 23 May–19 June), the biomass of most plant species was still low, and bison generally grazed stems together with leaves. *Carex atherodes* and *S. festucacea* were the only exception, with leaves only consumed. During the other periods of the year, grazing activity was limited to leaves for *Agropyron* spp., *C. atherodes*, *C. aquatilis*, *Calamagrostis inexpansa*, and *S. festucacea*. Dry matter digestibility varied between 40% and 75% throughout the year, tending to be higher for *Agropyron* spp. and *C. atherodes* than for the other species (Table 1).

Fortin, Fryxell & Pilote 2002 at 975–976.

"Bison path width averaged 1.78 ± 1.03 m ($n$ = 101) during the growing season and 1.91 ± 1.27 m ($n$ = 210) in winter, leading to a searched area of 57.9 $m^2$/min and 31.7 $m^2$/min, respectively." Fortin, Fryxell & Pilote 2002 at 976–978.

> Our field measurements indicated that resources were abundant enough to allow bison to meet their daily voluntary intake throughout the year. Hence, bison foraging fell into categories III and IV, conditions under which the optimal diet is potentially scale sensitive. During most of the year, both short- and long-term models suggest that intake rate would be maximized by specializing on a single plant type, but the most profitable type changed seasonally. During the winter and summer, bison diet should be ingestion limited over short periods of time, leading to foraging situation IV (Fig. 1).

Fortin, Fryxell & Pilote 2002 at 978.

"Our study demonstrates the potential dependence of optimal diet predictions on temporal scale. At both temporal scales considered, the optimal diet for bison should usually consist of a single plant type, but the identity of that type depends on the time scale under consideration." Fortin, Fryxell & Pilote 2002 at 980 (bison's narrow diets are determined by several factors).

> The observed diet was most consistent with short-term rather than long-term goals. For half of the sampling periods, short-term gains occurred at the expense of long-term gains. Bison "avoided" *Agropyron* spp., which would have enhanced daily intake, preferring instead *Carex atherodes*. Such findings are important because they constitute evidence that foraging decisions by bison reduce their potential long-term energy gain, contrary to established principles of classic optimality models (Barkan and Withiam 1989).
>
> . . .
>
> Several factors could contribute to short-term energy maximization by bison. First, bison may need to get relief from insect harassment, to scan for predators, or to maintain thermal balance or social status (Bergman et al. 2001). The time saved by selecting a diet that maximizes short-term intake appears to be rather small (31–63 min), but we have no idea of its potential fitness importance. Kagel et al. (1986) predicted that interruptions of foraging activity should lead to discounting of future rewards.

Fortin, Fryxell & Pilote 2002 at 980.

> *Agropyron* spp. is commonly grazed by many ungulate species (McInnis and Vavra 1987, Painter et al. 1993, Merrill et al. 1994, Ganskopp and Cruz 1999), and thus constitutes a potentially suitable resource. However, *C. atherodes* is more digestible than *Agropyron* spp. during some critical periods of the year, such as in late summer. Keeping the rumen microbial system primed to maximize gains during critical times of the year may be advantageous, and may require minimizing diet switches. From this perspective, rather than maximizing short-term gains, bison may simply optimize their energy balance over the annual seasonal cycle.

Fortin, Fryxell & Pilote 2002 at 981.

> In South Dakota, C4 grasses constituted 33–44% of the bison diet from early June through August and then declined to 15% by September 30. Bison use of C3 graminoids (sedges and grasses) increased from 52–58% in mid-June to mid-August to greater than 80% after September 1 (Plumb and Dodd 1993). Similar patterns in seasonal shifts in consumption of C3 and C4 grasses were found on the Konza Prairie (Vinton et al. 1993).
>
> . . .
>
> Bison enhance spatial heterogeneity in the prairie through their grazing patterns that results in patches of lightly grazed to heavily grazed areas that have sparse grass cover and little litter (Knapp et al. 1999, Fuhlendorf and Engle 2001). This spatial heterogeneity is

> important for grassland bird diversity.

Anderson 2006 at 639.

"[S]ite fidelity is an important evolutionary force shaping animal distribution." Merkle et al. 2015 at 1793.

"As with similar observations (Krebs 1971, O'Connor 1987), bison behavior and distribution was more consistent with predictions of patch choice behavior driven by site fidelity. Moreover, individual variation in site fidelity was related to home range size, suggesting that the consequences of this fine-scale density-dependent patch choice strategy influence multiple scales of space use, impacting the overall spatial distribution of individuals and the population." Merkle et al. 2015 at 1798.

"[S]ite fidelity is certainly an important influence on the structure of a home range over time (Börger et al. 2008). . . . when density-dependent factors (e.g., interference competition where animals more often occupy the most profitable sites) become evident, the propensity to disperse into new sites is higher (Matthysen 2005), a mechanism resulting in the development of a larger home range, and, ultimately, influencing population distribution through range expansion." Merkle et al. 2015 at 1798–1799.

> The dynamics of a population's range boundary tend to be positively correlated with its abundance (i.e., the abundance–occupancy relationship; Gaston et al. 2000). This relationship would indeed be expected from density-dependent energy-maximizing patch choice behavior (Gaston et al. 1997). Yet, the evolution of a species' range through dispersal is influenced by genetics (e.g., gene flow from the core area), landscape characteristics (e.g., barriers), and distribution of conspecifics (reviewed in Holt 2003, Kubisch et al. 2014). In addition to these mechanisms, we demonstrate that past experience (through information use) also impacts a species' range and is particularly influential regarding the extent of a range retraction after a decrease in abundance. Fidelity to known sites could, therefore, decrease variation in range boundary dynamics, making it difficult to predict range retractions (Gaston et al. 2000). Correspondingly, such a mechanism potentially explains why management efforts to reduce population size and trigger a retraction of range distribution are often ineffective.

Merkle et al. 2015 at 1799.

> In situations where species are confined to certain areas (e.g., protected parks), and the expansion of their range may lead to human–wildlife conflicts (Naughton-Treves 1998), our results suggest that reducing population abundance may not curtail dispersal beyond the protected area.
>
> In conclusion, animals may not always forage in the richest patches available, as ecological theory would predict, but their use of profitable patches is dependent on population dynamics and the strength of site fidelity. The impacts of this site fidelity foraging strategy transcends scales of space use, affecting home range dynamics and population distribution. For basic ecologists, our results speak to a change in how we understand density-dependent patch choice behavior and its influence on animal distribution. Traditional measurements of site quality, such as energy gains, only explain a portion of the process, and an animal's

familiarity (i.e., informational state) with a site has a profound influence on behavior (Piper 2011).

Merkle et al. 2015 at 1799–1800.

Bison use "area-concentrated search during winter foraging activity. Their movements between areas of suitable food patches were influenced by local environmental conditions . . . Bison also systematically avoided digging in areas where plants of low profitability lay under the snow." Fortin 2003 at 194.

PHOTO: Elke Duerr

Bison "adjust their searching behavior to the local distribution of food, and use this local information to assess food patch quality." Fortin 2003 at 202.

> [T]he timing and spatial location of nutritious forage is relevant to individual, population and species-level traits, behaviors and relationships.
>
> . . .
>
> [P]atch-dynamics . . . reveals that the heterogeneous environments of the Yellowstone Plateau provides young nutritious green forage for herbivores for almost half of the year; which may provide a unique resource within the Northern Rocky Mountains.
>
> . . .
>
> This pattern of forage-phenology may be unique in a broader geographic context and contribute to the diversity and abundance of large-bodied herbivores found in this ecosystem. It also may help to explain their seasonal migration strategy and how this might change in the absence of human intervention (see White et al. 2010 for a discussion of migration timing and human hunting pressure).

Piekielek 2012 at 124, 125, 140 (mapping the patch-dynamics of vegetation phenology in the Upper Yellowstone River Basin).

"Fires can have significant effects on ungulates up to four years post-fire, although effects diminish within this time (Pearson and Turner 1995). Substantial immediate post-fire ungulate mortality can result because of reduced forage and typical drought conditions reducing forage in unburned areas (Turner et al. 1994). In subsequent years, fire may stimulate primary productivity resulting in improved forage quantity and palatability (Turner et al. 1994)." Gates et al. 2005 at 50.

**Bison behavior, social order, and herd structure.**

> Individual bison do not segregate into territories, but tend to aggregate into dynamic groups that form, merge, and break-up as individuals feed, rest, and move across the landscape.

> Group movements are correlated, with associations of groups making back-and-forth movements across and between seasonal ranges over a span of days.
>
> . . .
>
> As the number of bison in northern Yellowstone increased, more bison spent summer on the traditional wintering area of the Lamar Valley, which increased the magnitude and extent of seasonal movements to lower-elevation areas (Meagher 1989b).

Auttelet et al. 2015 at 68 (footnote omitted).

> Mloszewski (1983:67), studying African buffalo, also states that "heavy and irregular predation, particularly by man, . . . often leads to erratic movements and even to herd disintegration." In addition, unsystematic removal of portions of a herd rather than complete cropping of entire social units not only frequently stampedes the surviving animals but also appears to create larger aggregations of animals in the vicinity of the hunting area. This is probably at least partly a response to the disruption of the existing social structure of the herds (Laws et al. 1975:105; Laws 1981:227).

Bamforth 1987 at 5.

> Hunting also may have affected grouping patterns of bison. Nevertheless, sport hunting and predation can have quite different effects on social behavior and demographics of ungulate populations (Berger 2005). We foresee little advantage to bison forming large groups in open areas in response to human hunting, which involves modern high-powered rifles and ammunition.

Bowyer et al. 2007 at 1056.

> Establishing permanent human settlements in a region also appears to increase herd size in neighboring areas, as the animals who previously inhabited the settled areas are driven into the ranges of neighboring herds. This increases local animal densities and requires that the new migrants be integrated into the existing social structure.
>
> . . .
>
> It is important to note that this process can also operate without intensive human occupation throughout an entire area if settlements systematically monopolize a critical resource which has a restricted distribution. Exclusion of wild animals from water sources is the most obvious example of such a situation.

Bamforth 1987 at 5.

Bison are gregarious with strong social bonds. Meagher 1973 at 46.

Bison live in extended families of mothers and daughters. "Older females strongly" influence the "direction of group movements across landscapes." Bison also use democratic (or group) decisions for initiation of movements. Little is known about how management practices that disrupt social organization affect individuals. "[D]isruption of social organization due to confinement in large groups" greatly increases stress in "young male bison compared with allowing them to freely range." Shaw 2012 at iii, v-vi.

Reducing bison in the wild to captivity results in fatal goring, injury, miscarriage, calf abandonment, stress, and other negative behavioral changes observed under current management practices. *See* U.S. Department of Agriculture Animal and Plant Health Inspection Service 2011 Freedom of Information Act records ("gutted," "impaled herself," "calf found drowned in creek," "Crushed in [corral]," "calf dead from starvation," "Found dead," "broken neck in chute," "calf found dead," "Cut left horn off," "slit in gut wall, intestines" with several bison euthanized from injuries).

PHOTO: Jackson Doyel

> Disruption of social bonds among individuals has severe behavioral and physiological effects, especially mother-infant separation (Carter, 1998; Gunnar, 2000; Patison, 2011). Aggressive interactions among individuals that are re-establishing social dominance as well as competition for resources lead to conflicts that are exacerbated in confinement (Koontz and Roush, 1996; Sands and Creel, 2004). Competition and conflict, amplified by confinement, induce a vicious cycle where increased FCM [fecal cortisol metabolites] secretion leads to ever increasing levels of aggression (Sapolsky, 1992; Möstl and Palme 2002). Prolonged aggressive interactions adversely affect food intake, are energetically demanding, and are thus potent stressors (Fletcher, 1978; Li et al., 2001; Patton et al., 2001; Sapolsky, 2002; Sands and Creel, 2004; Mooring et al., 2006).

Shaw 2012 at 99.

Of 53 bison in a National Park Service study (26 Northern herd and 27 Central herd observed from 1995–2001), 7 died from government trapping, 5 died from unknown causes, 4 from vehicle collisions, 3 from predation, 2 from winterkill, 2 from government shootings, and 1 from injury. Fuller et al. 2007 at 2368.

Deaths and injuries in captivity are a consequence of  Yellowstone National Park trapping wild bison for slaughter and quarantine.

Social order of bison is matrilineal. Matrilineal groups may include several generations of related individuals who travel together. Gardipee 2007 at 7 (citing McHugh 1972; Lott 2002; Halbert 2003).

Female philopatry to natal ranges was suggested by Gardipee (2007 at 10, 31–32) who observed highly differentiated population structure and substantial differences in haplotypes among breeding groups in the Northern and Central bison herds.

Meagher also recorded females repeatedly visiting calving sites to give birth. Meagher 1973 at 75.

Buffalo Field Campaign's observations of Central herd bison indicate female fidelity to birthing sites in

Hebgen basin.

Group sizes can range from 20 bison or more during winter to 200 during the summer. Herd sizes peak at 1,000 during the breeding season or rut. U.S. National Park Service 2018 at 3.

Once the rutting season is over, mature males separate into small groups or become solitary.

"Social behaviors lead to cultures that result in large individual variation in social and individual behaviors and demographic rates (Anderson 1991; Cam et al. 2002). Social interactions arising from individual behaviors cause population-level phenomena to vary in form and function (Lima & Zollner 1996; Sutherland 1996; Croft et al. 2008)." Shaw 2012 at 1.

> In polygynous mammals, social groups are typically composed of closely related philopatric females and their offspring and dispersal is male-based (Greenwood 1980; Dobson 1982). Retention of daughters within the maternal home range and male-based dispersal form the basis of sociality in many mammalian species (Armitage 1981). Social organization and fidelity to a landscape lead to culture, the collective knowledge and habits passed from one generation to the next about how to survive in a particular environment (De Waal 2001). A culture develops when practices that originate this way contribute to the group's success in solving problems, and cultures evolve as individuals in groups discover new ways of behaving — as with finding new foods or habitats or better ways to select a nutritionally balanced diet (Skinner 1981).

Shaw 2012 at 2.

> Ancestors of present-day Indians honored the social order they saw in bison by integrating it into their tribal organization. Buffalo hunters used social organization as the basis for successful hunting, and contrary to popular beliefs, their accounts state bison did not occur in vast herds; rather they lived in matriarchal families of 10 to 25 animals in the arid southwest and 60 to 75 animals in the more fertile plains (Mayer & Roth 1995).

Shaw 2012 at 2–3.

"[M]others and daughters form matriarchal relationships that influence group composition. . . . Mother-daughter associations illustrate that bison social organization is influenced by relatedness and that they may influence social group dynamics." Shaw 2012 at 109.

"More in-depth studies of associations among females and their offspring show extensive post-weaning associations between mothers and daughters (Green et al. 1989; Shaw & Carter 1990; Brookshier & Fairbanks 2003)." Shaw 2012 at 3.

"The benefits of sociality for related and unrelated individuals include obtaining protection from predators, enhancing reproductive success, learning traditional migratory routes, and knowledge of feeding sites and mineral licks to name a few." Shaw 2012 at 10–11.

"While we know little about how well wild animals learn and remember social companions and numerous vital landscape characteristics, the role of the matriarch as a repository of information is vitally important (McComb et al. 2001, Vidya & Sukumar 2005)." Shaw 2012 at 34.

"More generally, social interactions and locally adapted cultures are an essential part of the collective memory of a population, whereby individuals learn from their ancestors through their mothers. That knowledge, locally inflected, adds uniquely to the biodiversity of landscapes for species and has implications for conservation (Davis & Stamps 2004; Laiolo & Tella 2007)." Shaw 2012 at 52.

> In species such as bison that live in social groups, movements across landscapes, foraging, sentinel behavior, and babysitting are continually coordinated among individuals such that complex social organizations and behaviors emerge (Whitehead, 1996; Clutton-Brock et al., 1999; Wilson, 2000; Franks et al., 2002; Couzin and Krause, 2003; Couzin, 2006). When animals change activity and/or location, and the group remains intact, that outcome implies a consensus has been achieved through a group decision (Conradt and Roper, 2005; Ramseyer et al., 2009).

Shaw 2012 at 64.

"When bison move following rest they do so democratically while decisions regarding direction are made despotically" by matriarchs. Shaw 2012 at 109.

"For movement initiation, bison used a more democratic decision-making process: group movements did not begin until an average of 47% of adult cows departed the group and waited for the near majority to join them. Interestingly, the oldest females led this final post-rest movement behavior in 81% of the decisions, again verifying their importance in the decision-making process." Shaw 2012 at 64.

"Evolutionarily, the diverse and fluctuating Great Plains environment where bison evolved may also have encouraged exploratory behavior, including increased propensity to disperse (Lott 1991)." Shaw 2012 at 110.

"Exploratory movements by mature bulls, which subsequently establish annual migration paths to and from peripheral ranges, likely precede range expansion by cow/juvenile groups." Gates et al. 2005 at viii.

**Cultural transmission and evolution of bison migration.**

> By 1995, some bison from central Yellowstone made movements towards northern Yellowstone along the river and roadway corridor connecting Mammoth Hot Springs and the interior of the park (Taper et al. 2000). By 2005, more than 1,000 bison from central Yellowstone moved to the northern region of the park during winter. During subsequent winters, many of these animals were captured and shipped to meat processing facilities after attempting to cross the northern boundary of the park into Montana (White et al. 2011). The remaining bison either stayed in northern Yellowstone or continued to seasonally migrate between the central and northern regions of the park (Geremia et al. 2011, 2014b).
>
> Dispersal movements and range expansion by Yellowstone bison were often associated

> with severe snow events that interacted with bison density to limit nutritional intake and foraging efficiency (Meagher 1989b, 1998; Coughenour 2005; Plumb et al. 2009). Changes in distribution and seasonal movements continued as bison numbers increased, and eventually led bison to expand their winter range to lower-elevation areas outside the park boundary (Taper et al. 2000; Gates and Broberg 2011). Prior experience with particular routes and new foraging areas likely contributed to a rapid increase in movements by large numbers of bison during subsequent winters, even when snow conditions were relatively mild (Meagher 1989b; Geremia et al. 2011, 2014b).
>
> Range expansion can delay responses to food limitations since new ranges provide additional forage (Larter and Gates 1990). As a result, increases in winter range areas used by Yellowstone bison from 1976 onwards contributed to sustained population growth in both the central and northern regions of the park (Taper et al. 2000; Coughenour 2005; Plumb et al. 2009). However, culling and hazing bison back into the park to reduce the risk of brucellosis transmission to cattle in Montana limited range expansion by bison much beyond the boundary of Yellowstone National Park (Gates and Broberg 2011; White et al. 2011). Without this intensive management intervention, bison almost certainly would have continued to disperse to suitable habitat areas further outside the park (Plumb et al. 2009; Gates and Broberg 2011).

Auttelet et al. 2015 at 69, 71.

"Because dispersal does not usually lead to discovery of new habitat, it is more advantageous for home range knowledge to be transmitted from one generation to the next, and for yearlings to follow other adults after weaning." Gates et al. 2005 at 25.

> The apparent difference between winter herd sizes on the Canadian Plains and elsewhere can be explained as the adaptation of the bison to different environmental conditions in different areas. Snow is deeper and lasts longer and temperatures are lower on the Plains as one moves north (compare Court 1974 with Hare and Hay 1974).
>
> . . .
>
> [F]actors such as weather conditions, fires, and human conflict apparently disrupted what would otherwise have been fairly regular bison migrations. The well known wide range of climatic variability on the Plains (Borchert 1951; Thornthwaite 1941) must have led to a comparably wide range of forage and weather conditions with which the bison had to cope over the course of their lives, and on this basis alone there is no good reason to expect that the herds would have acted in exactly the same way every year.

Bamforth 1987 at 6 (citing factors identified by Moodle and Ray (1976) of variation in bison herding and migration patterns).

> Allen (1876), Hornaday (1889), and Roe (1970) have extensively cataloged the extent and results of the slaughter of the Plains bison which began systematically after 1830 and increased steadily in intensity until the species was almost completely exterminated by the

> end of the nineteenth century. This slaughter not only increased hunting pressure on the herds to almost unimaginable levels, but almost seems to have been purposefully designed to be as disruptive to the bison as possible. Hunters systematically camped at water sources to kill as many animals seeking water as possible and drive the rest away. Other preferred techniques of taking many animals included running the bison on horseback and shooting a herd down from ambush until the survivors fled. "Sport" shooting of bison from passing trains was common. By continuously reducing the bison population on the Plains throughout the nineteenth century, this predation must have affected records of their ecology: if there were fewer animals in any region, for instance, travelers through that region would have encountered them less often.

Bamforth 1987 at 9.

"[O]ne long term data set suggests that bison are increasingly using upland habitat." Gates et al. 2005 at 44 (footnote omitted).

The cultural transmission and evolution of bison migration is undercut by intensive government management actions.

> The portion of the Gardiner basin bison winter range outside YNP was delineated based on current bison management policy documents (United States Department of the Interior (USDOI), National Park Service (NPS) 2000). Bison could move beyond the Gardiner basin boundary to other foraging areas, however, they are not tolerated outside the Gardiner basin range because of concerns about brucellosis transmission risk from bison to cattle. Bison are culled if they travel past the boundary.
>
> . . .
>
> Like Gardiner basin, the portion of the West Yellowstone bison winter range outside YNP was delineated based on bison management policy and reflects where 100 bison are tolerated before culling actions are taken (USDI, NPS 2000) as opposed to where bison could move if allowed to expand freely (see Figure 3.1 for location of capture facilities).

Gates et al. 2005 at 44.

How government management is interfering with the cultural transmission of migration patterns over generations of bison is unknown, but the degree and intensity of management practices is certainly "expunging generations of knowledge" for each bison subpopulation.

> Today, Yellowstone bison contribute an important genetic lineage to plains bison that is not found elsewhere, except in populations started with bison relocated from Yellowstone National Park (Halbert and Derr 2008). . . . However, the population remains isolated because bison rarely move between Yellowstone National Park and the Jackson population in Grand Teton National Park and the National Elk Refuge — even though there are no barriers to such movements.

Auttelet et al. 2015 at 120.

> Bison that live in the central and northern regions of Yellowstone have significantly different distributions of alleles and genotypes, and are genetically distinguishable based on 20 alleles only found in one of the two regions (14 central; 6 northern; Halbert et al. 2012). This substructure was likely created and sustained by several events, including: (1) the population bottleneck caused by nearly extirpating Yellowstone bison in the late 19th century, (2) the creation of another breeding herd in northern Yellowstone from bison of unrelated breeding ancestry, and (3) human management thereafter (Meagher 1973; White and Wallen 2012). Analyses of mitochondrial DNA suggest these regional genetic differences have been maintained by strong female philopatry to breeding areas, with most females returning to the same area each year (Gardipee 2007; Wallen et al. 2013). Also, analyses of microsatellite DNA suggest there were only about two emigrants per decade between the two regions during the 20th century (Halbert et al. 2012).

Auttelet et al. 2015 at 123–124.

"Our findings indicate that learning and cultural transmission are the primary mechanisms by which ungulate migrations evolve. Loss of migration will therefore expunge generations of knowledge about the locations of high-quality forage and likely suppress population abundance." Jesmer et al. 2018 at 1023.

> From tropical savannas to the Arctic tundra, the migrations of ungulates (hooved mammals) can span more than 1000 km and are considered among the most awe inspiring of natural phenomena. Migration allows ungulates to maximize energy intake by synchronizing their movements with the emergence of high-quality forage across vast landscapes. Consequently, migration often bolsters fitness and results in migratory individuals' greatly out-numbering residents. Despite their critical importance, migrations are increasingly imperiled by human activities. Thus, understanding how migrations are developed and maintained is critical for the conservation of this global phenomenon. Ecologists have long speculated that memory and social learning underlie ungulate migration. Bison (*Bison bison*) remember the locations of high-quality forage and transmit such information to conspecifics, whereas moose (*Alces alces*) and white-tailed deer (*Odocoileus virginianus*) adopt the movement strategies of their mothers. Nevertheless, the hypothesis that social learning underlies the development and maintenance of ungulate migration has not been tested with empirical data.
>
> Animal migrations arise through a combination of learned behavior and genetically inherited neurological, morphological, physiological, and behavioral traits. When behavior is primarily a consequence of social learning and persists across generations—a phenomenon known as culture—information is transmitted from generation to generation. Culture is therefore regarded as a "second inheritance system," analogous to the inheritance of genes that underlie innate behaviors. Thus, if social learning is the primary mechanism allowing animals to gain information regarding the seasonal distribution of high-quality forage, cultural transmission may be the principal force by which ungulate migrations have evolved in landscapes conducive to migration.
>
> Ungulate migration is a strategy for exploiting altitudinal, longitudinal, and other topographic gradients of plant phenology that determine forage quality. The ability of

> ungulates to synchronize their movements with phenological waves of nutritious, green plants—a behavior known as "green-wave surfing"—can result in migratory movements far beyond an individual's perceptual range. Ungulates also can surf green waves of forage within year-round ranges, even in the absence of migration. Green-wave surfing may therefore represent a learned behavior that underlies migration, and such knowledge may accumulate over generations via cultural transmission.

Jesmer et al. 2018 at 1023 (endnotes omitted).

> Together, these results demonstrate that ungulates accumulate knowledge of local phenological patterns over time via the "ratcheting effect," wherein each generation augments culturally transmitted information with information gained from their own experience, a process known as cumulative cultural evolution. Cultural transmission therefore acts as a second (nongenetic) inheritance system for ungulates, shaping their foraging and migratory behavior and ultimately providing the primary mechanism by which their migrations have evolved.
>
> Across the globe, anthropogenic barriers have disrupted ungulate migrations, triggered declines in population abundance, and even caused local extirpations. Our results provide empirical evidence that learning and cultural transmission underlie the establishment and maintenance of ungulate migration. Because ungulate migrations stem from decades of social learning about spatial patterns of plant phenology, loss of migration will result in a marked decrease in the knowledge ungulates possess about how to optimally exploit their habitats. Hence, restoring migratory populations after extirpation or the removal of barriers to movement will be hindered by poor foraging efficiency, suppressed fitness, and reduced population performance. Thus, conservation of existing migration corridors, stopover sites, and seasonal ranges not only protects the landscapes that ungulates depend on; such efforts also maintain the traditional knowledge and culture that migratory animals use to bolster fitness and sustain abundant populations.

Jesmer et al. 2018 at 1024–1025 (endnotes omitted).

For detailed evidence and analysis on the increasing risk of extinction from habitat destruction, loss of corridors, and habitat fragmentation, together with removing migratory Yellowstone bison in government management actions, *see* factor 8.A.

**Ecology of bison grazing and migration.**

> The migration of bison in Yellowstone, with thousands of animals consuming tons of biomass as they move in unison, is a unique movement and foraging strategy now sustained in only a handful of migratory taxa worldwide.

Geremia et al. 2019 at 2.

> Long-distance mass migration is a conspicuous feature of most of the earth's tundra and grassland ecosystems that support herds of wild ungulates (Fryxell and Sinclair 1988). On

> the northern winter range of Yellowstone National Park, ungulates migrate between low-elevation winter range and high-elevation summer range (Meagher 1973, Houston 1982). After spending ≤7 months on the northern winter range, ungulates begin moving to higher elevations as the surrounding slopes and hillsides become free of snow in spring. During this migration, animals graze grassland and shrub-grassland intensively for the first 1-2 months after snowmelt, then move progressively upslope (Frank and McNaughton 1992). Thus, the movement to summer range is associated with ungulates grazing phenologically on young plant tissue that sweeps upslope through spring and summer. In fall, animals return to the winter range when the first "winter" storms deposit snow on high-elevation habitat.
>
> There are 2 common reasons given for the migrations of ungulates: predation reduction and diet enhancement (Fryxell and Sinclair 1988). In Yellowstone National Park, the migration from winter to summer range is closely related to the nutrient content of forage (Frank and McNaughton 1992, Frank et al. 1998).

Frank 1998 at 411–412.

> Results of analysis of forage nutrients suggest that Yellowstone ungulates must make a correct series of hierarchically organized feeding decisions to meet their mineral requirements. At the landscape or regional levels, grazers must follow young, nutritious vegetation as it sweeps upslope through the growing season. At the level of the individual plant, ungulates, particularly lactating females, may need to discriminate among forage species that vary considerably in mineral content.
>
> These findings have several implications for the management of ungulate populations. First, they indicate a potentially tenuous nutritional status of grazing mammals in the wild. Second, they identify minerals that may be particularly important supplements for wild populations. And third, the results emphasize the importance of seasonal migration of ungulates for maintaining the animals' nutritional condition and suggest potential deficiencies for animals whose migratory movements are restricted.

Frank 1998 at 412.

Frank's study has direct implications for Yellowstone bison because managers are intentionally interfering with migration patterns for each subpopulation, and killing substantial numbers of migrants each season.

"There are 2 management implications related to ungulates having indirect effects on aboveground production. First, changing the natural migratory patterns of ungulates by herding or fencing may lessen, break, or reverse the positive feedback between herbivores and their forage. Second, because grazers can indirectly influence their food supply, a grassland's carrying capacity can be modified by the ungulates themselves." Frank 1998 at 414.

> Grazers play an ecologically significant role in stimulating aboveground plant production. Both a physiological response by plants to defoliation and a grazer induced increase in N [nitrogen] availability are involved in this positive effect on forage. The seasonal migration is

> a critical component of this feedback, allowing grazed vegetation an extended period to recover when resources are sufficient to support plant growth.
>
> This research in Yellowstone National Park indicates that large herbivores, in addition to their direct impacts on ecosystems through consumption of plant material, have major indirect effects on ecosystem processes. Ecologically important feedbacks of ungulates have been demonstrated in other ecosystems and suggest that these interactions are a widespread phenomenon that needs to be considered by managers of ungulate populations.

Frank 1998 at 416.

> The ecological drivers of mass migrations and the threats that migrations confront are connected, as threats disable the drivers. Hence, we must first understand why mass migrations occur, in order to identify the threats, appreciate how they work, and arm ourselves to alleviate or pre-empt them. We identified 4 dominant factors driving mass migrations: seasonal availability of forage (quality/quantity), snow depth, use of traditional areas, and surface water availability.
>
> . . .
>
> Migrants move from locations where food quality and quantity is poor or inaccessible to places where it is more abundant, nutritious and available. Most migrants seek young grass, because this is most digestible and high in protein (Hanley 1982). The quality and quantity of grass depends on the availability of water (rain in tropical and temperate savannas and grasslands, snowmelt in northern mountains and plains), which varies in timing, amount, and distribution across these species' ranges (Deshmukh 1984, Williamson et al. 1988). Animals track the seasonal and shifting distribution of their forage ('green flushes') and therefore become migratory (our Table 2, McNaughton 1985, Fryxell & Sinclair 1988a, Morgantini & Hudson 1988, Murray 1995, Boone et al. 2006, Mueller et al. 2008). This driver explains the movements of 17 migrants. . . . Snowmelt across elevation gradients and the resulting vegetation response influences the movements of bison *Bison bison* . . . Deep snow obstructs migrants' access to forage in winter months. This driver affects migratory patterns in all of the North American and Eurasian migrants, by forcing them to move toward lower elevations or latitudes (Table 2). As above, migrants reverse movements during snowmelts, to capitalize on greening flushes of vegetation.
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> Changes in resource availability can be predictable or unpredictable, resulting in different migratory responses. The distribution of snow across elevations and interior (continental) regions is relatively predictable. Animals can conform to this regularity and become habituated to areas where forage is reliable over time. Hence, half of the northern migrants use traditional routes and ranges, often spanning generations.

Harris et al. 2009 at 57.

> [T]he relationship between environmental conditions. . .bison ecology and presents information suggesting that historical records document a period during which bison adaptations were being seriously disrupted. Direct extrapolations from historic to prehistoric times which rely on these records are therefore uncertain.

Bamforth 1987 at 1.

Ecological drivers for mass bison migrations include snow depth (Meagher 1989, Frank & McNaughton 1992), and vegetation greenup (Frank & McNaughton 1992), while threats to mass bison migrations include fencing (Berger 2001), over hunting/poaching (Dary 1974, Berger 2001). Harris et al. 2009 at 64–65 (Table 2).

> As part of an exhaustive analysis of animal migrations, Baker (1978:546-551) discussed the effects of the distribution and abundance of food and water on group dispersion and aggregation. Most of the time, water is available in relative abundance at a few restricted locations such as rivers or lakes, and animals (such as bison), which cannot obtain sufficient water from the plants they eat, often form relatively large groups at these locations. These aggregations, however, cannot remain permanently near water because they exhaust local forage as they feed; most ungulates, therefore, commute between feeding and watering areas (cf. Pennycuick 1979).
>
> Seasonal changes in forage conditions affect these movements. During the growing season, grassland herbivores are presented with a superabundance of highly nutritious food which can support high densities of animals in relatively small areas; the aggregations of many grazing animals for the annual rut are clearly coordinated with the period of greatest forage production. During the dry season in tropical regions or the winter in temperature regions, though, forage is of poor quality and is dispersed at low densities across the landscape. No small area can support many animals under these conditions, and dispersion during these periods is common.

Bamforth 1987 at 3.

"Overall, a herd of a given size will have to move less frequently and over shorter distances when forage and water are abundant and widely distributed than when they are sparsely and patchily distributed (also see McHugh 1958:12)." Bamforth 1987 at 3.

**Bison habitat use and migration.**

> Approximately 80% of YNP is covered in forest, of which 60% are subalpine-fir (*Abies lasiocarpa*)/lodgepole pine (*Pinus contorta*) communities (Despain 1990). These extensive lodgepole pine forests typically grow on nutrition-poor soils derived from rhyolite (Meagher and Houston 1998).

Gates et al. 2005 at 49.

> Yellowstone bison can move long distances in relatively short periods of time—occasionally traveling more than 30 kilometers (19 miles) in a single day and annually ranging over areas of 100 to 750 square kilometers (39 to 290 square miles; Meagher 1989b; Geremia et al. 2011, 2014b). They are considered migratory because most animals move back and forth between seasonal ranges to better access food resources (Senft et al. 1987; Mueller and Fagan 2008; Plumb et al. 2009).
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> The primary factors influencing bison migrations are: (1) seasonal vegetation changes that affect food quality, (2) the breeding season, (3) the distribution, size, and quality of foraging sites, and (4) snow accumulation that affects energy expenditures and access to food (Meagher 1973; Bruggeman et al. 2009b; Gates and Broberg 2011; Geremia et al. 2011, 2014b).

Auttelet et al. 2015 at 67, 68.

> In early autumn, bison make brief trips from summer ranges to most winter ranges, with nearly all animals subsequently returning to the summer range (Figure 4.2). These exploratory trips may enable bison to assess food availability across winter ranges or access remaining high-quality food prior to vegetation becoming older and dying (Geremia et al. 2014b).

Auttelet et al. 2015 at 71.

> Large annual migrations of bison to low-elevation winter ranges north and west of Yellowstone National Park highlight the importance of these areas (Plumb et al. 2009; Geremia et al. 2011). Most bison migration into Montana occurs in late February and March across the north boundary, and in April and May across the west boundary, as new grass begins to grow on lower-elevation ranges (Thein et al. 2009; Geremia et al. 2014b). Bison migration back to interior park ranges typically occurs during April through June, following the wave of growing vegetation from lower to higher elevations (Thein et al. 2009; Wilmers et al. 2013).

Auttelet et al. 2015 at 78.

> An alternative to constraining bison within Yellowstone National Park or artificially maintaining low numbers is to tolerate bison in nearby areas of Montana, but manage them when they encroach on cattle ranches, highways, and local communities (Treanor et al. 2013; White et al. 2013b). Movements of bison to the northern and western boundary areas of the park are affected by different dynamics . . .
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> In contrast, the timing and extent of bison movements across the northern park boundary depend on snow conditions, available forage, and the density of bison in the park (Geremia

> et al. 2011, 2014b). Large numbers of bison can rapidly move to the northern boundary when conditions severely reduce foraging efficiency, but relatively few bison exit the northern boundary when conditions are mild (Geremia et al. 2011, 2014b).

Auttelet et al. 2015 at 79.

"Meagher (1973:32–36) found that recent decreases in the bison population in Yellowstone Park led the remaining animals to forage over smaller areas." Bamforth 1987 at 10.

"Yellowstone National Park is not a self contained ecosystem, covering only 8,983 km$^2$ or slightly more than 10% of the Greater Yellowstone Ecosystem (80,503 km$^2$). The movements and population dynamics of large mammal populations need to be viewed at spatial scales significantly larger than the park itself." Gates et al. 2005 at 246.

> In the Greater Yellowstone Ecosystem, about three-quarters of bison, elk and pronghorn migration routes have been lost (Berger 2004), primarily due to lack of tolerance for bison outside of protected areas, winter feeding of elk, an increase in the local human population, and loss of habitat.

Gates et al. 2005 at 28.

"Key informants identified 5 bison winter ranges and 5 winter movement corridors in YNP (Figure 3.2). In northern YNP, two ranges were identified, Lamar Valley (233.80 km$^2$) and Gardiner basin (98.35 km$^2$)." Gates et al. 2005 at 43 (Lamar Valley and Gardiner basin are considered one continuous part of bison's northern range separated by the park's boundary).

> The near extermination of modern Plains bison (*Bison bison bison*) has made it impossible to derive the nature of prehistoric plains bison movements from herds in their natural environment. Quite simply, there are no Plains bison left on the open plains from which to construct a model.

Peck 2001 at 68.

Peck's thesis suggests bison migrated in relatively predictable annual cycles, at the regional level, in the past. Peck 2001 at 152–154.

> Bison herds follow long-established trails (Carbyn *et al*., 1993). The timing and direction of their movements are not fixed, however, and even the membership of herds and smaller "pods" is continually in flux (Larter and Gates, 1994). Bison will travel considerable distances in search of nutritionally high-quality grasses (Tieszen *et al*., 1998). Their movements therefore depend on many factors affecting the annual growth pattern of grasses, such as topography, hydrology, fire history, and the location of prairie dog towns (Barsh, 1990; Epp, 1988; Knapp *et al*., 1999; Shaw, 1997). In Yellowstone National Park, bison tend to overwinter in sheltered valleys, then pursue the edge of spring green-up to higher altitudes, but the seasonal routes they choose can change dramatically in response to severe weather (Meagher, 1997).

. . .

> Contemporary bison appear less density-dependent than other large herbivores (Knapp *et al*., 1999; Singer *et al*., 1998); that is, the number of bison can increase considerably without affecting the structure or stability of plant communities. This suggests that bison are particularly well adapted to sustaining large numbers over large geographical areas.

Barsh & Marlor 2003 at 579–580 n. 13.

The relationship between the availability of bison and the use of fire is well understood in historical use of the tool by Blackfoot hunters.

> One finding of recent research is the tendency of bison to prefer recently burned patches of prairie grass for foraging, especially in the early spring (Carbyn *et al*., 1992; Coppedge & Shaw, 1998; Knapp *et al*., 1999; Vinton *et al*., 1993). There are historical references to the firing of the prairie to attract bison to the vicinity of a *pisskan*, [a bison jump or pound] and to drive bison towards it (Arthur, 1975, pp. 24–25; compare Barsh, 1997a). Blackfoot may have moved their camps near certain *pisskan* in the early spring and then fired the surrounding prairies so that bison would be drawn to the fresh growth of grass. The locations of springs and streams may have been a more important limiting factor on bison numbers and movements than forage, moreover, especially during periods of relative aridity. Old bison trails still visible in the Alberta prairies follow watercourses as well as ridgelines.

Barsh & Marlor 2003 at 580.

Fire suppression and human developments in the bison's range has fragmented habitat connectivity that facilitated nomadic migrations over vast territories. Factors that drove bison to near extinction continue to threaten or endanger recovery of the migratory species throughout their range.

> The plains bison was originally a land-intensive, nomadic species that roamed over great distances on the North American continent. Large-bodied animals are especially vulnerable to the effects of habitat fragmentation because they require a large amount of space (Berger and Cunningham 1994). Fragmented populations can be more susceptible to inbreeding pressures, loss of genetic diversity, and extinction (Berger and Cunningham 1994). Conservation of plains bison is limited because most of the original range has experienced change from competing land uses including cultivation, cattle ranching, commercial bison ranching, natural resource extraction, and urban expansion (Johnson *et al*. 1994). These land uses constrain the potential of preserving or restoring large tracts of habitat for bison conservation.

Boyd & Gates 2006 at 16.

"Few opportunities exist to evaluate the unimpeded migration of large ungulates across expansive and heterogeneous landscapes unaltered by anthropogenic disturbance. Seasonal migrations of bison in Yellowstone have been reestablished after near extirpation during the early 20th century and we cannot be sure that current movement patterns reflect historic spatial dynamics." Geremia et al. Feb. 2011 at 6 (endnote omitted).

> Plains bison in Yellowstone National Park represent one of the last ecologically relevant populations in North America. Although bison are mainly confined to park boundaries, individuals migrate up to 80 mi (129 km) from lower elevations just outside the park to higher elevations in the central part of the park (fig. 53). There are three major bison migration routes within Yellowstone National Park: North, Central-West, and Central-North. Bison do not preemptively migrate to avoid deep snow in autumn. Instead they "play the winter," pushing a bit farther down the valleys with each snowstorm and sometimes lingering between summer and winter range for weeks or even months. Most Yellowstone bison have two migration routes: one they use in light winters, and an extended version they use during heavy winters. If snow remains thin, they stay close to their summer ranges deep inside Yellowstone. When snow piles up, bison head down river, moving to and beyond the park boundaries. While multiagency efforts are being made to accommodate these migrations, bison are still restricted to Yellowstone National Park and limited to areas just outside the park. Outside the park, bison are permitted on a small region near Gardiner and West Yellowstone, Montana, as well as near east entrance, near Cody, Wyo.

Kauffman et al. 2020 at 109.

A report of bison corridors, stopovers, and winter range from 92 female bison from 2004–2017 collected the following data:

Migration start and end date (median):
- Spring: April 12 to June 20
- Fall: February 19 to April 5

Days migrating (mean):
- Spring: 63 days
- Fall: 42 days

Migration corridor length:
- Min: 21 mi (33.8 km)
- Mean: 57 mi (91.7 km)
- Max: 81 mi (130.4 km)

Migration corridor area:
- 392,762 acres (158,945.1 ha) (low use)
- 120,420 acres (48,732.2 ha) (medium use)
- 7,331 acres (23,201.0 ha) (high use)

Stopover area: 39,882 acres (16,139.7 ha)

Winter Range Summary
Winter start and end date (median):

- March 27 to April 20

Days of winter use (mean): 28 days
Core winter range (50 percent contour) area: 149,397 acres

Kauffman et al. 2020 at 109 (mapping data can be found in the zip file Kauffman et al., *Ungulate Migrations of the Western United States*, (2020)).

Bison are most active during the day, and at dusk. Movements also occur at night.

"Most of the bison in Yellowstone are migratory, moving in spring from the lower wintering valleys to higher summer ranges, and reversing this altitudinal migration in the fall." Meagher 1973 at 77.

> Meagher views the occurrence of these movements, the routes used, and the destinations as products of environmental heterogeneity. Much of Yellowstone Park is forested. The preferred bison habitat is in the interspersed meadows. Seasonal changes in snow depth, temperature, presence of biting insects, and the annual cycle of the plant community create strong contrasts between areas situated at different elevations. These contrasts seem to determine the movements she observed.
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> . . .
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> Perhaps the unstable climate of the North American Plains and the varying resource distribution it produced, selected for the bison cows' propensity to explore. Whatever the reason, bison seem predisposed to range more widely than most other large ungulates. At the same time, Meagher's (1973) data make it clear that loyalty to a large traditional home range is an important feature of the Yellowstone population. How this ranging propensity manifests itself apparently depends on the particular environmental pressures on a particular population. In recent years the growing Yellowstone population has extended its winter range to previously unoccupied areas both inside the park and outside of it (M. Meagher, personal communication, 1987).

Lott 1991 at 143.

"Three bison winter ranges were defined in central YNP: Pelican Valley (55.16 $km^2$), Mary Mountain (151.8 $km^2$, including Hayden Valley and the Firehole), and West Yellowstone which spans the boundary of the park (79.93 $km^2$)." Gates et al. 2005 at 44.

Bison migrations are characterized by seasonal movements along altitudinal gradients from higher-elevation summer ranges to lower-elevation winter ranges. Geremia et al. Feb. 2011 at 1.

Geremia's study produced "the first evidence that the relationship between bison migration, climate, and density is logistic in form." Geremia et al. Feb. 2011 at 6.

Migrations differed at the herd scale. "The central and northern herds exhibit differential movement to the northern and western park boundaries and are exposed to different snow pack and vegetation phenology regimes." Geremia et al. Feb. 2011 at 1, 2.

> Recent movements by bison beyond the north boundary challenge the idea that the area occupied by bison expands with population size to maintain a relatively stable winter density. If that were the case, we would expect stronger support for the negative exponential model form which represents increases in numbers exiting the park beginning at lower herd sizes. Instead, we found high probability that fewer than 10 percent of the population exited the park under moderate levels of herd size (1,000–2,000), accumulated SWE (<60%), and aboveground dried biomass (>100%), above which numbers exiting rapidly increased (Table 2). We provide continued evidence of snow and herd size acting as controls on movements, and show that forage production affects migrations.
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> . . .
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> [B]ison movements were undoubtedly influenced by more than a century of management actions and human-induced alterations to the environment. Management of bison along the western park boundary during 2000–2005 predominantly involved aggressive hazing of animals back into the park as opposed to the northern boundary where thousands of migrants were culled or held in containment pens. Movements of central herd animals to the northern range increased during this time, and perhaps bison that were repeatedly hazed sought alternate routes to lower elevation wintering areas. More recently, aggressive hazing of bison outside the western boundary has been delayed until late April and observed numbers of bison outside the western boundary increased.

Geremia et al. Feb. 2011 at 6–7 (endnotes omitted).

> If migration by bison into Montana is restricted by forcing bison to remain within the park, or shortened by hazing animals back into the park before spring forage conditions are suitable, then bison numbers would ultimately be regulated by food availability within Yellowstone and the bison population would reach high densities before substantial winterkill occurs. These high densities of bison could cause significant deterioration to other park resources (e.g. vegetation, soils, and other ungulates) and processes as the bison population overshoots their food capacity within the park. Alternatively, migrating bison have been culled. Recurrent, large-scale culls of bison occurred with >1,000 bison culled from the population during winters 1997 (21%) and 2006 (32%), and >1,700 bison (37%) culled during winter 2008.

Geremia et al. Feb. 2011 at 7 (endnote omitted).

> Wintering areas were located along decreasing elevation gradients, and bison accumulated in wintering areas prior to moving to areas progressively lower in elevation. Bison movements were affected by time since the onset of snowpack, snowpack magnitude, standing crop, and herd size. Migration pathways were increasingly used over time, suggesting that experience or learning influenced movements.
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> . . .

> In montane environments, such movements along elevation gradients provide large herbivores access to newly emerging vegetation during the growing season, resulting in increased long-term rates of energy gain (Albon and Langvatn 1992, Wilmshust et al. 1995, Mysterud et al. 2001, Hebblewhite et al. 2008). Migratory movements may also diminish predation pressure as animals move beyond the boundaries of predator territories (Laundre et al. 2001, Fortin et al. 2004, Hebblewhite and Merrill 2007).

Geremia et al. 2014 at 346.

In a year-round "tolerance area" habitat suitability assessment for bison in Montana, biologists identified several impediments for bison migrating into the upper Gallatin headwaters (used by bison in the 1990s after a major crown fire in 1988), but suitable habitat and likely migration corridors into Tom Miner basin. *See* Geremia & Cunningham 2018 (identifying suitable bison habitat, migration pattern, and corridor maps).

**Seasonal habitat use and migration patterns of the Central bison herd.**

> Bison in central Yellowstone traditionally spent summer in the Pelican or Hayden valleys and on the Mirror Plateau and upper Lamar River drainage (Meagher 1973). They spent winter in these valleys or the lower-elevation Firehole River drainage (Meagher 1973). For decades, bison rarely moved between the Hayden and Pelican valleys during any time of the year (Meagher 1973, 1989b). During the winter of 1982, however, groups of bison moved through the Pelican Valley to the northern shore of Yellowstone Lake and into the Hayden Valley (Meagher 1998). In subsequent years, regular movements between the Hayden and Pelican valleys increased and bison that spent winter in the Pelican Valley stopped moving to the Mirror Plateau during summer (Meagher 1998). More bison began moving west from the Hayden Valley to the Firehole River drainage, and eventually, into the Madison Valley (Meagher 1998; Bruggeman et al. 2009c). By 1995, some bison from central Yellowstone made movements towards northern Yellowstone along the river and roadway corridor connecting Mammoth Hot Springs and the interior of the park (Taper et al. 2000). By 2005, more than 1,000 bison from central Yellowstone moved to the northern region of the park during winter. During subsequent winters, many of these animals were captured and shipped to meat processing facilities after attempting to cross the northern boundary of the park into Montana (White et al. 2011). The remaining bison either stayed in northern Yellowstone or continued to seasonally migrate between the central and northern regions of the park (Geremia et al. 2011, 2014b).

Auttelet et al. 2015 at 68–69.

"The central bison herd occupies the central plateau of Yellowstone, which extends from the Pelican and Hayden valleys with a maximum elevation of 2,400 m in the east to the lower-elevation and thermally-influenced Madison headwaters area in the west (Figure 1). Winters are severe, with snow water equivalents (i.e., mean water content of a column of snow) averaging 35 cm and temperatures reaching –42 C." Geremia et al. Feb. 2011 at 2.

"Bison from the central herd congregate in the Hayden Valley for the breeding season (15 July–15 August), but move between the Madison, Firehole, Hayden, and Pelican valleys during the rest of the year. Also, some bison from the central herd travel to the northern portion of Yellowstone during winter and commingle with the northern herd, with most returning to the Hayden Valley for the subsequent breeding period." Geremia et al. Feb. 2011 at 2–3.

Hebgen Basin IMAGE: Google Earth

> The central bison herd wintered primarily at elevations of 2,000–2,250 m in the major geyser basins within YNP and toward Hebgen Lake, Montana (Fig. 1). In winter, bison moved between areas that remained snow-free or with reduced snow cover within the major geyser basins to other geothermally influenced areas in the approximately 2,500 m elevation Hayden and Pelican valleys (Meagher 1973). The bulk of the herd summered in the Hayden and Pelican Valleys and intermingled with bison of the Northern herd in the latter area.
>
> Most of the central herd's range was within the Yellowstone caldera (Pierce and Morgan 1992, Good and Pierce 1996). Soils of the region were derived from rhyolitic rock or sedimentary deposits (Good and Pierce 1996). Vegetation within the central herd's range was a conifer forest of lodgepole pine (*Pinus contorta*) interspersed with Engelmann spruce (*Picea engelmannii*) and Douglas fir (*Pseudotsuga menziesii*), and mesic grasslands on sedimentary deposits. Extensive areas of conifer forest, swept by crown fires in 1988, were characterized by dense stands of regenerating lodgepole pine and sparse herbaceous ground cover. Mesic grasslands along the Madison, Firehole, and Gibbon (MFG) river valleys were characterized by a mixture of grasses, sedges (*Carex spp*.), and reedgrass (*Calamagrostis spp*.). Thermally influenced soils supported Nuttall's alkaligrass (*Puccinellia nuttalliana*) and thermal western witch-grass (*Panicum capillare*) with an intermixed herbaceous cover of hairy golden-aster (*Heterotheca villosa*) and sheep sorrel (*Rumex acetosella*; Despain 1987). The Hayden and Pelican valleys supported a predominantly big sagebrush (*Artemisia tridentata*), Idaho fescue (*Festuca idahoensis*) steppe. More mesic sites supported silver sage (*A. cana*) with tufted hairgrass (*Deschampsia cespitosa*) and sedges limited to drainages and adjacent areas (Despain 1987).

Gogan et al. 2005 at 1717–1718.

Central herd bison may be unique in selecting geothermally influenced habitats as refugia and movement corridors. Gates et al. 2005 at 48, 54.

Central herd bison also use a significant proportion of geothermally influenced habitats within their winter ranges (4.8% in Pelican Valley to 14.4% in Mary Mountain), and movement corridors (5.2% to 9.2%). Gates et al. 2005 at 48, 113, 127, 129, 55, *see also* Tables 3.1 and 3.2 and Figures 5.20–5.26.

The inclusion of geothermally influenced habitats as a significant proportion of habitat use represents an unusual ecological adaptation unique to Yellowstone bison.

PHOTO: Mike Burdic

Notably, Central herd migrations cross the calderas and landforms created by the Yellowstone Plateau volcanic field. Christiansen 2001 at G13, G18, G112. The Huckleberry Ridge Tuff and Henrys Fork calderas are also within the range of Central bison herd migrations.

Geothermally influenced habitats played a role in preventing the extinction of America's last bison in the wild. Meagher 1973 at 102.

> The Central or Mary Mountain Herd migrates to the lower elevations of the Madison-Firehole-Gibbon region to spend the winter. The Mary Mountain herd is well studied, initially based upon Meagher's (1973) dissertation work, along with her subsequent study and more recent studies (Gogan et al. 2001). Meagher (1973:Table 2) compiled historic records of bison sightings and counts prior to 1915. These records indicate the area may have served as a refuge from poaching for a small number of bison. As Meagher notes (1973:17):
>
>> Natural losses, coupled with scattering of the few remaining animals, left a minimal breeding population in the most remote places of the Pelican-Mirror-Upper Lamar country.

Cannon 2008 at 127.

> Pelican Valley is an important wintering area for bison and is one of the major study areas for understanding bison ecology (Meagher 1973). The valley begins in the east where Raven Creek leaves the high country of the [Absaroka] Mountains to the mouth of Pelican Creek at Mary Bay on the north shore of Yellowstone Lake (Figure 5.17). The valley sits at an elevation of approximately 2377 m (7800 ft) AMSL and is one of the few open grasslands on the Yellowstone Plateau. The remoteness of Pelican Valley probably helped protect the few remaining original Yellowstone bison from extinction in the late 19th and early 20th century (Meagher 1973).

Cannon 2008 at 130 (AMSL is a term for above mean sea level).

> Bison in YNP that historically have winter ranges restricted to Lamar (northern range), Mary Mountain (Hayden Valley-Firehole), and Pelican Valley (Meagher 1973; Fig. 1) have undergone major changes in numbers and distribution during the past 15 years (Meagher 1989; Meagher et al. 1997). Geographic designations no longer represent distinct wintering subpopulations because numbers occupying those locales change throughout winter. Lamar and Hayden valleys presently function as major summer range; summer use is limited on traditional winter ranges.

Smith et al. 2000 at 1130.

**Seasonal habitat use and migration patterns of the Northern bison herd.**

> [B]ison in the northern region of Yellowstone National Park traditionally spent summer on the Mirror Plateau and slopes of the Absaroka Mountains along the eastern boundary, but spent winter in the Lamar or Pelican valleys (Meagher 1973). However, progressive changes began in the mid-1970s when groups began to move west and travel downslope along the Yellowstone River and parallel road corridor to the Blacktail Deer Plateau and Gardiner basin during winter (Meagher 1989b). As the number of bison in northern Yellowstone increased, more bison spent summer on the traditional wintering area of the Lamar Valley, which increased the magnitude and extent of seasonal movements to lower-elevation areas (Meagher 1989b).

Auttelet et al. 2015 at 68.

> During summer, bison in northern Yellowstone are concentrated in an approximately 40-kilometer (25-mile) long region along the Lamar River from Cache Creek in the east towards the confluence of the Yellowstone River in the west (Geremia et al. 2014b; Figure 4.1). A portion of these bison make prolonged forays to the high-elevation Specimen Ridge and Mirror Plateau areas, with occasional trips to the Pelican and Hayden valleys.
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> . . .
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> As winter progresses, bison in northern Yellowstone move downslope to the lower Yellowstone River drainage (Tower, Slough Creek, Hellroaring) and Blacktail Deer Plateau. From there, bison may move further northwest to the lower-elevation Gardiner basin where snowpack is lower and new vegetation growth begins earlier in spring (Geremia et al. 2014b; Figure 4.3).

Auttelet et al. 2015 at 71.

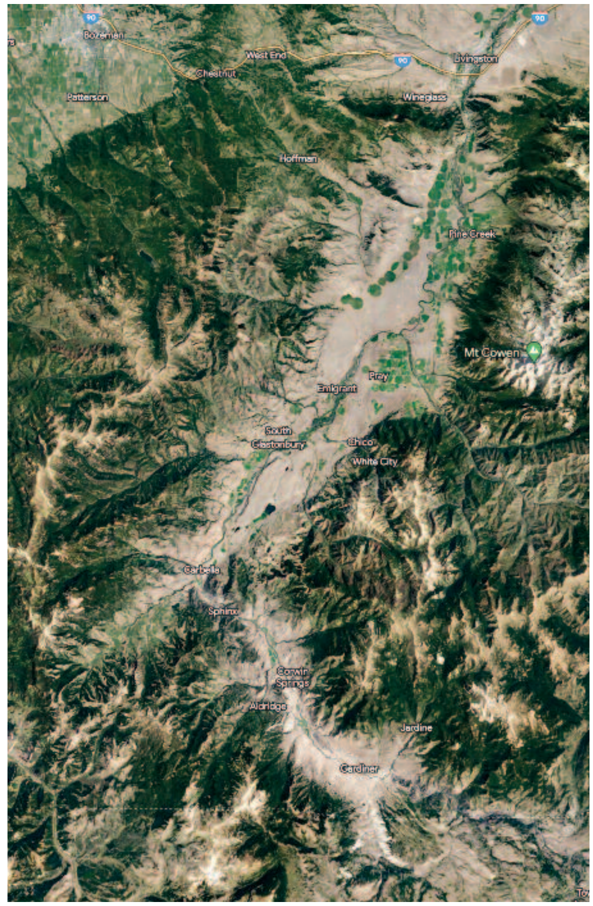
"The Lamar Valley and the Yellowstone River Valley north of the park (Figure 4.1) to Livingston and beyond was an important area for bison and Native peoples throughout the Holocene. This system can be considered the original Northern range for Yellowstone bison, functioning as an ecological continuum of grasslands that likely supported seasonal migrations by bison as far south as the high elevation ranges in the Upper Lamar Valley." Gates et al. 2005 at 77 (footnote omitted).

"The northern herd occupies the comparatively drier and warmer northern portion of Yellowstone. Elevation decreases from 2,200–1,600 m over approximately 90 km between Cooke City and Gardiner, Montana with mean snow water equivalents decreasing from 30 to 2 cm along the east-west elevation gradient." Geremia et al. Feb. 2011 at 2.

"Bison from the northern herd congregate in the Lamar Valley and on adjacent high-elevation meadows to the south for the breeding season, but move west towards lower-elevation areas nearer Mammoth,

Wyoming and Gardiner, Montana during winter."
Geremia et al. Feb. 2011 at 3.

> The northern bison herd wintered on rolling terrain on the northwestern half of its annual range at elevations of approximately 1,500 to 2,000 m near YNP's northern boundary (Fig. 1). In summer, most of these bison shifted their distribution to the upper Lamar Valley and adjacent Mirror Plateau at approximately 2,745 m, while some ranged southward in to Pelican Valley. With the exception of Pelican Valley, this herd's range was beyond the boundaries of the Yellowstone caldera, and geothermally influenced areas were uncommon. Valley bottoms were filled with glacial debris of andesitic, volcanic, and sedimentary composition (Despain 1987). Vegetation of the area was primarily grassland or big sagebrush steppe characterized by Idaho fescue, bluebunch wheatgrass (*Elymus spicata*), and bearded wheatgrass (*E. trachycaulus*; Houston 1982, Turner et al. 1994). Coniferous forest of Douglas-fir, Engelmann spruce, and lodgepole pine occurred at higher elevations and on north-facing slopes at the periphery of the grassland and sagebrush steppe (Houston 1982). The sagebrush steppe at lower elevations was interspersed with stands of conifers and aspen (*Populus tremuloides*). Approximately 35% of the northern herd's range burned in the 1988 fires (Despain et al. 1989).



Yellowstone River Valley from Gardiner to Livingston, MT IMAGE: Google Earth

Gogan et al. 2005 at 1719.

**Bison: a keystone species and ecological engineer.**

In the grassland ecosystems where the native species remains, bison engineer and shape ecosystem functions and processes while increasing native species diversity through their keystone ecological roles.

> The bison is a keystone species, increasing biodiversity by creating a mosaic of vegetation and microclimates through differential grazing, urine deposition, trampling, tree rubbing, and wallowing (Knapp *et al*. 1999; Truett *et al*. 2001). The presence of bison also increases faunal diversity, especially among small birds and mammals that flourish in vegetation mosaics (Truett *et al*. 2001).

Boyd 2003 at 2.

> The bison's lifestyle of upland grazing and their near-constant motion is key to their role as an ecological force that assists in shaping the grassland ecosystem (Manning 1995; Knowles and others 1998). Free-roaming bison graze as they move and this disturbance is vital to the heterogeneity of the grasslands (Meagher and Wallace 1993).

Garrett 2007 at 13–14.

> The net effect of these differential plant species responses was a significant increase in several components of plant diversity on sites grazed by bison over the 4-year period. In both watersheds, plant species richness, evenness, species diversity, and spatial diversity (heterogeneity) were higher in grazed compared to ungrazed areas. Greater plant species diversity on sites moderately grazed by bison relative to ungrazed sites supports specific predictions of the intermediate disturbance hypothesis and the generalized model of Milchunas et al. (1988) for grasslands. In the absence of grazing, a few tallgrass species dominate the community, whereas moderate grazing results in a more species rich mosaic pattern of shortgrasses, tallgrasses, and forbs and a mosaic pattern of canopy structure (Milchunas et al. 1988).
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> Bison caused greater increases in species richness and heterogeneity in the annually burned watershed than they did in the 4-year burn watershed. This is likely the result of the greater use of annually burned sites by bison on Konza Prairie (Vinton et al., 1993), and relatively larger shifts in the competitive balance between the dominant grasses and subordinate species in annually burned prairie where, in the absence of grazing, the tallgrasses typically exert stronger competitive effects.
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> Results of this study clearly indicate that bison grazing increases various components of floristic and spatial diversity in tallgrass prairie. Increasing empirical evidence indicates that increased floristic diversity confers greater ecological stability in grasslands, including greater year-to-year stability in the net primary productivity and species composition in response to drought or other stresses (Frank and McNaughton 1991, Tilman and Downing 1994).

Hartnett et al. 1996 at 418, 418–419, 419.

"In our study, moderate year-long bison grazing increased local plant species richness by 19 to 54%." Hartnett et al. 1996 at 419.

> The Green Wave Hypothesis (GWH) says the green wave—the progression of spring green-up from low to high elevations or latitudes—dictates the pace of herbivore migrations worldwide. Animals move in sync with the wave because young vegetation provides the best forage. We show the GWH needs to be revised to include group-forming grazers that not only move to find forage, but create forage by how they move. Bison, by moving and

> grazing en masse, release themselves from the need to "surf the wave." Their movements and grazing stimulate plant growth and delay plant maturation, which allows them to eat high-quality foods despite falling behind the wave while also modifying the progression of the green wave itself.

Geremia et al. 2019 at 1.

> To test if bison grazing was capable of altering forage quality, we conducted a grazing experiment during 2012 to 2017 in 1-ha field sites ($n$ = 30) located along migration corridors. Using 0.5 $m^2$ plots protected within exclosures paired with grazed plots ($n$ = 271), we found that bison grazing removed more than 50% of available plant tissue in the most intensely used areas (Fig. 3A). Intense grazing kept plants in low, dense stature, which enhanced forage quality (shoot N:C; Fig. 3 *B–D*). Notably, during mid and late summer (i.e., Julian days 200–289), grazing improved forage quality by 50–90% in plots with high bison use (Fig. 3B). In plots where bison grazed intensely, they maintained forage in a high-quality state beyond the spring green-up period.

Geremia et al. 2019 at 2.

> [T]he impact of wallowing is dependent on time since occurrence, with long-term effects creating patches of higher arthropod abundance and richness. . . . physical changes caused by bison behavior are important for maintaining arthropod biodiversity of tallgrass prairies, and bison may therefore be valuable conservation tools. Bison have been proposed as important candidates for rewilding portions of North America, and our results suggest that they could indeed be valuable toward this end.
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> Bison are strong allogenic ecosystem engineers (i.e., they behaviorally modify their environment) in the tallgrass prairies of North America. Engineering activities of bison include grazing, soil disturbance when moving, and wallowing. Many studies have addressed how bison grazing affects plant communities (Fahnestock and Knapp 1994, Collins and Smith 2006, Elson and Hartnett 2017, O'Keefe and Nippert 2017). Bison are graminoid specialists, and their preferential consumption of these competitively dominant plants increases plant diversity (Collins et al. 1998) and heterogeneity (Knapp et al. 1999), which in turn leads to cascading effects on other organisms (Joern 2005, Powell 2006, Moran 2014).

Nickell et al. 2018 at 1, 2.

> Wallowing behavior can also change seed distribution (Rosas et al. 2008). As bison continue to use a wallow, the soil compaction leads to greater water retention, which then reduces the efficacy of the wallow for this bison behavior (i.e., increased moisture reduces dust levels). The wallow is then typically abandoned, and bison move to other areas to wallow. This abandoned wallow will then be colonized by a distinctive plant community, adding additional heterogeneity to the ecosystem (Polley and Collins 1984, McMillan et al. 2011).

These abandoned wallows are also important habitat for many animals. For example, abandoned wallows can occasionally retain a considerable amount of water, which allows them to be utilized as amphibian breeding sites (Busby and Brecheisen 1997), although the frequency and abundance of water-filled wallows varies greatly with short-term weather fluctuations (Gerlanc and Kaufman 2003).

Wallows can be long-lasting structures, having effects on prairie plant communities for many decades (Knapp et al. 1999). With the drastic reduction of the bison population on the Great Plains since 1850 and subsequent replacement with cattle (Allred et al. 2011), which do not wallow, this important ecosystem modification process was lost.

Nickell et al. 2018 at 2–3.

PHOTO: Jackson Doyel

Bison wallowing causes much reduced plant biomass, reduced plant growth rates, and probably direct mortality to many arthropods from the extreme force of a 1000 kg animal. However, when a wallow is abandoned, the altered structure caused by past bison activity creates a microhabitat with modified physical resources and a subsequent distinctive biological community (Polley and Wallace 1986, Hartnett et al. 1997). Abandoned bison wallows retain different physical characteristics (e.g., higher water retention) compared to unmodified prairie, which allows them to support very different plant communities (Barkley and Smith 1934, Uno 1989). We showed in this experiment that these changes in physical and biological characteristics produce microhabitats that affect arthropod biodiversity, including patches of higher arthropod richness. The results therefore show that the area of the prairie the wallows occupy can support higher diversity of at least some arthropod groups. The pattern we found shows the importance of the disturbance time frame (Huston 1979). Although the short-term effects of bison wallowing were generally negative on arthropod abundance and diversity, the longer-term effects were much more complex (Gibson 1989).

In the abandoned wallows, there was a strong seasonal component in that arthropod abundance, especially in herbivorous species, was much higher in the early part of the season. Later into the season arthropod abundance was, depending on feeding group, lower or similar. Therefore, past bison wallowing appears to create a more seasonably variable arthropod community.

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> Previous research has shown that bison grazing increases arthropod abundance and diversity (Joern 2005, Moran 2014), while this study shows that bison physical disturbance behavior may lead to even higher abundance and diversity in select locations at certain time of the year. Therefore, when studying effects of potential ecosystem engineers, we argue it is important to investigate their myriad behaviors.

Nickell et al. 2018 at 9.

> [B]ison presence has significant effects on many bird species, although most impacts are explained due to their grazing effects (Powell 2006, Coppedge et al. 2008). For example, the grasshopper sparrow (*Ammodramus savannarum*), a species dependent upon arthropod resources, is more abundant in bison occupied areas (Powell 2006). Since bison are known to enhance arthropod abundance (Moran 2014) due to grazing and, according to this study, further enhance it (at least at times) because of their physical disturbance, we argue that their indirect effects on consumers should be more carefully considered.

Nickell et al. 2018 at 9–10.

"Many researchers have suggested that a rewilding of the North American prairies could be beneficial to the biodiversity of the region (Matthews 1992, Donlan et al. 2005, Svenning et al. 2016) and, given the relatively large areas of natural habitat that remain, could help transform the Great Plains back into a well-functioning biome (Fuhlendorf et al. 2009)." Nickell et al. 2018 at 10.

Numerous scientific studies have found substantial evidence of bison's role in creating a mosaic of habitats, in enriching biological diversity, and in restoring grasslands. Noser 2001 at 2.

> Most prairies were once grazed by herds of bison. Grazing rejuvenates forage production and alters vegetative species structure, maintaining a diverse natural prairie system. Results from a study by Harnett et al. (1996) show that bison grazing increases various components of floristic and spatial diversity in prairie systems.
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> Bison impact prairie species diversity in their selection of forage. The selectivity of bison grazing can be used as a technique to reduce the abundance of some species and thereby increase species diversity by allowing others to compete (Paulsen 1975). The mosaic habitat patches generated by bison grazing and non-grazing habits likely increased species diversity that would otherwise be excluded from the community by competition from the matrix grasses (Hartnett et al. 1996).

Noser 2001 at 2.

> The grass that grew after grazing was higher in nitrogen, more palatable, and not intermixed with dead tissue compared to the ungrazed areas. Grazed areas initially experienced short-lived increased productivity following grazing, but productivity eventually declined as loss of aboveground tissues was compensated for by movement of

carbon reserves from belowground. By repeatedly grazing the same areas, bison encouraged the growth of non-palatable species that are the forbs. This grazing pattern eventually encouraged shifting to other areas as forage quality declined. On average 6–7% of the grazing patches were abandoned annually (Knapp et al. 1999).

Anderson 2006 at 639.

[Custer State Park] incorporates prescribed burns and deferred bison grazing to systematically prevent ponderosa pine encroachment and improve prairie productivity and diversity (Walker et al. 1995). In a study by Pfieffer et al. (1994), rhizomatous grasses on sand ranges responded positively to fire and grazing.

. . .

Grazing improves the prairie system and controls ponderosa pine encroachment. Historical accounts of woody plant degradation conclusively suggest that woody plants fought a continual battle for survival in grasslands because of grazing, browsing and tramping effects of bison and because of recurrent wildfires.

Noser 2001 at 3.

Bison and the plant species they depended upon evolved together over a long period of time. The degradation that disrupted this fire and grazing dependent mixed grass prairie system in Custer State Park spanned many decades and will likely take that long to reverse.

Noser 2001 at 4.

"Bison grazing can offset negative effects of frequent burning on plant species diversity (Gibson and Collins 1990, Knapp et al. 1999)." Anderson 2006 at 639.

Bison also shape "the way fire, water, soil, and energy" move across the landscape. Sanderson et al. 2008 at 253–254 (citing Knapp et al. 1999).

Bison's keystone ecological roles enrich the abundance and diversity of native species. These beneficial, interconnected relationships are disrupted and reduced by management actions eliminating migratory bison from their range and habitat in the Yellowstone ecosystem.

PHOTO: Mike Burdic

"The trophic or engineering effects of some of mammal species are so large that they are considered keystone species whose effects are not only disproportionately large relative to their abundance, but are functionally irreplaceable (Power et al. 1996)." Lacher et al. 2019 at 944.

Some of the greatest impacts on landscape dynamics are driven by dispersal and migration

> of large mammals. Migratory herds of African elephants, American bison, buffalo (*Syncerus caffer*), and other bovids on land, and pinnipeds and cetaceans in the ocean, transfer nutrients and biomass across continents and oceans, and this movement shapes landscapes, seascapes, and freshwater environments.
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> American bison expand and maintain grasslands in North America, creating preferred open grassland habitat and higher quality forage for animals like prairie dogs (Knapp et al. 1999). The heterogeneous patches of grazed habitat alter fire regimes and structure grasshopper communities (Sinclair 1975). In addition, American bison wallows create small ponds across the grassland landscape that provide important habitat for amphibians and arthropods (Knapp et al. 1999; Gerlanc and Kaufman 2003; Joern 2005).

Lacher et al. 2019 at 946, 945.

"[B]ison grazing increased species richness, diversity and evenness (J) of grasshoppers. Grasshopper species richness was positively related to plant species richness and heterogeneity in plant height." Anderson 2006 at 639.

> Keystone mammal species—grazers such as prairie-dogs (*Cynomys* spp.) and bison (*Bison bison*) in western prairies, and dam-building beavers in eastern deciduous forests—played a crucial, and frequently unappreciated, role in maintaining many grassland systems.

Askins et al. 2007 at 1.

> Grassland-to-forest conversion at lower elevations was also likely influenced by reductions in populations of elk, bison, and other ungulates since European settlement of the region (Campbell et al. 1994, Brink 2008, Painter et al. 2018). While the historical interactions between grazing, fire, and grassland–forest ecotones are complex (Bachelet et al. 2000, White 2001, White et al. 2003*b*), the reduced pressure on woody shrub and tree recruitment that results from the removal of fire, grazing, and trampling clearly pushes the ecotone in favor of forests (Nelson and England 1971, White et al. 2003*b*, Painter et al. 2018). Increased aspen recruitment in Yellowstone National Park and in Alberta has been directly linked to reductions in elk browsing due to declining populations (White et al. 2003*b*, Painter et al. 2018), and bison extirpation has been linked with forest encroachment into aspen parkland since the late 1800s in North America (Campbell et al. 1994). Bison effects on forest–grassland boundaries result from browsing, trampling, wallowing, and toppling (Campbell et al. 1994, Bork et al. 2013, Baraniewicz and Perzanowski 2015). Bison primarily browse graminoids (Plumb and Dodd 1993), but they also browse woody shrubs, and broadleaf deciduous and CF [contiguous conifer] saplings (Leonard et al. 2017), which would limit forest expansion. We saw many large areas of young aspen stands in the 1913 photographs that may well date to the time of the bison extirpation.

Stockdale et al. 2019 at 15.

Heavy grazing by prairie-dogs or bison created a low "grazing lawn" that is the preferred habitat for many grassland bird species that are restricted to the shortgrass prairie and desert grasslands.

Askins et al. 2007 at 1.

PHOTO: Cindy Goeddel

Bison are graminoid feeders and often consume more of the dominant grasses than would be predicted by availability (Steuter et al., 1995). This preference may result in an increase in forb density, a key component for maintaining a high level of biotic diversity in tall-grass prairie (Turner et al., 1995). Consumption of browse or woody vegetation may have played a key role in the rise of the grasslands following the Pleistocene age and therefore increased the population of bison (Axelrod, 1985; Hartnett et al., 1997). Turner et al. (1995) view species richness as critical for a high level of biotic diversity. The higher the number of plant species, the greater potential for increased annual diversity. Bison can therefore be a critical factor by allowing forb species to flourish and providing habitat for species that rely upon forbs. Coppedge et al. (1998), examining bison diets through fecal analysis, reported bison preference for grass and sedges. This supports conclusions of Fahnestock and Knapp (1994) that bison grazing (in patches compared to ungrazed patches) enhanced water availability and productivity of forbs. Bison may also play an intricate role in altering competition between $C_3$ forbs and $C_4$ grasses. The shifts can be important for the structure of the plant community with grazing, or lack of grazing, and fire playing roles in the dynamics of certain grass species (Knapp, 1985; Briggs and Knapp, 1995).

Ecoffey 2009 at 15.

Like fire, bison grazing reduces aboveground standing dead biomass. But it is now clear that the unique spatial and temporal complexities of bison grazing activities (Figure 5) are critical to the successful maintenance of biotic diversity in this grassland.

Knapp et al. 1999 at 48.

American bison may accelerate seed dispersal to burned sites because American bison are attracted to recently burned areas.

Tesky 1995 at 6 (footnote omitted).

[L]oss of species diversity due to frequent burning was reversed by bison, a keystone herbivore in North American grasslands.

Collins et al. 1998 at 745.

> Bison graze on the C4 grasses and reduce their abundance, which favors unpalatable C3 forbs, which in turn enhances the plant diversity of the prairie.

Anderson 2006 at 639.

> [U]ngulates are important agents of change in ecosystems, acting to create spatial heterogeneity, modulate successional processes, and control the switching of ecosystems between alternative states.

Hobbs 1996 at 695.

> [B]ison urine deposition leads to patches of vegetation having much higher total aboveground plant biomass, root mass and N [nitrogen] concentrations.

Day & Detling 1990 at 171.

> The isolation of several viable AMF [arbuscular mycorrhizal fungi] taxa from bison feces indicates that wide-ranging bison could be a vector for at least some RFLP [Restriction Fragment Length Polymorphism] types among grasslands within YNP.

Lekberg et al. 2011 at 1292.

> Wallows are a unique ecological feature of prairie ecosystems created by bison. By rolling repeatedly in exposed soil, bison increase soil compaction in certain areas which aids in water retention. In the spring, these wallows produce temporary pools that can support ephemeral wetland species (Uno 1989). In the summer, wallows support a different vegetation structure and composition that is more drought and fire resistant (Collins and Barber 1986). The combined effect of bison wallows is an increase in spatial environmental heterogeneity and local and regional biodiversity (Hartnett et al. 1997).

Fallon 2009 at 2–3.

> [G]razing and wallowing create specific environments that result in greater plant diversity across the landscape by holding water in depressions, enabling colonization by pioneering plant species, and increasing the diversity and use of areas by other animals (Knapp et al. 1999; Truett et al. 2001; Fuhlendorf et al. 2006).

Auttelet et al. 2015 at 107.

> Western Chorus Frogs, *Pseudacris triseriata*, in tallgrass prairie breed in ephemeral aquatic habitats including intermittent streams and bison wallows.

Gerlanc & Kaufman 2005 at 254.

> The heterogeneous species assemblages of wallows enhance grassland species diversity primarily because wallows increase habitat diversity.

Polley & Wallace 1986 at 493.

> By continuously foraging, urinating, defecating, and removing older, dead plants in an area, they essentially cultivate their own 'grazing' lawns of high-quality grasses (McNaughton, 1984; Geremia and others, 2019). Like other ungulate species, migratory bison follow the wave of emerging green forage that moves up in elevation as spring progresses, snow melts, and temperatures warm. They then move back to low elevations when snow accumulates in the mountains in late winter. These behaviors are limited, however, by the area that most bison are allowed to occupy in the modern era.

Kauffman et al. 2020 at 106.

> [G]razers like bison are effective in changing some recalcitrant species of nitrogen to urea that is easily converted to ammonia, a plant-useable form of nitrogen. The increased availability of inorganic nutrients can enhance grassland productivity (Knapp et al. 1999). Grazing removes the physiologically older, less productive leaf tissue and these changes increase light and moisture for younger, more photosynthetically active tissue, which enhances aboveground production (Frank et al. 1998).

Anderson 2006 at 638.

> Bison and elk carcasses increased soil respiration and vegetation nutrient concentrations, and altered soil microbial communities in YNP, USA. While other studies showed that carcasses are 'hotspots' for specific plant and soil properties (Bump, Peterson, et al., 2009; Bump, Webster, et al., 2009), this study is, to our awareness, the first to extensively report how mammalian carcasses affect soil microbial communities in natural systems. We showed that elk, but not bison carcasses, negatively affected soil bacterial richness and diversity as well as fungal richness in YNP . . .
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> Soil microbial community changes were ungulate specific and varied across the YNP landscape . . . carrion has disproportional impacts relative to its input mass and drives soil microbial biodiversity and ecosystem functions.

Risch et al. 2020 at 1940, 1941.

> Bison were not only central to the Plains Indians' way of life, but also central to the ecosystem. Bison are considered ecological keystone species, defined as having a disproportionately large influence on their environment relative to their abundance through their coevolution with all life forms and land use behavior (Mills and Doak, 1993). For example, bison grazing promotes plant functional-group and species richness, alters patch structure across tallgrass prairie landscapes (Knapp et al., 1999; Koerner and Collins,

> 2013; Eby et al., 2014), and promotes higher species richness and compositional diversity in mixed-grass prairies (McMillan et al., 2019). Bison also modify their environment by moving across the landscape and creating disturbance in the form of stomping, wallowing, seed dispersal, and grazing (Harvey and Fortin, 2013); behavior that results in increased landscape arthropod, amphibian, and plant heterogeneity (Polley and Collins, 1984; Gerlanc and Kaufman, 2003; Nickell et al., 2018). Bison are migratory herbivores that can and need to move across large landscapes (Bolger et al., 2008; Plumb et al., 2009), and by altering widespread vegetation structure and composition, bison grazing subsequently impacts prairie wildlife communities (Truett et al., 2001). However, when densities are manipulated and movements are constrained, the ability of the species to have positive impacts on the landscape may be limited (Boyce et al., 2021; Kaplan et al., 2021). Modern prairie conservation relies on the keystone traits of bison to restore ecological function of grasslands; therefore, conservation measures should explore ways to allow bison to move and migrate.

Shamon et al. 2022 at 4.

> The [Northern Great Plains'] mean annual temperatures are projected to increase by 2.3–2.9°C over the next few decades (Wuebbles et al., 2017). Bison respond to warming and drought by shifting diet (Craine et al., 2015; Craine, 2021) and reducing asymptotic body mass (i.e., mature body size) (Martin et al., 2018; Martin and Barboza, 2020a,b).

Shamon et al. 2022 at 5.

> YNP and the surrounding area (Greater Yellowstone area) support an estimated 120,000 elk, 87,000 mule deer (*Odocoileus hemionus*), an unknown but low number of whitetailed deer, 5,800 moose, 3,900 bighorn sheep (*Ovis canadensis*), 2,000–4,000 bison, 800–1,000 mountain goats (*Oreamnus americanus*), and 400 pronghorn (*Antilocapra americanus*—Bangs and Fritts 1996; Varley and Brewster 1992).

Smith et al. 2000 at 1129.

> [B]ison dung in Yellowstone is a common host to a species of fly, *Hypodermodes solitaria*, that is currently very rare in North America. Up until the turn of the last century it was commonly collected in many high altitude and high latitude places on the continent. In this case, Yellowstone's bison reserve may act as the last refugia for a species of animal that was apparently once widespread throughout historic bison ranges of North America (M. Ivie, Montana State Univ., pers. commun.). For another example, studies in 1978 and 1993 showed that many of the 445 species of carrion beetles known to inhabit the northern range are heavily dependent upon ungulate carcasses (Sikes 1994). According to this work, "while a carcass is present, beetle abundance and species richness in a habitat greatly increases" (Sikes 1994). In these highly specialized carrion beetle communities, bison and elk carcasses host significantly different sets of species.

Yellowstone National Park 1997 at 76.

The Yellowstone ecosystem is the only place remaining in the world where the ecological relationship between grizzly bears and bison continues to evolve. Mattson 2017 at 2.

One of many keystone roles bison fulfill in the Yellowstone ecosystem is the natural winterkill of animals – a key source of food for grizzly bears and other native scavenger and predator species.

PHOTO: Jackson Doyel

> A bear was more likely to use a bison compared to an elk carcass, and rarely used mule deer (Fig. 3).

Green et al. 1997 at 1047.

> *Grizzly bear range in 1850 was positively related to occurrence in mountainous ecoregions and the ranges of oaks (*Quercus *spp.), pinon pines (*Pinus edulis *and* P. monophylla*), whitebark pine (*P. albicaulis*), and bison (*Bos bison*).*

Mattson & Merrill 2002 at 1123.

> [B]ison, perhaps one of the most important foods of grizzly bears on the Great Plains, were nearly extirpated from 1850 to 1920.

Mattson & Merrill 2002 at 1133.

> Although grizzly bears in other ecosystems consume meat in similar quantities as the GYE, grizzly bears in the GYE are unique in their consumption of bison (Mattson 1997, p. 167; Fortin *et al*. 2013a, p. 275; Gunther 2017*, in litt*.) and in their interactions with wolves to obtain carcasses (Ballard *et al*. 2003, pp. 261–262; Smith *et al*. 2003, p. 336; Metz *et al*. 2012, p. 556.

U.S. Fish & Wildlife Service 82 Fed. Reg. 30502, 30519 (June 30, 2017).

> The presence of bison and extensive communities of oaks such as *Quercus gambelii* or *Q. turbinella* would also enhance prospects for restoration by providing high quality bear food. The identification of such areas, if they exist, is a necessary next step toward ensuring the long-term survival of grizzly bears in the contiguous United States.

Mattson & Merrill 2002 at 1135.

> Meat from ungulates is a high-quality bear food. Because of foraging efficiencies, this is especially true of meat available in large volumes from concentrated sources. Given these two axioms, meat from bison—the largest-bodied of any surviving Holocene ungulates—is predictably of great value to grizzly bears wherever they have access to this food. Because of European-perpetrated extirpations, this no longer occurs anywhere other than in the Yellowstone ecosystem—a 1% remnant of a system that occurred throughout most of the

current western United States.

. . .

Data obtained during scientific investigations spanning nearly 60 years affirm not only the importance of meat to Yellowstone grizzly bears, but more specifically the disproportionate importance of meat from bison, primarily from carcasses.

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Yellowstone's grizzly bears are increasingly reliant on meat from ungulates because of declines in other important foods, notably cutthroat trout and whitebark pine. Substantial increases in conflicts over livestock and hunter-killed elk suggest that grizzlies are more often seeking meat under circumstances that bring them into conflict with humans—resulting in increasing levels of mortality for the involved bears. The one exception pertains to bison, specifically bison on Yellowstone National Park's Northern Range . . . obtained under circumstances that allow them to survive.

Mattson 2017 at 17.

PHOTO: Jackson Doyel

Preliminary results of a study of Yellowstone grasslands indicate bison grazing improved forage production and quality. Geremia et al. 2015–16 at 31–35.

The published results "show that Yellowstone's bison (*Bison bison*) do not choreograph their migratory movements to the wave of spring green-up. Instead, bison modify the green wave as they migrate and graze. While most bison surfed during early spring, they eventually slowed and let the green wave pass them by. However, small-scale experiments indicated that feedback from grazing sustained forage quality. Most importantly, a 6-fold decadal shift in bison density revealed that intense grazing caused grasslands to green up faster, more intensely, and for a longer duration. Our finding broadens our understanding of the ways in which animal movements underpin the foraging benefit of migration. The widely accepted Green Wave Hypothesis needs to be revised to include large aggregate grazers that not only move to find forage, but also engineer plant phenology through grazing, thereby shaping their own migratory movements." Geremia et al. 2019 at 1.

[A]ggregate grazers like bison (*Bison bison*) and wildebeest (*Connochaetes taurinus*) are ecosystem engineers, capable of modifying grasslands through their intense herbivory. For example, as bison and wildebeest move and graze their way across grasslands, they enhance plant productivity by as much as 40% and 100%, respectively. Large groups of animals migrating and foraging en masse may also be able to extend forage maturation along their migration corridors. If grazing is concentrated and sufficiently intense, it may alter the progress of the green wave itself, releasing aggregate grazers from the need to surf during migration.

Geremia et al. 2019 at 1 (endnotes omitted).

Bison migrating to find forage, and creating and improving forage for a longer duration through their foraging and migration patterns is a significant ecological contribution to the health of grassland dependent species in the Yellowstone ecosystem.

> [G]roup-forming grazers that not only move to find forage, but create forage by how they move. Bison, by moving and grazing en masse, release themselves from the need to "surf the wave." Their movements and grazing stimulate plant growth and delay plant maturation, which allows them to eat high-quality foods despite falling behind the wave while also modifying the progression of the green wave itself.
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> Notably, during mid and late summer (i.e., Julian days 200–289), grazing improved forage quality by 50–90% in plots with high bison use (Fig. 3*B*). In plots where bison grazed intensely, they maintained forage in a high-quality state beyond the spring green-up period.
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> In fact, grazing had a stronger influence on plant phenology than environmental or weather variables during the period when bison fell behind the green wave (*SI Appendix*, Fig. S1). Increased grazing of the same grasslands over time caused them to green up faster, more intensely, and for a longer duration (Fig. 4 *C* and *D*). Thus as bison migrate and graze, they modify the very resource wave that their movements track, altering the timing, pace, and extent of their migrations.
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> Rather than align their migrations to follow the spring wave of green forage, migratory bison—through their intense grazing in large aggregations—modify the green wave as they move across the landscape. Although foundational studies have established how aggregate grazers track and alter intake rate of nutritious foods, our work connects such grazing dynamics to modification of the green wave, which in turn alters the timing, pace, and extent of bison migrations.

Geremia et al. 2019 at 1, 2, 3 (endnotes omitted).

"The migration of bison in Yellowstone, with thousands of animals consuming tons of biomass as they move in unison, is a unique movement and foraging strategy now sustained in only a handful of migratory taxa worldwide." Geremia et al. 2019 at 2.

> The migrations of large herbivores are dwindling across the globe, and their absence has likely caused significant alterations to ecosystems. A century and a half ago, the American West was occupied by tens of millions of bison moving seasonally across its big landscapes.

> With their aggregated grazing across vast areas, phenological patterns would have been radically different from what they are today. Currently, only 20,000 bison remain protected in conservation herds, and only 8,000 of those are allowed to freely move across large landscapes. Moreover, today's model of bison conservation involves maintaining small bison populations within fenced areas and actively managing their abundance for light to moderate grazing. The massive bison migrations that existed before European settlement are gone. Conserving North American ecosystems as a semblance of what they were prior to the loss of bison will involve the restoration and protection of large herds. Restoring lost bison migrations will require that these animals be allowed to freely aggregate, intensely graze, and move in sync with landscape-level patterns of plant phenology.

Geremia et al. 2019 at 3–4 (endnotes omitted).

Bison shape and influence grassland ecosystem diversity through shared behaviors (rubbing, horning, wallowing) in large migratory herds. Butler 2006 at 451–452.

Bison also prevent forests from encroaching into grasslands numerous native species depend on, and act as ecosystem engineers across the landscape.

> Bison inadvertently act as "ecosystem engineers" by creating and responding to heterogeneity across the landscape (Gates et al. 2010). They create greater plant diversity by preferentially feeding on grasses and avoiding some flowering plants, while preventing plant community succession through hoof action and horning or rubbing on trees and shrubs (Meagher 1973; Coppedge and Shaw 1998; Knapp et al. 1999). Their heavy bodies and sharp hooves combine to till the soil and disturb roots of grasses and grass-like plants (Frisina and Mariani 1995). This prevents grassland succession to shrubs or trees and provides grasses with greater access to sunlight, which is important for growth (Knapp et al. 1999). Large groups of bison contribute to natural disturbances that influence plant species composition and distribution across large portions of grasslands and shrub steppe, similar to fire, windthrow, and mass soil erosion events (Augustine and McNaughton 1998; Turner et al. 2003; Collins and Smith 2006; McWethy et al. 2013).

Auttelet et al. 2015 at 108.

> Frequent and recurrent fires can produce a mosaic of different-aged stands, or an environment of high diversity (Cannon 1996). Post-fire studies of lodgepole pine succession indicate that the number of species of plants, birds, and mammals increases continuously for about 25 years following fires, then decreases rapidly following canopy closure (Taylor 1969). The increased fire frequency and the opening of forests may have had significant effects on local bison populations occupying the forested mountains.
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> . . .
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> Higher frequencies of forest fires are noted on the Yellowstone Plateau around 1000 BP (Meyers et al. 1995).

Cannon 2008 at 70–71, 74.

According to a U.S. Forest Service Fire Effects Information System study, "[f]ire is important in creating and maintaining American bison habitat. Fire regenerates grasslands and enhances production, availability and palatability of many American bison forage species." Tesky 1995 at 7 (endnotes omitted).

"The conversion of forests to grasses caused by the fires of 1988 increased the ecological carrying capacity of elk and bison by about 20 percent." Yellowstone National Park 1997 at 105.

Tesky's fire study also found:

> • Forest fires may also play a role in maintaining sedge-grasslands, important winter habitat for bison.
> • Intense bison grazing of recently burned habitat may reduce fuel loads and function as firebreaks.
> • The slaughter and near extinction of bison "may have shortened fire return intervals and increased fire severity during the early settlement period."
> • Bison grazing and fire patterns could provide a valuable tool for naturally managing northern mixed-grass prairie.

Tesky 1995 at 7 (endnotes omitted).

> The Nature Conservancy initiated a patch-bum grazing system on some of its large, bison-grazed grasslands in the Great Plains in the late 1980s (Steuter and others 1990). While the method varies, the basic idea is to annually burn part of a grassland (on a scheduled derived from an estimated aboriginal fire-return interval) and then give grazers, such as bison, access to both the burned and unburned portions of the pasture. In general, bison spend the majority of their time grazing in the most recently burned portion, less time in the portions burned in prior years, and very little time in the remaining portion during the grazing season. Thus, burning results in intense grazing pressure during the first year after the fire, which opens up space between the dominant grasses for new growth of forbs, particularly short-lived annuals and biennials. Those "weedy" forbs become dominant during the next year or two and then slowly subside under competition from the recovering perennial grasses. The periodic intense disturbance is also likely to help other longer-lived plants establish new individuals through seedlings.

Helzer & Steuter 2005 at 167.

"The keystone herbivore hypothesis suggests that large grazing mammals maintain open grasslands, and if these herbivores are removed by human predation, grasslands may succeed to other vegetation types such as shrubland or forest (Owen-Smith 1987)." Gates et al. 2005 at 26.

The extirpation of bison as a keystone species and ecological engineer is a contributing factor in the demise of grassland ecosystems, one of the most endangered but least protected ecosystems in the world, once home to some of the largest wildlife assemblages the Earth has ever known. Henwood 2010 at 121.

This great loss of bison diversity has profound consequences for the ecosystem, and Indigenous peoples with ancestral ties to "their brother," who "continues to survive in their natural migration" on "sacred ground" in Yellowstone, and who recognize the bison as a sacred species and caretaker of the Earth. Chief Arvol Looking Horse, 19th Generation Keeper of the Sacred White Buffalo Calf Pipe (quoted in Buffalo Field Campaign April 15, 2008).

"Because biology has been absent from design decisions, park boundaries do not conform to ecological boundaries and most parks and other reserves are too small to maintain populations of wide-ranging animals over the long term or perpetuate natural processes." LaDuke 2000 at 71–72.

**Bison's sacred ecology and relation with Indigenous peoples.**

> The *Inila Oyate* (Plant Nation) was chosen to lay down a beautiful carpet of grass for the buffalo to come to earth and tell the *Lakota Oyate* how to live their lives. The buffalo has taught them to protect their families and each other through strong spiritual thoughts and belief. In turn, the buffalo is looked upon as a sacred brother and a role model.

PHOTO: Jean Hirsch

. . .

> *Tatanka* and native plants communicate with each other about which plants can be used as medicinals for healing and can pass this knowledge on to human beings. The buffalo has also been assigned a specific role within the grassland ecosystem by the Creator and will eventually show this power to some humans that are worthy of the knowledge. *Tatanka* has been given or assigned certain plants to eat. He wakes up the plants in the spring time w/ the vibrations of his hooves so they will begin their annual growth cycle.
>
> *Tatanka* likes to graze burned areas for the tender new shoots of grass that are come up in the springtime.

. . .

> *Tatanka* is a very strong spiritual creature and has certain powers given to him by the Creator that invigorates the plant life around him. He has the ability to use the plants as medicinals and can use them for his own health or show them to others. He can heal himself by consuming certain plants that grow in certain locations at certain times of the year. He communicates with plants through his keen sense of smell. He makes sacred things happen on the prairie just through his presence and this power can rub off on those that come near him.

. . .

> The bison is a special animal because he can find the medicines that he needs to heal

himself and he will show the Native People these plants. He will go to areas where these certain plants grow so he will have them at his disposal. The bison recognizes that he has a certain role both within his society and within the ecosystem. His role in the ecosystem is to continually trim the plants and to fertilize them. The bison understands that he has a spiritual role to play in the grasslands and today he also recognizes that he has a crucial role in the restoration of these very same grasslands.

The Native People knew that after a fire, *Tatanka* would be there the following spring and so, they burned portions of the grasslands regularly. They would burn also because they knew that the fire would restore the vitality of the plants. *Tatanka* taught this to the people. The people knew that when they saw an imbalance of males and females among the bison that they must hunt them so that they were in balance once again.

Garrett 2007 at 57–58, 59–60, 67.

*Just as the Dust Bowl was the beginning consequence to the 1800's massacre of the great buffalo herds, the recent slaughter will just be a continuity of those dire consequences. We have yet to see the full scale of their absence from the plains ecosystem. From the time our ancestors could see the buffaloes' role as the caretaker of Un-ci Ma-ka, they've been held sacred. Can we stretch our memories and our vision to comprehend its ultimate significance to our survival? This herd in Yellowstone is but a remnant of the earlier herds, but it is a very precious gene pool. Why can't we see that? This ceremony is not an empty ritual. It is an act of responsibility to the spirits of our relatives and an act of humility that they do not abandon us. Hopefully, it can also bring some measure of healing to those that do care.*

Releasing of the Spirits Ceremony at Stephens Creek.
PHOTO: Darrell Geist

Rosalie Little Thunder, Sicangu Lakota (quoted in Buffalo Field Campaign April 15, 2008).

*Let it be known that Yellowstone territory; the habitat of the last wild Buffalo Nation – is sacred ground, it has been a SACRED SITE for the First Nation's people, and for all humanity who hold deep respect for all Creation. The Buffalo Nation has confirmed this fact; by where they have ended up, continuing to survive in their natural migration, struggling to live in a peaceful manner. These Buffalo that lost their lives in Yellowstone did not die by Natural Law, nor were their spirits honored with ceremony. This is why we must go there to perform a ceremony of honor for those that lost their lives by the misunderstanding of human-kind and pray to Wakan Tankan (Great Spirit) for pity of how gifts were unappreciated. We must pray with all those who grieve and be grateful for them. We must pray for the healing of the human Spirit, to understand the connection to all living beings on Un-ci Ma-ka.*

Chief Arvol Looking Horse, 19th Generation Keeper of the Sacred White Buffalo Calf Pipe (quoted in Buffalo Field Campaign April 15, 2008).

*There is a similar teaching in my own culture, the Anishinaabeg. During midwinter ceremonies, an elder's voice will rise as the drum quiets. "The buffalo gave their lives so that we might live," she will say. "Now it is our turn to speak for the buffalo, to stand for our relatives."*

LaDuke 2000 at 68.


ARTWORK: Woody Crumbo, 1952, Library of Congress

> [Z]oologist Tom McHugh remarked in his modern study of the buffalo that the species seem to exhibit a complexity of interactions and appears to be organized into a complex and discernible order of rank (McHugh 1974). The *Lakota* possess a much deeper understanding and knowledge of the buffalo social structure and reverently speak of buffalo character regarding their behavioral patterns that discern them from other nations of animals (Valandra 1993). The *Lakota* observe that the buffalo exhibit grief associated with death, care associated with illness, play associated with leisure, and spirituality associated with celestial ceremonial times cavorting and playing. *Lakota* people have witnessed buffalo cavorting and playing in great fields of sunflowers in what appears to be a sacred manner during celestially important times of the year (Valandra 1993; Goodman 1992). The *Lakota* people say that the buffalo's thundering hooves awaken the plants in the springtime by vibrating the earth alerting the plants' root systems that it is time to begin allocating resources to their above-ground parts (Valandra 1993). They also understood that the hooves of 30-50 million buffalo broke the prairie soil's crust and allowed valuable moisture to infiltrate into the soil rather than runoff into surface waters.

Garrett 2007 at 18–19.

### 3. Legal status of Bison.

Bison are "Near Threatened" and nearly qualify as "Vulnerable" in North America. Aune, Jørgensen, & Gates 2018 at 1; International Union for Conservation of Nature 2012 at 15, 20–22 (a vulnerable taxon is "considered to be facing a high risk of extinction in the wild.").

Plains bison are threatened in Canada. Committee on the Status of Endangered Wildlife in Canada (COSEWIC) 2013.

A species that is threatened is a "wildlife species that is likely to become Endangered if nothing is done to reverse the factors leading to its extirpation or extinction." COSEWIC 2022 (definitions and abbreviations).

The COSEWIC is an advisory body to the Minister of Environment and Climate Change Canada who assess and determine the conservation status of wildlife species at risk of extinction. Under the Species at Risk Act, Canada considers COSEWIC's designation in establishing the government's official list of species at risk of extinction.

Canada has not officially included plains bison on the government's schedule of wildlife species at risk of extinction. COSEWIC 2022 (Plains Bison).

Wood bison are threatened in the United States. U.S. Fish & Wildlife Service 77 Fed. Reg. 26191 (May 3, 2012) (reclassifying wood bison from endangered to threatened).

Wood bison were listed as endangered in 1978, threatened in 2003, and redesignated as a species of Special Concern in 2013 under Canada's Species at Risk Act. COSEWIC 2022 (Wood Bison).

A species of Special Concern "is a wildlife species that may become Threatened or Endangered because of a combination of biological characteristics and identified threats." COSEWIC 2022 (definitions and abbreviations).

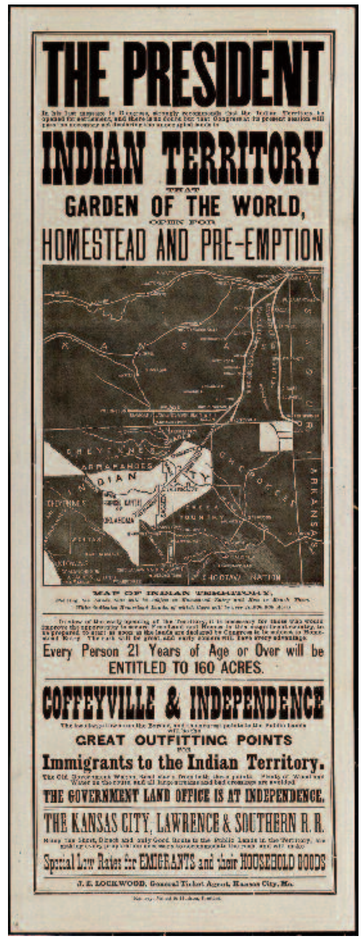
Wisent are endangered in Europe. Massilani et al. 2016 at 2.

PHOTO: Peter Dettling

**4. A brief history of the destruction and near extinction of bison in North America.**

The decimation of North American bison in the 19th century from millions of individuals to less than 1,000 and extinction of the migratory species across one-third of the continent's habitat coincided with the arrival of European Americans and population expansion of settlers.

The reintroduction of the horse. Establishing trading posts and military forts. Congressional passage of land grants to facilitate the expansion of railroads. The building of ports for commerce. The Industrial revolution and the development of a market trade in bison robes and hides. U.S. military forts and troop deployments that aided and protected the new commerce and development of the market in bison. The simultaneous waging of U.S. military campaigns against Plains Indian tribes and the forceful relocation of Indigenous peoples onto far-off reserves opened up vast amounts of land for European American settlers. The signing of the 1862 Homestead Act by President Abraham Lincoln spurred population expansion of settlers westward who seized control of 270 million acres of land following the Civil War. The introduction of settler's cattle and sheep into bison's range. The foreign diseases cattle and sheep introduced for which bison had no previous exposure to or immunity. Ineffective and nonexistent laws and regulatory mechanisms. Abrupt changes in climate and extended droughts. Driven by Manifest Destiny, these converging factors played a decisive role in the rapid extinction of bison populations throughout North America in a remarkably short period of time. *See* National Archives (2020) and Library of Congress (2020) reference source material on the role of mapping, land grants, and the expansion of railroads and settlers in the destruction of bison and appropriation of the migratory species' range and territory.




This poster advertises railroad travel for "immigrants to the Indian Territory." It presumes that land in current-day Oklahoma would soon be open to settlement. It says that, in his last message to Congress (President Grover Cleveland's annual message to Congress on December 3, 1888), the President strongly recommended "that the Indian Territory be opened for settlement, and there is no doubt but that Congress...will pass the necessary act declaring the unoccupied lands in Indian Territory...open for homestead and pre-emption." The Indian Appropriations Act of 1889 officially opened "unassigned lands" in Oklahoma Territory to white settlers under the guidelines of the Homestead Act.

The National Archives https://www.docsteach.org/documents/document/indian-territory-poster/6392/2

> This extinction event gathered together many key inventions of modernity: fast-loading rifles with longer reach, convenient train depots, manufacturers in the east who needed tougher leather for complex belting systems, a popular press that documented the killings with articles, letters and cartoons, a rising commodities financial and corporate network, and ranchers and homesteaders ready to move into cleared areas and use new farming technology to get the plains to grow food. With this technological and social convergence aimed at harvesting the bison, it took about two decades to go from 30 million to approximately 1,000 bison left on the planet. These few animals remained in scattered pockets that included the protected area of Yellowstone National Park and the New York Zoological Society's Bronx Zoo, as well as being kept in small numbers on a few private ranches that held onto the animals.

Schuster 2017 at 103.

With the complicity of State and U.S. government authorities, the North American bison was systematically slaughtered to near-extinction in the 19th century.

The destruction of bison "was the product of war as well as commercial hunting and, at the very least, aided and abetted by the US Army" who intentionally destroyed the "environmental infrastructure" that sustained Indigenous peoples including their "dwellings and shelters, winter clothing, food stores, horses, and hunting prey." Kreike 2021 at 313–314, 312.

"Beyond the free ammunition provided, the frontier military posts also furnished protection, supplies, equipment, markets, storage, and shipping facilities to the hide hunters." Smits 1994 at 332; *see also* Liles 1993 at 44–89, 117–124 (providing evidence of the interrelated role of military forts, trading posts, railroads, and hunters in the market-driven demise of bison roaming the wild).

General Sheridan "built a fort in the heart of the indigenous American hunting grounds to interfere with their hunting. By establishing several supply depots for his own troops and allowing the soldiers to hunt buffalo and other game for sustenance, the general denied the indigenous Americans valuable prey, thereby practicing a form of scorched earth." Kreike 2021 at 309.

"Indirectly, the US Army greatly contributed to the destruction of the buffalo: it did not enforce treaties reserving bison ranges for indigenous American hunters, and commercial white hunters operated from its forts, receiving protection and logistical assistance." Kreike 2021 at 312–313.

PHOTO: Heads of the buffalo killed by poacher Edgar Howell in Yellowstone National Park in 1894. National Park Service.

Major battles erupted between hide hunters, the Comanche and other tribes over treaty-secured bison hunting grounds. The ensuing "buffalo wars" were ended by the U.S. Army's relentless campaign against and subsequent decimation of Indigenous tribes – opening up vast territories to bison hide hunters. Taylor 2007 at 12.

The converging forces of a U.S. military campaign strategy to impoverish the bison from the Great Plains and forcibly restrict nomadic Indigenous tribes to reservations, together with unsustainable commercial market exploitation of bison and the introduction of domestic livestock that degraded bison's range and habitat, and rapid ecological change, led to the extirpation of bison from nearly all of their indigenous range in North America. Smits 1994 at 314 ("traditional interpretations have inadequately defined (and revisionists have underestimated) the army's involvement in the destruction of the bison."); Isenberg 2000 at 2 ("The volatile grassland environment itself was a factor; drought, cold, predators, and the competition of other grazing animals accounted for much of the decline."), at 3 ("Livestock belonging to Euroamerican emigrants . . . degraded the valleys . . .") (citing West, *The Way to the West*, 1995).

The reintroduction of the horse and introduction of domestic cattle and sheep into bison grasslands, and rapid changes in climate, were also factors driving the migratory species to near extinction. Flores 1991 at 469–470.

> [T]he adoption of the horse by the Plains tribes and the advent of white “sportsmen” and commercial hunters introduced a different approach to hunting which ultimately brought the bison to the brink of extinction by the second half of the nineteenth century, and must have seriously disrupted the herds long before that time.
>
> . . .
>
> The advent of white bison hunters and the commercial slaughter of the 1800’s, in addition to the changes in native hunting practices, clearly increased the human pressure on the herds far beyond the capabilities of the Plains tribes. Allen (1876), Hornaday (1889), and Roe (1970) have extensively catalogued the extent and results of the slaughter of the Plains bison which began systematically after 1830 and increased steadily in intensity until the species was almost completely exterminated by the end of the nineteenth century. This slaughter not only increased hunting pressure on the herds to almost unimaginable levels, but almost seems to have been purposefully designed to be as disruptive to the bison as possible. Hunters systematically camped at water sources to kill as many animals seeking water as possible and drive the rest away. Other preferred techniques of taking many animals included running the bison on horseback and shooting a herd down from ambush until the survivors fled. “Sport” shooting of bison from passing trains was common. By continuously reducing the bison population on the Plains throughout the nineteenth century, this predation must have affected records of their ecology: if there were fewer animals in any region, for instance, travelers through that region would have encountered them less often.

Bamforth 1987 at 8, 9 (finding evidence of the development of the commercial fur trade spurred an increase in native hunting of bison for trade, which was made possible by reintroduction of the horse).

Abrupt changes in climate including extended droughts, the introduction of non-native diseases and competition from European and African cattle and sheep in the bison’s range were contributing factors in extirpating the migratory species throughout their indigenous range. Isenberg 2000 at 2, 3; Flores 1991 at 469–470 (finding evidence of severe drought and a corresponding absence of bison bones in the archaeological record; several extended periods of drought struck the Great Plains in the 19th century); Boyd & Gates 2006 at 15 (“regional drought, introduced bovine diseases, and competition from domestic livestock” and horses played a role).

Three severe droughts influenced by La Niña struck North America from the mid 1850s to the mid 1860s, the 1870s, and 1890s adding “to the complex mix of factors leading to the near extinction of the American bison.” Seager & Herweijer 2011 at 1.

Ecological niches — river valleys — that aided bison’s adaptations to severe drought were occupied by Indigenous people, settlers, and their ever increasing number of grazing cattle, sheep and horses. “With the best grasses unavailable to them” bison died in vast numbers. Seager & Herweijer 2011 at 3.

Travel routes facilitating settler’s westward movement across the bison’s range in search of land and gold facilitated the extermination of bison populations and also degraded the environment causing hunger, starvation, and strife for Indigenous peoples.

[T]he discovery of gold in Montana brought new challenges. Gold strikes such as that on Grasshopper Creek [in] 1862 led to the birth of Bannack City and other boomtowns as prospectors flooded into the area to "strike it rich." Shoshones who depended upon a strong fall bison hunt for winter provisions suffered and tensions arose as settlements as well as travel routes drove game out of key hunting areas.

. . .

[B]y the early 1860s hunger resulting from environmental degradation compelled many Shoshones to turn to war. As travelers and settlers exterminated the remaining game populations west of the Divide, new routes of travel and the founding of gold-mining settlements depleted areas that had remained bison-rich into the 1850s, such as parts of southwestern Montana.

Hodge 2013 at 299, 300.

The arrival of Spanish horses (Flores 1991 at 469), Euro-Americans with repeating firearms (Schullery & Whittlesey 2006 at 137), expansion of the railroads (Ecoffey 2009 at 7) the emergence of a market economy and commercial hunting trade (Boyd & Gates 2006 at 15), and development of a market in robes and hides with its emphasis on females which would have affected calf survival (Shaw & Lee 1997 at 171), devastated bison and reduced their numbers from as many 30 to 60 million to a few hundred by the 20th century.

PHOTO: from *Legacies and Lessons of the History of the Bison,* Andrew C. Isenberg, Temple University

"[P]rofit motive created by technological change and maintained by robust export markets" account, in part, for bison's rapid demise and near extinction. Taylor 2007 at 45.

The American Fur Company set up a trading network with Indigenous peoples to obtain bison products for eastern elites, shipping 10,000 pounds of tongues on the steamboat *Yellowstone* to St. Louis in 1831. Sprung 2010 at 29, 30.

Eastern cities and the markets of Europe, sold on the romance of the buffalo robe, hastened the buffalo's demise. Buffalo coats, softer than lamb's wool, were warm and stylishly wild—the frontier brought to the salon. The hides, transformed by new methods of tanning, became belts, bags, the uppers for the most fashionable boots and shoes; the preferred leather for carriage tops, sleighs, and hearses; the prize material for the drive belts in the factories of the Industrial Revolution; and armor and jackets for the English, French, and German armies, which were resupplying in the wake of Bismarck's wars.

Ketcham 2008 at 8 (endnote omitted).

"Nearly a million and a half buffalo were killed for their robes in the upper Missouri region in 1857 alone," according to F.F. Gerard, a Cree interpreter and trader in the employ of the American Fur Company. Brister 2013 at 55.

"[T]he railroads were a major transportation link in the buffalo hide trade." Taylor 2007 at 44.

"British imports of buffalo hides shot from under 50,000 in 1871 to an estimated 620,000 four years later." Ketcham 2008 at 9.

Commercial tanneries in Germany, Great Britain, and the United States perfected the use of bison's tough hides to run the factory belts and machinery fueling the Industrial Revolution, speeding along the migratory species' demise in the wild. Sprung 2010 at 40–41.

The "tougher and thicker" bison hides were in demand to refit accouterments (leather soles, belts, etc.) for the British Army's soldiers, and to run the strapping on cotton gins. Taylor 2009 at 10, 11.

> The hides are collected in the West by the agents of Eastern houses; they are simply dried, and then forwarded to either New York or Baltimore for export . . . The low price that these goods have reached on the English market, and the prospect of a still further decline, may in time put an end to this trade, but *at present the hides are hunted for vigorously, and, if it continues, it will take but a few years to wipe the herds out of existence* (my emphasis).

Taylor 2009 at 9 (quoting the London Times reporting from New York City in 1872) (footnote omitted).

By one estimate, based on firsthand accounts and shipping records, at least 4,500,000 buffalo were slaughtered between 1872 and 1874. Brister 2013 at 59 (citing Mayer & Roth, *The Buffalo Harvest* (1958)).

Operating from Dodge City, Kansas 5,000 hunters wastefully killed "*three, four, or even five*" bison for every hide brought to market — nearly 1.4 million hides from 1871 to 1875. Hubbard 2016 at 63 (quoting Colonel Richard Irving Dodge, U.S. Army); Hornaday 1889 at 494 ("at least half of those actually taken were lost."); Lueck June 2002 at 21 ("Thus nearly 4 million bison were killed . . . in order to recover fewer than 1.5 million hides.").

Bison hunters were unceasing in their pursuit, harming bison's reproduction by hunting through the rut and surrounding water sources — forcing bison to die from thirst or hunter's bullets.

> "Reproductive success likely declined with group size in the 1870s, as unceasing predation (by hide hunters) prevented the congregation of the herds in the rutting season, upsetting the bison's patterns of migration and reproduction and thus inhibiting a recovery of the bison's population."

Hubbard 2016 at 68 (quoting Isenberg) (endnote omitted).

> For those buffalo who managed to find a water source that was free from hunters, this was their behavior: "they would rush and crowd in pell-mell, crowding, jamming, and trampling down both the weak and the strong, to quench a burning thirst. Many of them were rendered insane from their intolerable, unbearable thirst."

Hubbard 2016 at 68–69 (quoting hide hunter John R. Cook) (endnote omitted).


Source Unknown

PHOTO: National Park Service
Photograph of bison skulls, Hugh Lumsden, 1890

William Hornaday map illustrating the Extermination of the American Bison.

A herd of 500,000 bison in Montana was recorded in 1875. Bamforth 1987 at 10 (citing observations collected by Roe, *The North American Buffalo* (1970)).

Shortly thereafter an assembly of 5,000 hunters and skinners decimated half a million bison within 150 miles of Miles City, Montana, from 1880 to 1883. Hornaday 1889 at 513; Lueck June 2002 at 22.

In three seasons concluding at the end of 1883, the entire northern herd was reduced to less than 100 bison, "not counting the 200 in Yellowstone Park." Lueck June 2002 at 22 (citing Hornaday).

A year later, "more than one-fourth of the 2,300 Blackfeet in the United States starved to death." Zontek 2003 at 37.

> The development of the railroad and federal policies such as the 1862 Homestead Act sped the westward movement of settlers and the result was a loss of the buffalo (Licht, 1997). By 1840, most bison east of the Mississippi River were gone, and by 1880 most bison in the southern plains and east of the Missouri were also eliminated. 'The Great Slaughter' of bison

> occurred between 1870 and 1890. The US Army encouraged buffalo hide hunters and the railroad to increase the harvest of the buffalo which resulted in The Great Slaughter (Geist, 1996; Sample, 1987).

Ecoffey 2009 at 7.

Wars with Plains Indian tribes and treaties provide evidence of Indigenous people fighting and negotiating "in a "natural" effort to preserve their landscape and hence provide a suitable habitat for their cultural mainstay, the buffalo nation." Zontek 2003 at 33.

> The Red River War of 1874–1875 on the southern plains and the Lakota resistance of 1876–1877 on the northern plains occurred when these treaty rights broke down as hide hunters and soldiers invaded the southern hunting grounds preserved by treaty followed by another Euro-American invasion of the northern hunting grounds. Native Americans responded by sacrificing their lives to preserve their landscape. Famed Lakota spokesman Black Elk and Luther Standing Bear recollected this time of landscape change. Black Elk explained the detriment of the reservation process, "The Wasichus (whites) came, and they made little islands for us and other little islands for the four-leggeds and always these islands are becoming smaller."

Zontek 2003 at 34 (providing evidence of how Indigenous peoples used treaties to preserve buffalo hunting grounds and exclude Euro-Americans who broke the treaties and invaded the hunting grounds where Indigenous peoples fought and gave their lives to prevent the buffalo's demise) (endnote omitted).

> Either way, the native people of the Great Plains did not receive an opportunity to prove their stewardship of their environment, the last bastion of the immense bison herds. The Army confined the Indians to reservations and applauded the demise of the bison; Euro-American hide hunters blasted the herds into oblivion; the American government failed to lift a finger to prevent the service of such injustice; and Euro-American agriculturalists carved-up the land while changing the biota which ultimately prohibited any possible resurgence of free-ranging bison herds reminiscent of the previous thousands of years.
>
> . . .
>
> Archeologist Michael Wilson further articulates the impact of the near extermination of the buffalo nation as being a virtual end of the world from a philosophical perspective: "[It] removed far more than a food source: it knocked out the underpinnings of an entire cultural pattern, from subsistence to ceremonialism. Their prime link with the Creator disappeared as much a memory as the unfenced open plains" (Wilson, "Bison in Alberta," in Foster, Harrison, and MacLaren, eds., Buffalo, 14).

Zontek 2003 at 35, 68 n. 93.

Driven by Manifest Destiny, Euro-American settlers embraced the narrative that divine providence sanctioned the extermination of Indigenous peoples and the bison that sustained them in every respect, as the land was an empty wilderness awaiting the settlers' civilized arrival and succession. Barnard 2020 at 382.

> “[A] treasure trove destined by God and nature to benefit a more deserving race . . . supported by the current theological opinion that Christians had obviously been ordained by providence to inherit the earth and the Indians, being heathen could not hope to oppose the process.”

Eder 2000 at 6 (quoting Daniel Boorstin, *The Americans, The Colonial Experience* (1958) on settler’s view that Indigenous peoples had no title or occupancy rights to ancestral lands they resided in for thousands of years).

> “Unless they are localized and made to enter upon agricultural and pastoral pursuits they must ultimately be exterminated.”

Eder 2000 at 22 (quoting F. V. Hayden’s 1872 Report of the U.S. Geological Survey of Wyoming conducted under the authority of the Secretary of the Interior).

> “The quickest way to compel the Indians to settle down to civilized life was to send ten regiments of soldiers to the plains with orders to shoot buffalos until they became too scarce to support the redskins.”

Kreike 2021 at 313 (quoting General Sherman in the *Army Navy Journal* (1869)).

> “When we get rid of the Indians and buffalo, the cattle will fill this country.”

Brister 2013 at 59 (quoting General Nelson Miles in Brown & Felton, *Before Barbed Wire* (1956)).

Driving bison to extinction across hundreds of millions of acres of land also cleared bison’s range for the arrival of settlers and their cattle.

Based on data reported from the U.S. Department of Agriculture, the number of cattle soared from 25 million in 1867 to over 55 million in the late 1880s. Taylor 2007 at 31.

Cattle numbers in Wyoming jumped from 90,000 to 500,000 between 1874 and 1880. Eastern Montana hosted more than 500,000 cattle by 1883. Brister 2013 at 58.

Cattle numbers in Park County, Montana jumped from 14,000 to 37,000 between 1880 and 1890. A few thousand sheep boomed to nearly 200,000 in the same period. Haggerty 2004 at 49, 50 (citing U.S. Dept. of Agriculture data).

Two years of severe droughts and especially harsh winters from 1885–1887 killed 80 to 90 percent of cattle on the Great Plains. Mintz & McNeil 2018 (overgrazing and destruction of grasslands led to range wars between cattle and sheep ranchers).

In Montana, ranchers lost 362,000 head of cattle — more than half the territory’s herd. History.com 2009 (recording overstocked ranges and a summer drought followed by severe cold and a snow-crusting event killed millions of cattle in 1887); Haggerty 2004 at 218 (“The epic winter of 1887 solidified the case against open range grazing” making way for barbed wire fenced ranches in Paradise Valley).

Bison inhabiting the Rocky Mountains were subject to the same factors driving their extinction on the Great Plains and throughout North America.

Sport and market hunting rapidly reduced bison range and abundance throughout the Yellowstone ecosystem with reports of bison being trapped and appropriated for private benefit.

> The capture of calves by local ranchers interested in starting private herds was probably most prevalent in Lamar and the west-side wintering areas.

Meagher 1973 at 17, *see also* Table 2 at 18–22 (for reports on how tourist and market hunting and illegal poaching nearly exterminated the indigenous bison remaining in Yellowstone).

In 1875, hunters killed thousands of elk, bison, deer, pronghorn antelope, and bighorn sheep on the Northern Range including in the Lamar Valley, "while their carcasses were poisoned to kill predators and scavengers." Yellowstone National Park 1997 at 3.

Even after the creation of Yellowstone National Park in 1872, nonexistent, weak, and ineffectual wildlife protection laws (the Lacey Act of 1894) left the few bison remaining in the wild vulnerable to people killing for amusement and poachers pursuing the vanishing chance to kill a bison. Cope 1885 at 1038 ("The bison have been . . . reduced to a herd of about sixty individuals, and the elk have been decimated. . . . English shooters killed, for their amusement, twenty or thirty from the bison herd without taking any part of the animals for their use. . ."); Meagher 1973 at 17 (hunting "by both the park hotel construction crews and Cooke City miners" along with poachers decimated the bison remaining); *see also* Gates et al. 2005 at 81–83 (on how bison were nearly extirpated in the wild despite passage of the Lacey Act giving the federal government sole jurisdiction to protect wildlife and to punish crimes for illegal take).


PHOTO: University of Calgary. Only chariot buffalo team in the world owned by Bob Yokum and Edd Carr, The Stampede, Calgary, September 1912.

Yellowstone National Park Superintendent Norris estimated 600 bison remained in 1880. Meagher 1973 at 17.

A resident bison population inhabiting the Hayden and Firehole valleys was extirpated in the late 1800s while a small remnant population of 22 to 30 bison evaded extirpation in the wild in the Central interior range. Gates et al. 2005 at vi.

By the turn of the 20th century, only 23 wild bison remained in the United States seeking refuge in Yellowstone National Park under the armed guard of the U.S. Army. Meagher 1973 at 12, 17.

In 1902, a small introduced population of 21 bison was captively bred on the Northern range and gradually released from husbandry, a management policy that ended in 1952. Meagher 1973 at 12, 67.

> As elder historian Mose Chouteh related in one of the more remarkable accounts in the

> recorded oral histories, some years earlier, a Pend d'Oreille man named Atatice? (Peregrine Falcon Robe), who had a special relationship with buffalo, had proposed to the chiefs that the people herd some of the orphaned calves back west of the mountains to begin a herd on the Flathead Reservation. The people could see that the numbers of buffalo were already declining, and inter-tribal conflicts over the dwindling resource were intensifying. But Atatice? was suggesting a fundamental change in the people's way of life, and the relationship with the buffalo. After three days in council, the leaders remained divided, so Atatice?, out of respect for the tribal way of making major decisions by consensus, withdrew his proposal.
>
> In the late 1870's, however, the chiefs, seeing that the conditions were continuing to worsen, allowed Atatice?'s son, Ɬatatí (Little Peregrine Falcon Robe), to carry out the idea. About six calves survived the journey west. Ɬatatí raised them near the Flathead River at the home of his mother, Sapin Mali. They grew to about 13 in number. Some years later, Ɬatatí's stepfather, Samwel, sold the herd to Michel Pablo and Charles Allard. Pablo and Allard ranged the buffalo in the grasslands along the Flathead River, where the herd quickly grew to hundreds of animals.
>
> In 1896, Allard died, and in 1901 some of his portion of the herd was sold to the Conrad family of Kalispell. Other portions of the Allard herd were sold to Howard Eaton, a friend of Charles Russell. Eaton later sold his animals to Yellowstone Park. Thus the origin of the Yellowstone Park herd were in part the buffalo originally saved by Ɬatatí.

Smith, Salish-Pend d'Oreille Culture Committee 2011 at 15–16.

The remnants of the Pablo–Allard bison herd freely roamed and flourished on 1.3 million acres of Flathead territory until Congressional passage of the Flathead Allotment Act in 1904, an "act of privatization, enclosure, and settler encroachment." Mamers 2020 at 130. Signed into law by President Theodore Roosevelt, the Act left the bison bereft of tribal communal lands serving as range for the herd. Zontek 2003 at 112.

> The parceling out of the valley into private homesteads made way for an influx of settlers and the increased importation of cattle and other domesticated livestock. In addition to the great losses endured by the Flathead peoples, allotment meant Pablo's growing bison herd would no longer have access to the open valley where they had been protected for two decades.
>
> . . .
>
> Canada's purchase of the Pablo herd was a critical measure in the survival of the species. However, the sale forced by allotment policy meant the loss of the protective relationship Pablo and the other members of the Flathead community had entered into with the buffalo. Further, the transfer of the animals to Canadian state ownership appropriated this protective relationship for the purposes of settler state-building via park-building and tourism.

Mamers 2020 at 130, 132.

"Surrounded, corralled and carted away" to another country, the fate of the bison on the Flathead foreshadowed the coming domestication of the last herds taken from the wild, the forced assimilation and dispossession "of Indigenous peoples, of Indigenous land and life," an appropriation to benefit the arrival of settlers and the cattle that would supplant and replace bison, the monarch of the plains. Mamers 2020 at 138; Zontek 2003 at 36–37.

## Timeline of Bison Extinction in the Wild

Bison present in eastern forests in 1700.

Bison driven to extinction east of the Mississippi River by 1820 save Wisconsin where they were eliminated in 1832.

Fort Union established in 1828 at the confluence of the Yellowstone and Missouri Rivers in North Dakota.

Market for bison robes begins in the 1820s lasting into the 1880s.

Expansion of the railroads in the 1860s through the 1880s effectively divides bison into northern and southern herds. (Railroads reach Cheyenne in 1867, Salt Lake City in 1869, Denver in 1870, Dodge City in 1872, Bismarck in 1873, El Paso in 1881, and Miles City in 1881).

Based on fur trading company records of hides shipped, an estimated 31,000,000 bison were killed between 1868 and 1881.

Sharp's .50 caliber rifle developed in 1872.

President Grant signs into law a Congressional bill creating Yellowstone National Park in 1872 from ceded portions of lands negotiated in a series of treaties with the Blackfeet, Apsáalooke (Crow), Shoshone and Bannock Tribes, an Act that came at great cost to Indigenous peoples.

Indigenous tribes suffer military defeats throughout the 1870s (opening more bison range for market hunting).

Hunters decimated southern bison herds in Colorado and Kansas (1871–1874).

Hunters decimated bison herds in Texas and Oklahoma (1874–1880).

Hunters decimated northern bison herds in Dakota Territory, and the Territories of Montana and Wyoming (1880–1884).

Hornaday's 1889 survey finds 1,091 wild and captive bison in North America.

A bison population inhabiting the Hayden and Firehole valleys in Yellowstone was extirpated in the late 1800s.

Amidst the remains of their near extermination, a buffalo bone trade picked the bone ricks dry (1884–1892).

Bone pickers generated $40,000,000 in commerce (the bison remains were made into fertilizer, sugar-processing filters, buttons, knife handles, and glue).

Sources: Lueck 2002 at S613, S618; Ecoffey 2009 at 7; Barnett 1975 at 2–3, 13; Gates et al. 2005 at vi; Eder 2000 at v, 24, 63–75, 76–77, 97–98 (several Indigenous tribes possess reserved treaty hunting rights, even more tribes were forcibly excluded from lands traditionally used for thousands of years in the newly created Yellowstone National Park).

ILLUSTRATION: The last of the buffalo. C.M. Russell, 1899. Library of Congress

**5. Discreteness and significance of the Yellowstone bison distinct population segment.**


PHOTO: Peter Dettling

The best available evidence supports designating Yellowstone bison a distinct population segment as that term is used in the Endangered Species Act (16 U.S.C. § 1532(16)) in determining whether a species is threatened or endangered "throughout all or a significant portion" of their indigenous range. 16 U.S.C. § 1532(20), (6).

The distinct population segment of Yellowstone bison is discrete, significant, and unique to the subspecies to which they belong.

The loss or extinction of Yellowstone bison would represent the complete loss of the only population continuously inhabiting their indigenous and ecological range in the contiguous 48 States, loss of unique ecological adaptations in the Yellowstone ecosystem of which they are an integral part of as a keystone species and ecological engineer, and the loss of unique genetic and significant wild characteristics and traits. *See also* Buffalo Field Campaign & Western Watersheds Project 2014 at 24–31 (providing evidence of discreteness and significance incorporated in its entirety by reference here).

Bison inhabiting the mountainous region and river valleys of the Yellowstone ecosystem are the only representative population of the wild species remaining in their indigenous range and habitat in the contiguous 48 States.

The loss of any Yellowstone bison herd or the population would result in a significant gap in the range of the wild species remaining in North America.

An independent assessment of the state of knowledge about the distinct population segment found:

- The only representative population of migratory bison persisting in the wild since prehistoric times.

- Bison have roamed, adapted to, and evolved in the bioregion since the recession of the last glaciers 10,000 to 12,000 years ago.

- A resident bison population inhabiting the Hayden and Firehole valleys in Yellowstone was extirpated in the late 1800s.

- A remnant bison population escaped extinction in the eastern Central interior of Yellowstone National Park.

- Expansive grasslands in the Madison Valley and Snake River Plains were the likely source of some bison migrating to summer ranges in the Central interior of Yellowstone National Park.

• Bison's Northern range extends from the Lamar Valley to the Yellowstone River Valley to Livingston, Montana, and the Northern Great Plains beyond.

Gates et al. 2005 at vi.

Yellowstone bison are physically and geographically isolated from self-sustaining wild bison populations, if any remain.

The best available evidence indicates there has been no genetic interchange — human introduced or natural — from any other bison population for well over a century.

For over 120 years, Yellowstone bison have remained discrete or markedly separated from self-sustaining wild bison populations, if any remain, as a consequence of:

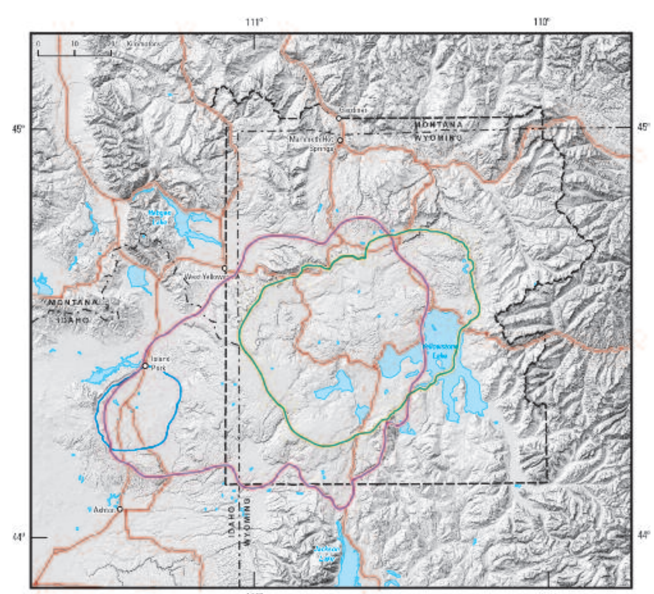
- Market hunting, and the lack of effective legal or regulatory protections, which destroyed an untold number of migratory populations in the Greater Yellowstone bioregion and drove bison to near extinction throughout North America.
- Appropriating bison range and habitat for livestock, agriculture, and other human land uses.
- The destruction of long distance migration corridors, and loss of interconnectivity between self-sustaining wild bison populations facilitated by corridors.
- The destruction of and loss of connectivity to habitats supporting self-sustaining wild bison populations elsewhere, if any remain.
- State and federal regulatory mechanisms preventing migration and natural genetic interchange between wild self-sustaining bison populations elsewhere, if any remain.

The biological and ecological significance of Yellowstone bison is distinguished by the unique migrations and foraging strategies of the Central and Northern herds.

In itself, the phenomenon of long distance migrations by wild bison is an endangered characteristic of the distinct population segment.

"The migration of bison in Yellowstone, with thousands of animals consuming tons of biomass as they move in unison, is a unique movement and foraging strategy now sustained in only a handful of migratory taxa worldwide." Geremia et al. 2019 at 2.

Persistence of Yellowstone bison in their indigenous range may not have been possible without adaptation of the migratory species to geothermally influenced habitats created by the Huckleberry Ridge Tuff, Henrys Fork, and Yellowstone calderas.



MAP: Yellowstone Volcano Observatory

Central herd bison select geothermally influenced habitats as refugia and movement corridors. Gates et al. 2005 at 48, 55 (Tables 3.1 and 3.2).

Central herd bison use a significant proportion of geothermally influenced habitats within their winter ranges (4.8% in Pelican Valley to 14.4% in Mary Mountain), and movement corridors (5.2% to 9.2%). Gates et al. 2005 at 55 (Tables 3.1 and 3.2).

> Most of the central herd's range was within the Yellowstone caldera (Pierce and Morgan 1992, Good and Pierce 1996).

Gogan et al. 2005 at 1718.

> Significant areas of geothermally influenced habitat are present in the Firehole, Gibbon and Norris Geyser Basins, Hayden Valley and in the Pelican Valley winter ranges (see Chapter 3 and note red polygons in Figure 5.1) in which diminished snow cover increases access to forage, and reduces the cost of thermoregulation and movements.

Gates et al. 2005 at 113.

> [G]eothermally-influenced areas provide refuge for a significant part of the Central subpopulation in harsh winters.

Gates et al. 2005 at 127.

> Significant areas of geothermally-influenced habitat in the Central Ranges provide refugia for bison in severe winters and reduce snow cover, resulting in reduced costs for accessing forage, travel, and possibly thermoregulation.

Gates et al. 2005 at vii.

> That bison have survived . . . in a valley such as Pelican in spite of severe winters suggests that a margin for survival might be represented in parts of the Yellowstone environment which does not occur elsewhere.
>
> The survival factor for bison in parts of Yellowstone may be the existence of thermal areas.

Meagher 1973 at 113.

The inclusion of geothermally influenced habitats as a significant proportion of habitat use represents an unusual and significant ecological adaptation unique to Yellowstone bison.

Notably, Central bison herd migrations cross the calderas and landforms created by the Yellowstone Plateau volcanic field. Christiansen 2001 at G13, G18, G112.

Henrys Fork caldera near Island Park, Idaho, is also within the range of Central bison herd migrations. *See* Yellowstone Volcano Observatory 2007 map.

Geothermally influenced habitats likely played a role in averting the extinction of the country's only population of bison continuously roaming their indigenous range and habitat in the wild.

> Geothermal activity can also modify snow pack. YNP has the highest density of geothermal features in the world . . . Geothermal features generate heat that can dramatically reduce snow cover and lengthen the growing season, both at geothermal basins and along the banks of streams and rivers influenced by warm water (Meagher 1973, Despain 1990), thus improving forage availability at these sites (Bjornlie and Garrott 2001). Geothermal sites and geothermally influenced shorelines may therefore be key refugia for bison during severe winters (Despain 1990, Meagher et al. 2002).

PHOTO: Jackson Doyel

Gates et al. 2005 at 48 (citation and web page omitted); Meagher 1973 at 98–103 (finding sedges, less snow or snow-free sites, and ice-free streams provide forage, water, and travel routes for bison).

The biological and ecological significance of Yellowstone bison is also represented in the markedly different structure of the distinct population segment.

Characteristics distinguishing the distinct population segment of Yellowstone bison from other plains bison populations remaining in North America include:

- The identification of two "genetically distinct and clearly defined subpopulations . . . based on both genotypic diversity and allelic distributions."
- "[T]wo independent and historically important lineages" with "nearly half—10 of 22 modern plains bison haplotypes—of all the known haplotypes in plains bison" present in just 25 bison sampled.
- The only surviving natural occurrence of wild bison occupying their indigenous range and habitat since prehistoric times.

Halbert et al. 2012 at 1; Forgacs et al. 2016 at 1, 6; Gates et al. 2005 at vi.

> Bison that live in the central and northern regions of Yellowstone have significantly different distributions of alleles and genotypes, and are genetically distinguishable based on 20 alleles only found in one of the two regions (14 central; 6 northern; Halbert et al. 2012).

Auttelet et al. 2015 at 123.

In addition, scientists have found significant distinctions between the Central and Northern herds in the Yellowstone bison population including:

- Different tooth wear patterns (Christianson et al. 2005 at 674).

- Different parturition timing and synchrony (Gogan et al. 2005 at 1716).
- Longitudinal differences in migration patterns (Halbert 2012 et al. at 368).
- Differential migration at the herd scale (Geremia et al. 2011 at 6).
- Spatial separation between herds (Olexa & Gogan 2007 at 1536).
- Differences in diet (Birini & Badgley 2017 at 6–7).
- Differences in plant communities, diet, and environmental conditions (Fuller et al. 2007 at 1925).
- Fidelity to breeding territories and female philopatry to natal ranges (Gardipee 2007 at 10, 31–32).
- Detection of strong substructure in mitochondrial DNA (Gardipee et al. 2008).

Halbert's (2012) finding corroborates earlier findings by Olexa & Gogan (2007) who identified 2 subpopulations: the Northern and Central bison herds, and Meagher's (1973) earlier finding of 3 subpopulations.

Additionally, another study demonstrated results indicating "some level of population subdivision" in the Yellowstone bison population. Halbert 2003 at 146, 147 (finding "sufficient evidence to exclude the possibility of a single, admixed bison population").

The U.S. Fish & Wildlife Service's policy of recognizing threatened or endangered distinct population segments is:

> to protect and conserve species and the ecosystems upon which they depend before large-scale decline occurs that would necessitate listing a species or subspecies throughout its entire range. This may allow protection and recovery of declining organisms in a more timely and less costly manner, and on a smaller scale than the more costly and extensive efforts that might be needed to recover an entire species or population.

Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act, 61 Fed. Reg. 4722, 4725 (Feb. 7, 1996).

In interpreting the agency's policy, the U.S. Fish & Wildlife Service must follow Congress's instruction on designating distinct population segments "in a clear and consistent fashion" and exercising your authority "sparingly and only when the biological evidence indicates that such action is warranted." 61 Fed. Reg. 4722 (Feb. 7, 1996) (citing Senate Report 151, 96th Congress, 1st Session).

The best available evidence presented herein indicates large-scale loss and extirpation of self-sustaining populations of wild plains bison throughout their range in North America from which the subspecies has yet to recover.

Because Yellowstone bison are at risk of extinction from the same factors jeopardizing plains bison in the wild, protecting and recovering the distinct population segment would be a significant step in conserving the subspecies and the ecosystems on which they depend for survival.

The U.S. Fish & Wildlife Service's inquiry into designating distinct population segments must consider three elements:

1. Discreteness of the population segment in relation to the remainder of the species to which it belongs;
2. The significance of the population segment to the species to which it belongs; and
3. The population segment's conservation status in relation to the Act's standards for listing (i.e., is the population segment, when treated as if it were a species, endangered or threatened?).

61 Fed. Reg. 4722, 4725 (Feb. 7, 1996).

A population segment is "discrete" if it meets either one of the following conditions:

1. It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation.
2. It is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(d) of the Act.

61 Fed. Reg. 4722, 4725 (Feb. 7, 1996).

If a population segment is considered discrete, the U.S. Fish & Wildlife Service must then consider "its biological and ecological significance . . . in light of Congressional guidance" to use your authority sparingly "while encouraging the conservation of genetic diversity." 61 Fed. Reg. 4722, 4725 (Feb. 7, 1996).

In examining the "scientific evidence of the discrete population segment's importance to the taxon to which it belongs," the U.S. Fish & Wildlife Service must include, but are not limited to considering:

1. Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon,
2. Evidence that loss of the discrete population segment would result in a significant gap in the range of a taxon,
3. Evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range, or
4. Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

61 Fed. Reg. 4722, 4725 (Feb. 7, 1996).

In 2007, the U.S. Fish & Wildlife Service "determined that there is substantial information indicating" Yellowstone bison "may meet the criteria of discreteness and significance as defined in our policy on distinct vertebrate population segments (DPS)." 72 Fed. Reg. 45717 (Aug. 15, 2007).

In 2015, the U.S. Fish & Wildlife Service found "substantial scientific or commercial information indicating" Yellowstone bison "may qualify as a DPS." Federal Docket No. FWS-R6-ES-2015-0123 at 2.

In 2019, the U.S. Fish & Wildlife Service concluded "that there is substantial information supporting a potential designation of" Yellowstone bison "as a single DPS of the Plains bison subspecies." Federal Docket No. FWS-R6-ES-2019-0085 at 4.

In summary, the best available biological evidence supports designating Yellowstone bison as a distinct population segment.

The U.S. Fish & Wildlife Service must now properly consider and examine evidence Yellowstone bison are threatened or endangered throughout all or a significant portion of their indigenous range warranting legal protection and recovery pursuant to the Endangered Species Act.

PHOTO: Jackson Doyel

### 6.A. Bison's indigenous range.

Prior to the arrival of Americans of European descent, bison roamed and inhabited various bioregions across one-third of North America's land mass. Hornaday 1889 at 377.

The migratory species once roamed long distances in vast herds across the North American continent from the Great Lakes region to the Appalachian Mountains, to the Gulf and Atlantic Coastal Plain, the Chihuahuan desert, through the grasslands and prairies of the Great Plains into the Intermountain basins, from the Rocky Mountains to the Boreal Forest, and reaching the Arctic Lowland Taiga.

> Bison originally ranged across most of North America (Figure 3.1). Plains bison were most abundant on the Great Plains, but they also radiated eastward into the Great Lakes region, over the Allegheny Mountains, and toward the eastern seaboard into Florida; westward into the Nevada, Cascade, and Rocky Mountains; northward to mid-Alberta and Saskatchewan; and southward along the Gulf of Mexico into Mexico (Reynolds *et al*. 1982; Danz 1997). There are also records of bison occurring at high elevations in mountainous regions (Fryxell 1928; Meagher 1986; Kay and White 2001).

Boyd 2003 at 20.

Original Range of the Bison, 1720 - 1903, Hart


One source calculates an expanse of bison range of 9,486,204 $km^2$ or 3,662,643 square miles — more than 2,300,000,000 acres. Sanderson et al. 2008 at 255.

The territory and range of migratory bison once spanned over 20 major habitat types or ecoregions the wildlife species adapted to in North America. Sanderson et al. 2008 at 255, *see also* (Figure 1) at 256 and (Table 2) at 257; Bailey's map *Ecoregions of North America*.

One of the most vital bison bioregions, the Great Plains grasslands, comprises 400 million acres of contiguous habitat, most of which has been converted to agriculture, farmland, and grazing livestock that has resulted in 55 threatened or endangered grassland species, and another 728 designated as candidates for Endangered Species Act listing. Garrett 2007 at 3, 4–5.

> The Yellowstone bison of historic times were a remnant of a once much more extensive bison population, known to trappers and Indians, which

> inhabited the mountain ranges and the intermountain valleys of the Rockies and extended on west into Washington and Oregon. Most of these bison were gone by the 1840s . . . Considerable numbers of bison once lived close to the park. Many skulls have been found in the Red Rock Lakes area, approximately 35 miles west of Yellowstone . . . Many skulls have also been taken from the Mud Lake area of Idaho, approximately 55 miles southwest of Yellowstone . . . Doane (1876) comments that "buffalo skulls are strewn by thousands —" in the Yellowstone valley about 40 miles north of the park. Accounts of wild bison adjacent to and within the park, dating from 1860 through 1902 (Appendix II) leave no doubt that substantial numbers of bison inhabited the Yellowstone Plateau at all seasons, and long before the killing of the northern herd of Great Plains bison in the early 1880s.

Meagher 1973 at 13–14 (citations omitted).

Meagher's compilation of European American observations (1860–1902) provides evidence that Yellowstone bison's range extended far beyond today's State and federal government imposed boundaries.

**West and Southwest of Yellowstone National Park**

- In crossing Low Pass from Henry's Lake to the Madison, Raynolds recorded "one band of buffalo among the hills."
- Hague wrote buffalo "occasionally wander beyond the Park Borders into Idaho and Montana with the first fall of snow, returning to their mountain homes with the approach of spring."
- Park Superintendent reported "rumors of a herd of nearly one hundred having been seen in Idaho outside the Park."

**Northeast of Yellowstone National Park**

- At Lake Abundance, Henderson observed "All game plenty–buffalo."; "full of buffalo" at Broadwater River.
- Pierrepont also reported seeing "a herd of buffalos numbering about a hundred and eighty" near Lake Abundance.

**North of Yellowstone National Park**

- Henderson recorded seeing "Thousands of buffalo" on the Middle Boulder River.
- Haines quoted local newspapers who reported "a herd of bison in the Snowy's" north of the park in the Absaroka Range.

**Yellowstone National Park**

- The Park Superintendent reported "three distinct or separate herds of bison within or adjacent to the Park."
- Several reports (from Marble, Murri, and a Park Superintendent of "undoubted evidence") of Dick Rock, a poacher based out of Henry's Lake, capturing several buffalo calves in the Bechler Meadows area.
- Burgess saw two buffalo "wintering" on the Snake River.

Meagher 1973 at 116–135 (Appendix II).

A more extensive survey of European American reports found "[p]rehistoric bison distribution in the GYE can perhaps best be summarized simply by saying that bison appear to have been living everywhere where habitats were suitable." Schullery & Whittlesey 2006 at 136.

In the first decades of European American contact with the Greater Yellowstone bioregion, bison were "spectacularly abundant in lower river valleys and prairie habitats, and were all but exterminated" by 1882. Schullery & Whittlesey 2006 at 135.

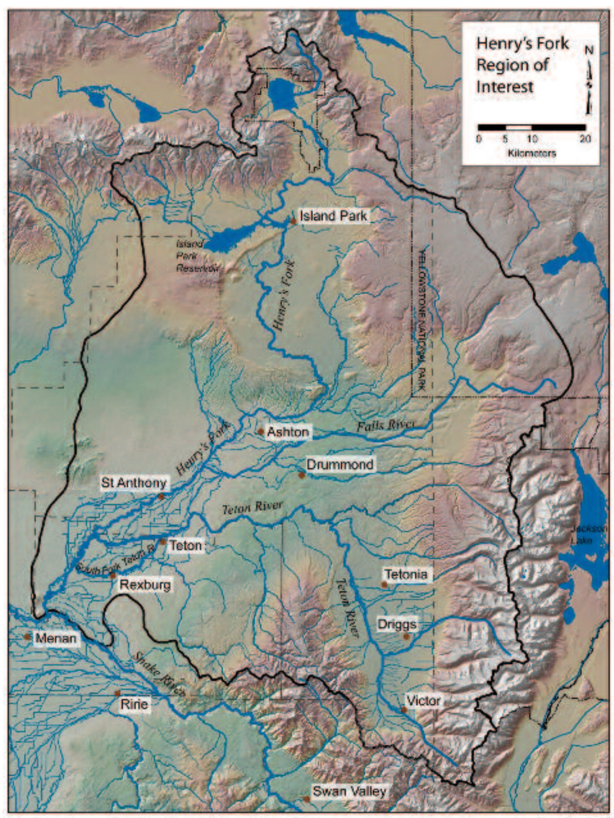
Bailey's research of European American recordings provide evidence bison were "widely distributed in the intermountain valleys of the Rocky Mountains in the United States. A major regional concentration once occurred in the upper Snake River drainages of southeast Idaho, in the upper Green River drainages of southwest Wyoming, and over the continental divide along the uppermost tributaries of the Jefferson River in southwest Montana (Fig. 1, Tables 1–3)." Bailey 2016 at 4, *see also* Bailey's graphic depicting observations at 11, and recordings, Tables 1–5 at 12–22.

Recordings from 1805–1845 indicate "bison were widely distributed in intermountain valleys, with a major regional concentration spanning parts of Idaho, Montana and Wyoming." Bailey 2016 (graphic).

According to one approximation, prior to the arrival of European American settlers bison occupied 20,000 km$^2$ or 4,942,108 acres of habitat from the headwaters of the Yellowstone and Madison Rivers to the lower valleys. Plumb et al. 2009 at 2377.

However, the authors rely on recordings made by European Americans in a period of time when bison were being extirpated across their range. Plumb et al. 2009 at 2378 ("an approximation of pre-settlement distribution based on archived reports and journals of expeditions through the area"). In addition, the authors did not disclose their methodology supporting their approximation of Yellowstone bison range and habitat.

Furthermore, the authors do not discuss why they excluded known bison migrations including across Targhee Pass over the Continental Divide into Henrys Fork basin and caldera, or following the Bechler River south to Jackson Lake and Grand Teton, and exclude range bison once occupied, e.g., the Snake River plain and Gallatin Valley that other sources such as Gates include as Yellowstone bison range.




MAP: Cal Poly Humboldt, Humbolt.edu

> The Lamar Valley and the Yellowstone River Valley north of the park (Figure 4.1) to Livingston and beyond was an important area for bison and Native peoples throughout the

> Holocene. This system can be considered the original Northern range for Yellowstone bison, functioning as an ecological continuum of grasslands that likely supported seasonal migrations by bison as far south as the high elevation ranges in the Upper Lamar Valley. Davis and Zeier (1978: 224) described the lower Yellowstone Valley as an exceptional area for Native people to gather, drive and kill bison. Eight bison jumps and three kill sites have been documented south of Livingston. The closest jump site to Yellowstone National Park is 25 km north of the park boundary. It was used during the late prehistoric period between 1,700 and 200 b.p. (Cannon 1992). There is evidence of a human use corridor from the Gallatin and Madison River drainages into the interior Yellowstone National Park. Several major bison kill sites are located in the Gallatin Valley outside of Bozeman Montana. Archaeological sites in Fawn Pass provide evidence in support of the hypothesis that Native people moved between the Gallatin drainage and the interior of the park. Chert and obsidian projectile points were found at the Fawn Pass site. The chert implements likely originated west of the park. The obsidian is being fingerprinted to determine its origin. Approximately half the projectile points were the Pelican Lake type, the most commonly represented prehistoric culture in Yellowstone National Park, dating from 1000 B.C. to A.D. 200. Other points were assigned to the McKean Complex, dating to around 3500 B.C. McKean Complex sites are also quite common in the park. There is an obsidian source at Cougar meadows in west central Yellowstone Park. The material is inferior to the Obsidian Cliff source and was only used for making utility implements like knives and scrapers rather than projectile points. An obsidian artifact found at Yellowstone Lake was determined to be Cougar Creek Obsidian.

Gates et al. 2005 at 77 (footnotes omitted).

> Prehistorically, Yellowstone bison ranges were probably the "tips of the fingers" of seasonal migration from large source populations associated with expansive grasslands (Figure 4.1) lying to the north, west and southwest around the Yellowstone Plateau. The high mountains on the east side of Yellowstone National Park and discontinuous habitat would likely not have supported bison migration. Historical accounts indicate that interior ranges also supported resident bison populations (Meagher 1973: Appendix II). Today, the bison of Yellowstone National Park are a source population with the potential to reoccupy surrounding grasslands systems if incompatible land uses and policies did not constrain expansion. There are no free-roaming bison populations in adjacent areas containing habitat contiguous with the park. The closest contemporary population is in the Jackson Valley, separated from Yellowstone bison ranges by the Continental Divide and an expansive tract of coniferous forest.

Gates et al. 2005 at 79 (footnote omitted).

> The Gallatin and Madison Valleys and the Snake River Plain contain extensive grasslands that served as habitat for large numbers of bison (Figure 4.1), source populations for bison entering the park from the west. In 1880, Superintendent Norris commented on the presence of about 300 bison on the Madison Plateau and Madison River (Meagher 1973: 118). He speculated that the winter range of this population may have been outside the park. M. Meagher inferred that bison would have migrated into the park from the west in

> the spring and summer by several routes: the chain of wet meadows along the Bechler River in the southwest corner of the park; diffuse movements across the Madison Plateau; and through Raynolds Pass and other low passes in the Continental Divide west of the Park. There is little available evidence for or against the possible use of the Madison River corridor during prehistoric or the early historic period. Meagher (1973: 23) cites Raynolds (1867) who in 1860 saw "bison among the hills" while traveling from Henry's Lake to the Madison River west of the park. Bison were present in this corridor in the 1950's (Meagher 1973: 23) and the corridor is heavily used by contemporary bison (Bjornlie and Garrott 2001).

Gates et al. 2005 at 80 (footnote omitted).

Yellowstone bison climb mountains, and forest fires open migration paths for bison who are drawn to the growth of nutritious grasses.

Yellowstone bison migrations eastward over the Continental Divide following the Shoshone River occurred over most of the latter 20th century and became consistent after a major forest fire in 1988. Wyoming Game & Fish Department 2008 at 7, 10–11.

> To the east of the Yellowstone Plateau lies the Bighorn Basin, a large intermontane basin. The area lies within the rain shadow of the high plateau, and mountains of the GYE make the area relatively arid. Within this modern arid, shortgrass environment, bison were hunted 10,000 years ago during a period when the climate was probably more humid and cooler (Figure 5.6).

Cannon 2008 at 99, *see also* 100–101 (location of the Horner site, along the Shoshone River, described by Jepson (1953:11) as containing the skeletons of about 200 bison of the modern species).

Greater Yellowstone Ecosystem, Joshua Stevens, NASA Earth Observatory

Bison occupied portions of the present day Hyalite-Porcupine-Buffalo Horn Wilderness Study Area but were extirpated around 1889. Craighead 2015 at 117. The majority of grasslands and shrub-steppe within the wilderness is in the southwest corner of the Buffalo Horn drainage along the northwest border of Yellowstone National Park. Craighead 2015 at 118.

Jourdonnais assessed bison winter range in the Upper Gallatin and found suitable habitat in Daly, Lodgpole, Taylor Fork, and Porcupine drainages. Jourdonnais 2006 at 8, *see also* Upper Gallatin Potential Bison Winter Range map at 9.

Additionally, Schullery & Whittlesey's study of settler's observations of bison being eliminated from ranges in the Greater Yellowstone bioregion spanned "several decades before 1880" which led the authors to conclude that “[i]n almost no case prior to 1880, however, does the written historical record provide the means of calculating any herd size for any locale. Nor does such a spotty and intermittent set of records allow us to assume that a sighting of a certain herd in a certain valley or meadow in a certain year meant that bison occupied that site similarly year after year.” Schullery & Whittlesey 2006 at 136.

Based on Gates, Meagher, Schullery & Whittlesey, Cannon and other sources, Plumb’s approximation of the extensive loss of bison range must be considered a minimum range loss for two of many probable headwaters and river valleys in the Yellowstone ecosystem.

What the historical record compiled by European Americans tells us is Yellowstone bison migrated in response to the occurrence of drought, fire, severe winter, and human disturbances, influencing and leading bison to shift their migrations to hospitable range and habitats as circumstances changed.

PHOTO: Jackson Doyel

**6.B. Bison's current indigenous range.**

> Much has been written about the destruction of the great herds that once ranged through the plains and prairies of this continent. Certain basic facts must be remembered when we consider the disappearance of the buffalo as a wild animal. The needs of a developing country and a growing population cannot be ignored. Men cannot live in close association with the wild buffalo. Wild buffalo just do not mix with farmlands, grazing livestock, communities of homes and playing children. The reasons behind the destruction of the buffalo and the manner in which the herds were destroyed, almost to the extermination of the species, are less easily defended.

U.S. Fish & Wildlife Service 1977.

The current representation of bison "functioning as wild" is limited, reduced, or extinct in over 20 major habitat types or ecoregions the migratory species adapted to in North America. Sanderson et al. 2008 at 255, *see also* Figure 1 and Table 2 at 256 and 257 (counting 1,236 herds, mainly commercially propagated ranched bison, i.e., domestic livestock, because to do otherwise would create "an opponent, the bison industry . . . where an ally may have stood" in the ecological recovery of bison).

PHOTO: Cindy Goeddel

The ecological settings (representation), current size (resiliency), and number of sites (redundancy) with bison populations "functioning as wild" and recognized as wildlife is depauperate in North America.

Systemic pressures are jeopardizing the migratory species' representation, resiliency, and redundancy in their Yellowstone range.

Systemic pressures are also jeopardizing Yellowstone bison's long-term survival, viability, and evolutionary adaptation in the wild through:

- population isolation,
- loss in range and habitat,
- loss of long distance migration corridors,
- loss of connectivity to habitats,
- loss of connectivity between self-sustaining populations,
- loss in ecological roles, functions, and processes, and
- loss in natural selection processes.

The current range of bison is <1% of the migratory species' distribution circa 1500. Sanderson et al. 2008 at 256.

Within <1% of the fragmented range remaining, only four geographically isolated bison populations in the

United States meet the International Union for the Conservation of Nature's criteria for "functioning as wild."

A current range map showing the remaining distribution of bison populations "functioning as wild" can be found in Aune, Jørgensen, & Gates 2018 at 4.

In their indigenous range, bison are regionally extinct in 40 States including Montana and Idaho, and possibly extinct in Texas. Aune, Jørgensen, & Gates 2018 at 2–3.

"The species' current range is restricted by land use and wildlife management policies in the southern area and by wildlife and reportable disease management policies in the northern portion of the North American range." Aune, Jørgensen, & Gates 2018 at 2.

PHOTO: Debbie Odom

In the contiguous 48 States, the only representative population of bison continuously roaming their indigenous range since prehistoric times is the unique and distinct population segment of Yellowstone bison. Meagher 1973 at 1; Gates et al. 2005 at vi.

Bison use Yellowstone National Park for summer rutting territories, fall habitat, winter range, and spring calving grounds. Migration corridors remaining in Yellowstone National Park allow bison to move to contiguous range and habitat on the Custer Gallatin National Forest. Geremia & Cunningham 2018 at 6–10.

Bison use the Custer Gallatin National Forest for fall habitat, winter range, spring calving grounds, and to some extent, summer range and exploratory movements.

Bison's exploratory movements cross additional jurisdictions over the Continental Divide and mountain ranges in all directions:

**West, Southwest, and Northwest**
• over Targhee Pass into Idaho to Henrys Fork basin and caldera, and Island Park. Montana Fish, Wildlife & Parks and Montana Dept. of Livestock 2013 at 39.
• over Raynolds Pass following the Madison River in Montana. Meagher 1973 at 118.
• over Raynolds Pass following the Madison River into the Madison valley in Montana. Lulka 1998 at 100, 101.
• 15 miles south of Big Sky, Montana. Lulka 1998 at 100.
• to Henry's Lake, Idaho to Ennis, Montana. Meagher 1973 at 149.

**North**
• following the Yellowstone River in Gardiner basin over the hydrological divide into Tom Miner basin. Geremia & Cunningham 2018 at 9.
• from Gardiner basin to Joe Brown Gulch to Dome Mountain over the hydrological divide into Paradise valley in Montana. Montana Dept. of Livestock 2013.
• from Gardiner Basin to Dome Mountain into Dailey Basin ("tracks indicated those animals

(<6) crossed the hydrologic divide east of Joe Brown Creek. A few other bison moved as far north as Big Creek that winter, but they traveled through Yankee Jim Canyon on the west side of the Yellowstone River." Lemke 2006 at 2.

**East and Southeast**

• in the Absaroka Mountains over Cooke Pass, Sunlight Basin, Wood River, Crandall Creek drainage, over Sylvan Pass along the North Fork of the Shoshone River, and the Thorofare River in Montana and Wyoming. Gates et al. 2005 at 80.

**South**

• following the Bechler River to Jackson Lake and Grand Teton in Wyoming. Gates et al. at 80; Meagher 1973 at 23.

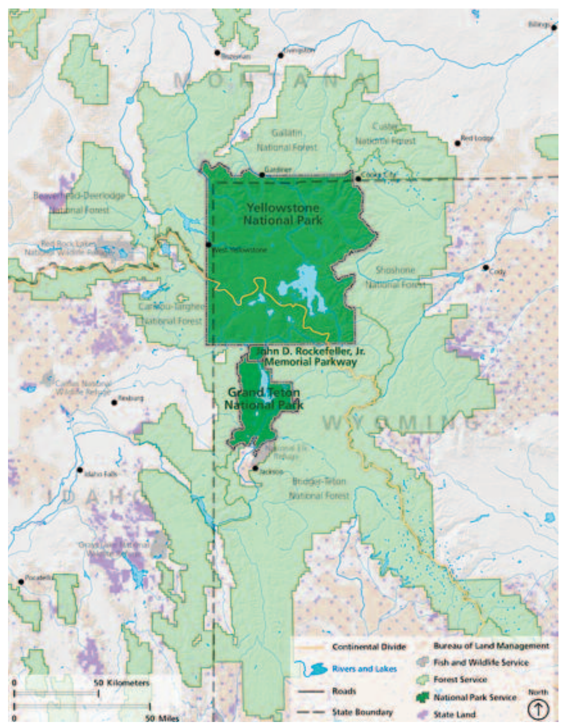
In the period 1942–1985, bison movements beyond park boundaries in all directions were documented for 26 years. Lulka 1998 at 62–63 (Table 1) (citing Clark & Kopec 1985), *see also* Figure 8 at 64 (Location of Known Historic Bison Movements Beyond Yellowstone National Park).

Meagher also charted reports of known bison movements beyond park boundaries from 1942–1967. Meagher 1973 at 149.

There are no State or federal regulatory mechanisms for conserving Yellowstone bison's range, migration corridors, connectivity to habitat, and exploratory movements.

The migratory species' distribution across their range in the Yellowstone ecosystem is strictly confined by government imposed "tolerance zones" inside Yellowstone National Park and on the Custer Gallatin National Forest.

In addition to the U.S. government, State management actions also limit, reduce, or eradicate bison migrating in their current range in Montana, Idaho, and Wyoming. All of these government authorities impose restrictions on Yellowstone bison's range.




MAP: National Park Service

As a consequence of governments enforcing "tolerance zones," connectivity to habitat, long distance migration and exploratory movements in Yellowstone bison's range is at risk.

784,560 acres of bison habitat is available in Yellowstone National Park primarily located in Wyoming, and covering portions of Montana and Idaho.

Bison historically occupied about 20,000 square kilometers (4,942,108 acres) in the headwaters of the Yellowstone and Madison Rivers (Plumb et al. 2009). As of 2008, they occupied 3,175 square kilometers (784,560 acres) predominantly inside Yellowstone National Park. The current tolerance areas include about 200,000 acres on the west side and about 105,000 acres in Gardiner Basin on the north side. Prior to the Governor of Montana's decision, the tolerance zones were 12,500 acres on the north and about 70,000 acres to the west.

Custer Gallatin Final Terrestrial Wildlife Report 2017 at 133.

PHOTO: David Martin

Yellowstone National Park is trapping wild bison for slaughter and domestication (quarantine) in their current range. Inadequate regulatory mechanisms for conserving or protecting bison's range has resulted in Yellowstone National Park becoming the largest source of population loss.

By one approximation, bison are restricted to about 15% of their indigenous range in the Yellowstone ecosystem. Plumb et al. 2009 at 2377.

Other estimates of bison's indigenous range are much more expansive in comparison to currently restricted bison range. *See* Gates et al. 2005 at 77, 79, 80; Schullery & Whittlesey 2006 at 135, 136; Bailey 2016 at 4.

There are "no self-sustaining herds of wild plains bison" across 145 million acres of National Forest habitat in the Western Region alone. U.S. Forest Service Region 2 Regional TES Species Program Leader Warren 2011; U.S. Forest Service 2015 Table 1.

There is no publicly enforceable regulatory mechanism in place to ensure Yellowstone bison persist as a viable self-sustaining wildlife species on National Forest ranges in the Yellowstone ecosystem.

There is no viable self-sustaining population of wild Yellowstone bison anchored by National Forest ranges in Region 1, Region 2, and Region 4.

The government limits and reduces Yellowstone bison range on the Custer Gallatin National Forest in Region 1.

Due to government intolerance, bison roam only one landscape on the Custer Gallatin National Forest — the Madison, Henrys Lake, Gallatin, Absaroka and Beartooth Mountains. Custer Gallatin Draft Assessment Report of Ecological, Social and Economic Conditions 2016 at 40–41.

On the Custer side of the National Forest, NatureServe ranks bison in South Dakota as S3 vulnerable, at "moderate risk of extirpation in the jurisdiction due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors." NatureServe 2021 at 3.

The lack of regulatory mechanisms to ensure bison persist in their indigenous range is preventing the native species from roaming four out of five landscapes on the Custer Gallatin, and government intolerance is depleting bison genetic diversity in the remaining landscape or ecological setting on the National Forest.

> Given current constraints on bison tolerance, there is no expectation that bison would be re-established outside of the landscapes that are adjacent to Yellowstone National Park. Therefore, habitat was assessed only for the Madison, Gallatin and Beartooth landscape. Currently, within the Madison, Gallatin, and Beartooth landscape, there are 293,151 acres (12.5 percent) of potentially suitable habitat for bison on the Custer Gallatin National Forest. Of that amount, 224,143 acres are grass and shrub lifeforms (Figure 18).

Custer Gallatin Final Terrestrial Wildlife Report 2017 at 134 (foreseeing no re-establishment of bison on their National Forest range outside confined "tolerance" zones for the life of the land management plan).

Habitat available in confined "tolerance areas" on the Custer Gallatin does not translate into bison use or suitability.

Bison prefer traveling the narrow band of flat, low elevation habitat along the Yellowstone River in Gardiner basin, typically using flat areas or rolling foothills dominated by sagebrush grassland vegetation. Lemke 1997 entire; Lemke 2006 entire.

The South Fork and Watkins cattle grazing allotments on the Custer Gallatin are suitable habitat, but the government prohibits bison from moving South of the Madison River to the South Fork and Watkins Creek in Hebgen basin. Swilling 2011 at 6.

The best available evidence indicates bison use a fraction of habitats under current government confined "tolerance zones" on the Custer Gallatin. Wallen 2012 (published in Montana Fish, Wildlife & Parks and Montana Dept. of Livestock 2013 (Appendix D)); *see also* Geremia & Cunningham's 2018 habitat suitability score covering manager's restricted "tolerance area" for bison.

Pretending habitat is available for bison to roam in government imposed "tolerance zones" is evident in the 249,126 acres "available" as opposed to the habitat bison use or are predicted to use: 83,751 acres on the Custer Gallatin and some private lands in Gardiner basin and Hebgen basin. Wallen 2012.

Furthermore, State and federal management actions reduce habitat use in Gardiner and Hebgen basins, and few if any bison naturally roam habitat "available" in the Upper Gallatin River after being extirpated by the government in the early 1990s. Geist & Mease pers. observations; White et al. 2018 at 11.

The government is appropriating National trust public lands in Yellowstone bison's range and habitat for cattle while imposing "tolerance zones" on native bison roaming their home range.

A significant factor reducing and limiting bison range is the Custer Gallatin National Forest's cattle grazing program. Another factor is the National Forest permitting several fencing and associated cattle guard schemes to intentionally disrupt bison's natural migrations, connectivity to habitat, and exploratory movements.

There is no publicly enforceable regulatory mechanism for conserving or protecting bison's range on the Custer Gallatin National Forest.

Beyond Yellowstone National Park, bison migrating into Wyoming are confined to restricted areas.

The State of Wyoming manages for the removal of low numbers of migratory bison in restricted areas including on National Forest habitat in Region 2. In their current range, Wyoming law reduces Yellowstone bison genetic diversity to virtually zero.

Bison migrations onto the Shoshone National Forest in Region 2 occurred over most of the latter 20th century and became consistent after a major forest fire in 1988. From 1988–1997, up to 30 bison were annually observed on the North Fork of the Shoshone River. After two seasons of being hunted, only individual bull bison (less than 10) were observed. Wyoming Game & Fish Department 2008 at 7, 10–11, 12.

Under Wyoming law, the migratory species falls under the authority of the livestock board who can order Game & Fish to remove bison from their range. Wyoming Game & Fish Department 2008 at 15; Wyo. Stat. Ann. § 23-1-302(a)(xxvii) (2022).

The outcome of enforcing Wyoming law and placing the native species under livestock authority effectively reduces wild Yellowstone bison genetic diversity to virtually zero on their current range on the Shoshone National Forest.

Wild bison are a critically imperiled species in the State of Idaho.

Bison migrating through and beyond Yellowstone National Park and the Custer Gallatin are purposely eradicated under Idaho law despite being identified as a critically imperiled species.

> It is the purpose of the provisions of this section to provide for the management or eradication of bison . . . .

Idaho Code § 25-618(1) (2021).

Yellowstone bison migrate onto the Caribou-Targhee National Forest and elsewhere in Idaho where the species' conservation ranking is S1, a "critically imperiled species at high risk because of extreme rarity." Adams & Dood 2011 at 108.

Under Idaho law, State and federal officials shoot or eliminate any bison from the Yellowstone population migrating in their current range on National Forest habitat in Region 4, and elsewhere including Island Park and along Henrys Fork. Associated Press 2012 (two bulls shot near Island Park); Buffalo Field Campaign 2009 (lone bull shot south of Twin Creek); Buffalo Field Campaign 2017 (two bulls shot near Henrys Lake Flats); Montana Fish, Wildlife & Parks and Montana Dept. of Livestock 2013 at 39 ("bison have occasionally migrated into Idaho with the most recent occurrence being July 2012 when two bull bison made the 20 mile trek to Island Park Idaho. Previous to that, the last report of bison traveling into Idaho was in 2009.").

### 7.A. The biological status of wild bison populations in North America.

The representation, resiliency, and redundancy of self-sustaining populations of wild bison is depauperate in North America and at risk in Yellowstone.

Self-sustaining populations of wild bison are "so depleted in numbers that they are in danger of or threatened with extinction." 16 U.S.C. § 1531(a)(2).

Bison are "Near Threatened" with few populations "functioning as wild" in North America. Aune, Jørgensen & Gates 2018 at 1.

Bison nearly qualify as "Vulnerable" and "therefore considered to be facing a high risk of extinction in the wild." Aune, Jørgensen & Gates 2018 at 1; International Union for Conservation of Nature 2012 at 15, 20–22.

The vast loss in bison range (>99%) and populations remaining in the wild (<1%) are conditions reflecting a high risk of extinction. Sanderson et al. 2008 at 252–253 (finding "no place" where "the full range of ecological and social values of previous times" for bison is expressed); Stroupe et al. 2022 at 1 (bison experienced a species-level near extinction event resulting in a population loss >99%).

Loss of connectivity between wild self-sustaining bison populations, and extirpation from ecological settings throughout the migratory species' range are additional conditions reflecting a high risk of extinction.

The lack of representation, resiliency, and redundancy of self-sustaining populations of wild plains bison in North America are factors warranting consideration for listing and recovering the subspecies under the Endangered Species Act.

According to the Secretary of the Interior, bison "remain functionally extinct to both grassland systems and the human cultures with which they coevolved." Secretary of the Interior 2023 at 2.

In the 48 contiguous States, bison in the wild are regionally extinct in 40 States including Montana and Idaho, and possibly extinct in Texas. Aune, Jørgensen & Gates 2018 at 2–3.

Depending on the jurisdiction and context, bison are legally classified as wildlife and/or domestic livestock.

> Canada, the United States and Mexico list bison nationally as both wildlife and domestic livestock. Legal status varies among State and Provincial jurisdictions. In Canada, four provinces and two territories classify bison as both wildlife and livestock. Bison are legally classified as livestock in the United States [and] only 10 states classify bison as wildlife in all or portions of the state. An additional threat to populations of this species is culling to prevent the spread of bovine tuberculosis and brucellosis.

Aune, Jørgensen, & Gates 2018 at 6.

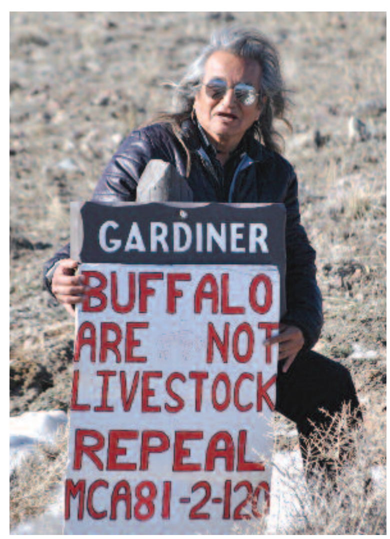


PHOTO: BFC Archives

No one is certain how many buffalo were on the continent before Anglo settlement. However, accounts of early explorers estimated the bison population in the hundreds of millions, while later scientists approximated the population between 15-20 million (Cushman and Jones, 1988), 28 million (Flores, 1991), 60 million (Hornaday, 1890) and 30 million to 60 million (McHugh 1972).

Ecoffey 2009 at 4.

Using Geographic Information System data, one source calculates the "carrying capacity" for wild bison ranged from 20 to 44 million on the Great Plains. Weber 2001 at 50.

Based on the principles of conservation biology, a self-sustaining wild bison population is defined herein as:

- persisting in the wild as a self-sustaining population large enough to preserve genetic diversity and avoid inbreeding for centuries;
- evolving under a preponderance of natural selection processes that preserve the migratory species' wild traits and characteristics;
- adapting and dispersing in an array of large protected habitats to withstand, and recover from, catastrophic events, random and systematic pressures; and
- fulfilling their keystone ecological roles in the ecosystem and bioregion they are an integral part of.

The definition is applicable in determining the survivability of a self-sustaining wild Yellowstone bison population, and relevant to the evidence and analysis of threats the migratory species is facing, for example:

- The "wild genome in a wild environment" must be retained for wild bison to persist as a migratory species evolving under a preponderance of natural selection processes vis-à-vis widespread and ongoing domestication and artificial selection processes. (Wildlife biologist James A. Bailey PhD, 2013 "a book about why and how to retain wildness in bison for future generations.").
- For each distinct herd, a census of 2,000–3,000 bison is necessary "to avoid inbreeding depression and maintain genetic variation." (Population geneticist and conservation biologist Philip W. Hedrick PhD, 2009).
- Minimum viable populations require at least 5,000 adult individuals. (Ecologist and conservation scientist Lochran W. Traill PhD, 2010).
- An effective population size of 5,000 or more is necessary "to maintain evolutionary potential and long-term genetic viability." (Ecologist and evolutionary biologist Russell Lande PhD, 1995).

The International Union for Conservation of Nature's Red List Assessment, which examines the risk of extinction, estimates the population ranges, trends, and sizes of the five plains bison populations "functioning as wild" in North America as follows:

- Yellowstone National Park, 784,559 acres of range with a stable population of 4,875 bison.

• Grand Teton National Park/National Elk Refuge, 360,000 acres of range with a decreasing population of 825 bison.

• Apsáalooke (Crow Tribe), 22,000 acres of range with a stable population of 1,000 bison.

• UTE Tribal–Book Cliffs managed in cooperation with Utah, 1,471,000 acres of range with an increasing population of 600 bison.

• Pink Mountain located outside the indigenous range of plains bison in Canada, 790,737 acres of range with a stable population of 877 bison.

Aune, Jørgensen, & Gates 2018 Supplemental Material (Tables 1 and 2) (classifying bison into three categories based on a number of criteria, e.g., a population of more than 1,000 older than one-year of age, to distinguish domesticated from wild bison. The International Union for Conservation of Nature's key is a "formal repeatable system of criteria for deciding which bison populations to include in the Red List Assessment" as a "wild" bison population).

> The meaning of the term wild may be inferred from the IUCN definition of the Red List category 'Extinct in the Wild': "a taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range . . .

Aune, Jørgensen, & Gates 2018 Supplemental Material (Table 1).

The International Union for Conservation of Nature's Red List Process key and criteria for classifying bison populations "functioning as wild" considers:

• the physical environment in which bison exist, including the range area within which a wild population "roams and is sustained by range resources without human-imposed spatial limits on movements,"
• that can sustain a functioning wild population exceeding 1,000 bison "in the range area without nutritional supplementation," and
• with "unrestricted access to resources within the entire range area."

Aune, Jørgensen, & Gates 2018 Supplemental Material at 1–5, *infra*.

The range area for bison populations includes a significant caveat and "excludes locations where population distributional limits are imposed for management purposes" outside the government-defined range area.

In addition to physical environment and range resources, the International Union for Conservation of Nature's criteria also consider "species patterns, (e.g. genetics, demography), reproductive and natural selection processes (e.g. mating system, resource competition, resource selection, predation), and social factors that may influence the persistence of a wild population (e.g. laws, policies, societal support)."

The International Union for Conservation of Nature's definition of a wild bison population includes the "patterns of adaptation and geographic variation arising from species formational processes and occurs in locations where ecological and socio-ecological conditions support reproductive and natural selection and continued evolution of the species in the long term (centuries)."

The criteria for a large sustainable population (>1,000 bison older than 1 year with a mature bull to female ratio of 20:100 or 1 bull for every 5 females) is disputed and contested by the best available science and evidence presented herein.

Of twelve assessed, two plains bison populations in the United States are classified as functioning as wild public: Yellowstone National Park and Grand Teton National Park/National Elk Refuge.

PHOTO: Joanne Murray

One plains bison population in Canada is classified as functioning as wild: Pink Mountain, located outside of the subspecies' indigenous range.

Two plains bison populations are classified as functioning as wild tribal: Apsáalooke (Crow Tribe), and the UTE Tribal–Book Cliffs population managed in cooperation with Utah.

According to the International Union for Conservation of Nature, a sustainable or large population normally exceeds 1,000 bison. Only the Apsáalooke (Crow Tribe) bison and Yellowstone bison meet the International Union for Conservation of Nature's criteria for a sustainable or large population.

Five wood bison populations in Canada, and none in the United States, are classified as functioning as wild:

- Hay-Zama, 1,750,027 acres with an increasing population of 644 bison.
- Greater Wood Buffalo National Park, 14,332,112 acres with a decreasing/stable population of 4,885 bison.
- Mackenzie Bison Sanctuary, 5,189,212 acres with a decreasing population of 714 bison.
- Nahanni, 2,891,132 acres with an increasing population of 431 bison.
- Aishihik, 2,718,159 acres with an increasing population of 1,470 bison.

Six bison herds representing almost two-thirds of the extant wild populations "are anchored by National Parks, Refuges or Sanctuaries" without which "the future survival of American bison would be in serious jeopardy." Aune, Jørgensen, & Gates 2018 at 2.

The International Union for Conservation of Nature classifies bison as "Near Threatened" in light of the species dependence on conservation programs "to persist beyond the next 5 years, a very limited number of viable populations (five), and large number of small (13 of 20 less than 400) isolated populations." Aune, Jørgensen, & Gates 2018 at 1.

Were active conservation programs to cease, the wildlife species would qualify for threatened status. Aune, Jørgensen, & Gates 2018 at 1.

Because of the total number of mature bison functioning as wild or semi-wild (11,248–13,123 individuals) in isolated populations, with few providing conditions for natural movements between subpopulations, and only four subpopulations with more than 1,000 individuals, the wildlife species nearly qualifies as "Vulnerable" and "considered to be facing a high risk of extinction in the wild." Aune, Jørgensen, & Gates 2018 at 1; International Union for Conservation of Nature 2012 at 15, 20–22.

The remainder of the continental bison population (97%) is held in private ownership and raised in captivity in commercially propagated market herds. Aune, Jørgensen, & Gates 2018 at 1.

The International Union for Conservation of Nature's Green Status Assessment, which examines the effectiveness of conservation actions towards a species recovery, scores bison as "Critically Depleted" as the migratory species is "Absent" from many ecological settings throughout their indigenous range. Rogers, Ranglack, & Plumb 2022 (finding the remaining population is "severely fragmented").

Conservation actions for a species is assessed "against three essential facets of recovery" identified by Akcakaya et al. 2018: fully recovered, viable, and performing ecological functions "in all parts" of the species' range. "These factors contribute towards a "Green Score" ranging from 0–100%, which shows how far a species is from its "fully recovered" state." International Union for Conservation of Nature 2022.

Akcakaya's framework for assessing the success or not of conservation actions towards a species recovery is relevant in determining bison's biological status as a wild species:

> 3 common dimensions of recovery have emerged (e.g., Sanderson 2006; Redford et al. 2011). One is viability as the minimal requirement for recognizing a species as recovered. A fully recovered species is viable. That is, it has the attributes necessary for long-term persistence (e.g., large, stable, healthy, genetically robust, replicated populations, which are demographically sustainable and resilient and have adaptive capacity) and therefore a very low risk of extinction. A second dimension of recovery is functionality. A fully recovered species exhibits the full range of its ecological interactions, functions, and other roles in the ecosystem. A third dimension is representation. A fully recovered species occurs in a representative set of ecosystems and communities throughout its range.

Akcakaya et al. 2018 at 1130.

Bison's "Green Score" is 17% with scientists foreseeing a "continuing decline in area, extent and/or quality of habitat" for the wild species. Rogers, Ranglack, & Plumb 2022.

Shaffer & Stein provide another framework for judging the science and evidence on bison's biological status by applying the conservation biology principles of representation, resiliency, and redundancy – "saving some of everything" and "saving enough to last" – to examine and investigate a species' condition. Shaffer & Stein 2000 at 308, 310.

In applying Shaffer & Stein's conservation biology principles to Yellowstone bison:

> Representation is saving distinct herds "in an array of different environments," and "the ecological and evolutionary patterns and processes" that allow for natural selection, adaptation, and reproduction in the wild.
>
> Redundancy is the ability to withstand catastrophic events by "having essential backups" elsewhere "as a hedge against the failure of any individual" distinct herd in the wild.
>
> Resiliency is the ability to withstand systematic pressures, random disturbances, and adverse events in protected habitats large enough to accommodate each distinct herd's dispersal and recovery in the wild.

The "ecologically extinct" status of the wildlife species (Freese et al. 2007 at 175) reflects the vast loss in the "array of different environments" and "ecological and evolutionary patterns and processes" (Shaffer & Stein 2000 at 308) that maintain and generate bison populations in the wild.

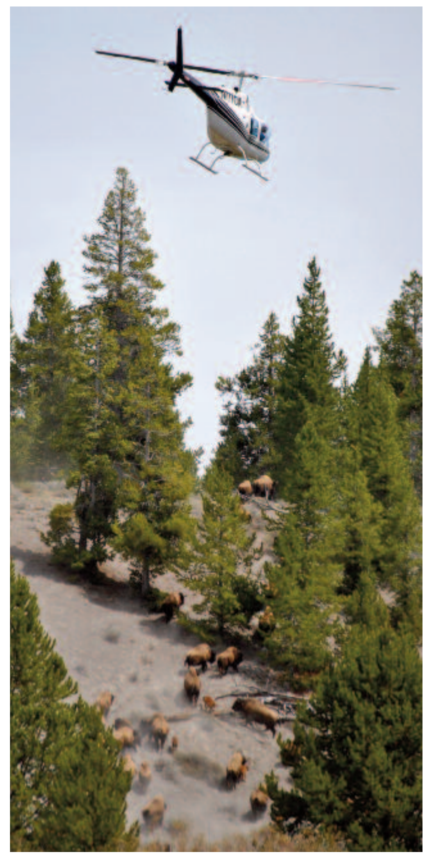


PHOTO: Jackson Doyel

The evidence detailed herein demonstrates ecological and evolutionary processes, natural selection, and adaptation in the wild have been undermined by a preponderance of artificial selection and domestication processes imposed by State and federal managers on Yellowstone bison.

State and federal government actions have decimated the Central bison herd, an indicator that one of the "essential backups" in the Yellowstone bison population is failing to recover from systematic pressures "sufficient to produce a population decline." Geremia 2022 at 5–6 (documenting a significant loss in the Central bison herd from 3,553 to 847 in the period 2005–2017); Shaffer & Stein 2000 at 309, 310 (if the "continuing, systematic pressure . . . cannot be relieved, the species will become extinct.").

Domestication of "conservation" herds is widespread and an ongoing threat to the natural adaptation and evolution of wild bison including Yellowstone's distinct bison herds.

As a whole, the condition of bison as a "wild" species is at risk.

Bailey's (2013) investigation of wildness in Yellowstone bison and other "conservation" herds found demonstrative evidence of "pervasive, ongoing domestication of the plains bison genome."

> This insidious threat is more serious than cattle-gene introgression. It is more serious than the loss of genetic diversity because gradual domestication is receiving less attention (and loss of genetic diversity is part of the domestication process). The brush with extinction is not

over. For more than 100 years, we have been slowly domesticating plains bison, leading to genetic extinction of the wild form.

Bailey 2013 at 197.

> [S]uccessful biodiversity conservation means saving more than the species themselves. It means saving the ecological and evolutionary patterns and processes that not only maintain but also generate those entities we call species. Because every species' genetic makeup is shaped, through natural selection, by the environments it has experienced, successful conservation also means saving populations of each species in the array of different environments in which it occurs.

Shaffer & Stein 2000 at 308.

> [B]iological systems need *redundancy* in the engineering sense of having essential backups in place to guard against complete system failure. . . . *resiliency* is also essential for the long-term survival of a species.
>
> . . .
>
> Virtually any factor that can bring a species to extinction can operate in one of two different ways, either as a systematic pressure or as a random perturbation.
>
> . . .
>
> Whether or not the species survives depends on the balance between its initial population size, the degree to which the random environmental factors depress population growth, and the duration of the unfavorable conditions.
>
> . . .
>
> Clearly, any species subjected to a continuing, systematic pressure sufficient to produce a population decline is not viable. If that pressure cannot be relieved, the species will become extinct. On the other hand, a species with a population growth rate that, on average, is positive, may or may not be viable. Its long-term survival depends on the number and size of its populations in relation to the types and amounts of random perturbations they are likely to experience.
>
> The relationship between habitat area and a species' population size and persistence has been demonstrated for an array of species on a variety of scales (Meffe and Carroll 1997). For example, Newmark (1995) documented a strong negative relationship between the size of 14 western North American national parks and the number of local mammal extinctions from those parks in the years since their establishment.
>
> . . .

> We do know that, all else being equal, the chances of maintaining a species at a site will increase as the size of the site increases. Further, we know that, all else being equal, the chances of maintaining a species overall will increase as the number of sites at which it is maintained increases. We can think of the size of sites as a measure of *resiliency*, and the number of sites as a measure of *redundancy*.
>
> Saving enough to last will require designing conservation sites that are large enough to support populations of the target species and that are resilient to the types of random perturbations inherent in the natural world. . . Saving enough to last will therefore also require protecting enough sites to provide the backup redundancy necessary as a hedge against the failure of any individual population.

Shaffer & Stein 2000 at 309–310 (emphasis in the original).

Bailey visited sites and gathered data reported in Boyd's (2003) status review for each known bison "conservation" herd.

Bailey's review of domesticating practices rating the status of wildness in bison "conservation" herds can be viewed as a reasonable measure of the migratory species' representation, resiliency, and redundancy.

Bailey's evaluation accounts for the ecological settings in which bison "conservation" herds still occur, the preponderance of human selection and lack of natural selection processes influencing bison's ability to adapt to environmental changes (representation), the size of sites available for bison to withstand stochastic disturbance events (resiliency), and the distribution and number of sites available for bison to withstand catastrophic events (redundancy).

Bailey based his criteria in part on a "scorecard" published by 28 bison biologists measuring the contributions of bison herds to the ecological recovery of the wildlife species. Bailey 2013 at 187.

Common threats Bailey found for bison include small, isolated populations (loss of connectivity); limited ranges and the lack of potential to expand ranges (a factor limiting population sizes); and perhaps more concerning of all, a preponderance of human selection processes (domestication), and loss of natural selection processes.

PHOTO: Jackson Doyel

According to Bailey's ecological and evolutionary baselines, a wild population requires a minimum of 500 square miles (320,000 acres) of range and 2,000 bison for each population or subpopulation where substructure is evident. Bailey 2013 at 80 ("Computer modeling suggests that a herd of 2000–3000 bison will lose an estimated 5% of its allelic diversity" every 100 years.).

Under Bailey's baseline, no "conservation" population remaining in the wild has reached or is maintained in a size where bison genetic diversity is not lost. Only Yellowstone's Northern herd exceeds 2,000 bison; the Central herd does not.

The range of Yellowstone bison exceeds 320,000 acres but is limited and reduced by State government actions in Montana, Idaho, and Wyoming, and federal government actions within the jurisdictions of Yellowstone National Park and National Forests in the region.

While the range of bison populations in the UTE Tribal–Book Cliffs and Grand Teton National Park/National Elk Refuge exceed 320,000 acres, "[h]erds with fewer than 2000–3000 have compromised evolutionary potentials." Bailey 2013 at 179.

Bailey identified forty-four "conservation" herds of 16,500 bison in their indigenous range in the United States, and reviewed twenty-eight herds with supplemented data from Boyd (2003), Dratch & Gogan (2010), site investigation and interview. Bailey 2013 at 179, 197.

Bailey found:

> Thirty four herds have 400 or fewer bison; of these herds, nineteen have fewer than 100 bison.
> Only four herds south of Canada have more than 1000 bison.
> Only the Yellowstone herd "is large enough to limit loss of genetic diversity to moderate levels in the long term."
>
> (Large bison herds allow evolved social and dominance relations and contributes to natural selection of wild characteristics in good times and bad).
>
> Eleven herds live on ranges of less than 1 square mile (640 acres).
> More than 60% of forty-four conservation herds have ranges of or less than 10 square miles (6,400 acres).
> Four herds have ranges of at least 100 square miles (64,000 acres) with caveats: Badlands includes much barren ground; Custer State Park is forested; Jackson is artificially fed; Yellowstone is mainly high elevation habitat.
>
> (Small ranges limit herd size, undermine ecological contributions and relationships, limit mobility, do not maintain natural selection, represent a major limiting factor for wildness, and are a major factor of domestication).
>
> Ranges of fourteen herds are subdivided by cross fencing to permit pasture rotation.
> Eight herds with more than 100 bison are managed with rotation grazing systems, much like domestic livestock.

(Pasture rotation constrains bison from selecting foraging habitat and creates unnatural foraging effects upon vegetation).

At least twenty-five herds are subject to annual, or more frequent, roundups and handling chutes.
At least eight more herds have less frequent roundups and handling in "squeeze" chutes.

(Roundups facilitate processes leading to domestication of bison).

Selective culling is routine in thirty-five herds; five more herds will likely be subject to selective culling once herd sizes are reached.
Few managers emphasize random culling or retention.
Bison are killed based on sex, age, size, appearance, and behavior.

(Selective culling is a major factor weakening or replacing natural selection).
(Inadvertent selection for characteristics based on genetically-linked traits is likely common).
(Bison are killed before the values of the fittest individuals are fully realized in natural selection).
(The distinct population segment of Yellowstone bison is subject to nonrandom and selective culling and roundups with an emphasis on killing bison carrying antibodies to *Brucella abortus*, although bison may not be infected and may be resistant to the cattle-introduced disease).

Only three herds are managed primarily by hunting.

(Hunting rules are rarely if ever based upon consideration of evolutionary effects).

Significant natural mortality was noted in six of twenty-eight herds.
Very few bison die of natural mortality in eighteen of twenty-eight herds.
Natural mortality is likely even less common in the remaining sixteen herds of small size.

Thirteen herds are routinely fed.
At least eight additional herds are fed during deep snows or drought.

(Natural selection for dominant, energy efficient bison is weakened in twenty-one herds).
(Unnatural concentration of bison and routine feeding increases rates of disease transmission and densities of disease organisms).

Seventeen herds are regularly vaccinated for diseases (from one to eight herds).
Vermicides to control parasites are used in many of the seventeen herds.

(Veterinary practices weaken natural selection for disease resistant bison and modify coevolution of disease organisms; outcomes for flora and fauna are unstudied and unknown).

Sixteen herds are managed with skewed or highly skewed sex ratios (adult bull to female ratios of 1:3 to 1:15).

(Selection leading to skewed sex ratios weakens or eliminates the natural selective value of bull competition, and female selection of mates is reduced or lost).

Only Yellowstone bison face significant natural predation by bears and wolves.

(Unlikely natural selection values of predation will be restored).
(Without predators, the value of and natural selection for acute senses in bison is diminished).

Twenty-eight herds are located in States (or parts of them) that do not recognize bison as wildlife but as livestock.

Bailey 2013 at 179, 182–186, 136, 83.

**Chart 11.1 Conservation herds of plains bison on native USA range, 2011**

| | Number of bison | Range (sq. mi.) |
|---|---|---|
| * Yellowstone NP, WY, MT | 3700 | 3500 |
| * Medano Ranch, TNC, CO | 2000 | 70 |
| * Tallgrass Preserve, TNC, OK | 1950 | 36 |
| * Custer SP, SD | 1100 | 110 |
| * Wichita Mtns, NWR, OK | 650 | 67 |
| * Badlands NP, SD | 600 | 100 |
| * Ft. Robinson, SP, NE | 500 | 5 |
| * Niobrara Valley, TNC, NE | 500 | 30 |
| * Antelope Island, UT | 500 | 43 |
| * Jackson Valley, WY | 500 | 110 |
| * Wind Cave NP, SD | 400 | 43 |
| * National Bison Range, MT | 350 | 29 |
| * T. Roosevelt NP South, ND | 350 | 72 |
| Clymer, TNC, TX | 320 | 2 |
| * Ordway Prairie, TNC, SD | 300 | 5 |
| ** Henry Mtns., UT | 300 | 45 |
| * Ft. Niobrara NWR, NE | 290 | 25 |
| * Konza Prairie, KS | 275 | 4 |
| Broken Kettle, TNC, IA | 250 | 4 |
| * Cross Ranch, TNC, ND | 200 | 6 |
| * Amer. Prairie Reserve, MT | 200 | 50 |
| * T. Roosevelt NP North, ND | 175 | 38 |
| * Maxwell State Reserve, KS | 165 | 4 |
| Land between Lakes, KY | 120 | 1 |
| ** Prairie SP, MO | 120 | 5 |

| | | | |
|---|---|---|---|
| * Tallgrass Nat. Preserve, KS | | 100 | 2 |
| Book Cliffs, UT | | 100 | uncertain |
| Neal Smith NWR, IA | | 71 | 3 |
| * Caprock SP, TX | | 62 | 1 |
| * Sully at Ft. Niobrara NWR, NE | | 61 | shared |
| Blue Mounds SP, MN | | 56 | 1 |
| ** Rocky Mtn. Arsenal, CO | | 55 | 4 |
| Smoky Valley, TNC, KS | | 45 | 5 |
| ** Genesee Park, CO | | 34 | 1 |
| Fermi Lab, IL | | 32 | <0.5 |
| ** Daniels Park, CO | | 28 | 1 |
| * Sandsage State Preserve, KS | | 20 | 6 |
| Sandhill State Wildl. Area, WI | | 15 | <0.5 |
| Hot Springs SP, WY | | 11 | 1 |
| Bear Butte SP, SD | | 11 | ? |
| Wildcat Hills State Recr. Area, NE | | 10 | 1 |
| Bear River SP, WY | | 8 | <0.5 |
| Sully's Hill NWR, ND | | 7 | 1 |
| Lame Johnny Creek, TNC, SD | | ? | for sale |
| | Total bison | 16,541 | Total range 4,432.5 |

* 24 herds visited in this study.
** 5 herds, managers contacted by mail in this study.
SP = State Park. NWR = National Wildlife Refuge. TNC = The Nature Conservancy.

Chart recreated from James A. Bailey, *Rating our Conservation Herds*, (Ch. 11 in *American Plains Bison Rewilding An Icon* Far Country Press, Sweetgrass Books 2013).

For a detailed summary of surveys on bison's conservation status, *see* factor 8.B.

Data from Bailey's (200) petition to list plains bison as threatened under the ESA, Boyd's (2003) status review of bison "conservation" herds, Dratch & Gogan's (2010) summary of genetic diversity in U.S. Dept. of the Interior bison herds, and Aune, Jørgensen & Gates' (2018) assessment of "free-ranging" bison populations is recreated in the following tables.

PHOTO: Jackson Doyel

**Table 1. Twenty one free-ranging bison populations for Red List Status Assessment 2017**
Aune, Jørgensen, & Gates, *American bison (Bison bison)*, Table 2, Supplemental Material (2018).

| Country (Subspp.) | Jurisdiction | Status | Managing Authority | Range Size | N | Trend |
|---|---|---|---|---|---|---|
| United States (Plains Bison) | Grand Teton National Park/National Elk Refuge | Functioning as wild | Federal/State | 360,000 | 825 | Decreasing |
| United States (Plains Bison) | Yellowstone National Park | Functioning as wild | Federal/State | 784,559 | 4,875 | Stable |
| Canada (Plains Bison) | Pink Mountain | Functioning as wild | Provincial | 790,737 | 877 | Stable |
| Canada (Wood Bison) | Hay–Zama | Functioning as wild | Provincial | 1,750,027 | 644 | Increasing |
| Canada (Wood Bison) | Greater Wood Buffalo National Park* | Functioning as wild | Federal Territorial | 14,332,112 | 4,885 | Decreasing/Stable |
| Canada (Wood Bison) | Mackenzie Bison Sanctuary | Functioning as wild | Territorial | 5,189,212 | 714 | Decreasing |
| Canada (Wood Bison) | Nahanni | Functioning as wild | Territorial | 2,891,132 | 431 | Increasing |
| Canada (Wood Bison) | Aishihik | Functioning as wild | Territorial | 2,718,159 | 1,470 | Increasing |
| United States (Plains Bison) | Delta Junction | Wild limited population | Provincial | 90,000 | 342 | Stable |
| United States (Plains Bison) | Farewell Lake | Wild limited population | State | 640,000 | 400 | Increasing |
| Canada (Wood Bison) | McCusker River | Wild limited population | Federal | 185,329 | 150 | Increasing |
| United States (Plains Bison) | House Rock State Wildlife Area–Grand Canyon NP | Wild limited population | State | 100,000 | 400 | Increasing |
| United States (Plains Bison) | Henry Mountains | Wild limited population | State | 300,000 | 325 | Increasing |
| Canada (Plains Bison) | Prince Albert National Park | Wild limited population | Federal | 185,329 | 244 | Decreasing |
| Canada (Wood Bison) | Etthithun Lake | Wild limited population | Provincial | 62,764 | 250 | Increasing |
| Canada (Wood Bison) | Chitek Lake | Wild limited population | Provincial | 939,000 | 300 | Increasing |
| Canada (Wood Bison) | Nordquist | Wild limited population | Provincial | 2,718,159 | 193 | Increasing |
| United States (Plains Bison) | Chitina | Wild limited population | State | 12,784 | 32 | Stable |
| United States (Plains Bison) | Copper River | Wild limited population | State | 12,874 | 143 | Increasing |
| United States (Plains Bison) | Crow Tribe** | Wild Tribal | Tribal | 22,000 | 1,000 | Stable |
| United States (Plains Bison) | UTE Tribal–Book Cliffs | Wild Tribal | Tribal/State | 1,471,000 | 600 | Increasing |

* Includes Slave River Lowlands, Ronald Lake, Wenzel Lake, and Wabasca.
** Corrected name of tribe with jurisdiction.

Range size is estimated in acres.

## Table 2. Summary of herd size and indicators of genetic diversity for U.S. Department of the Interior bison herds

Peter A. Dratch & Peter J.P. Gogan, *Bison Conservation Initiative, Bison Conservation Genetics Workshop: Report and Recommendations,* Table 1, (Natural Resource Report NPS/NRPC/BRMD/NRR–2010/257, National Park Service, Fort Collins, CO, Oct. 2010)
(after Halbert and Derr 2007a; Halbert et al. 2008; L. Jones, pers. comm. 2010, Robert Schnabel, pers. comm. 2010).

| Herd name (abbreviation) | Estimated population size | Introgression present[a] | Allelic richness[c] | Expected heterozygosity[d] | Average FST[e] | Unreplicated conservation unit[h] |
|---|---|---|---|---|---|---|
| Fort Niobrara National Wildlife Refuge (FN) – original herd | 90 | Yes | 4.23 | 65.1 | 0.106 | |
| Fort Niobrara National Wildlife Refuge (FNSH) – formerly located at Sullys Hill* | 61 | Suggested[b] | 3.91 | 59.9 | NA[f] | |
| Theodore Roosevelt National Park – North (TRN) | 312 | Yes | 3.16 | 52.2 | 0.139[g] | |
| Theodore Roosevelt National Park – South (TRS) | 371 | Yes | 3.8 | 58.2 | 0.111 | |
| National Bison Range (NBR) | 350 | Yes | 4.51 | 66.4 | 0.133 | Yes |
| Neal Smith National Wildlife Refuge (NS)** | 71 | Suggested[b] | 4.43 | 66.8 | | |
| Rocky Mountain Arsenal (RMA)*** | 44 | Suggested[b] | 4.44 | 64.2 | | |
| Wichita Mountains National Wildlife Refuge (WM) | 650 | Yes | 4.16 | 61.2 | 0.149 | Yes |
| Badlands National Park (BNP) | 875 | Yes | 3.86 | 57.8 | 0.107 | |
| Grand Teton National Park (GT) | 900 | Suggested[b] | 3.19 | 53.5 | NA[f] | |
| Wind Cave National Park (WC) | 350 | Suggested[b] | 4.29 | 65.2 | 0.123 | Yes |
| Yellowstone National Park (YNP) | 3000**** | None detected | 4.15 | 62.5 | 0.133 | Yes |

a Based on mitochondrial DNA typing following Ward et al. 1999 and a panel of 14 nuclear microsatellites following Halbert et al. 2005.
b Introgression was not directly detected in these herds using microsatellite markers, but it is highly suggested due to the source of the herd and/or initial testing using single nucleotide polymorphisms (Robert Schnabel, pers .comm.).
c RA, average of allelic richness values across markers; calculated based on a minimum sample size of 15 (El Mousadik and Petit 1996).
d HE, average expected heterozygosity (Nei 1987).
e FST averaged across clusters assigned by STRUCTURE (Evanno et al. 2005) analysis.
f These (composite) herds were assigned to multiple clusters. Average FST calculations not possible.
g The TRN herd is directly descended from the TRS herd, which was in turn derived directly from the FN herd. It is well-established from other indices that these three herds (TRN, TRS, and FN) are closely related. Drift has likely acted to drive allele frequencies within this herd and differentiation of this herd such that inflated average FST values are detected.
h Based on analysis of herd contribution to overall diversity, following Petit et al. 1998. These herds represent unique sources of bison diversity which is unreplicated among the DOI herds.

* The entire Sullys Hill herd was moved to Fort Niobrara NWR in 2006. They are maintained separately from the original Fort Niobrara herd.
** Based on genetic evaluation, in 2006, all bison at Neal Smith were donated to a local Native American tribe, and a new herd was established with 39 bison from the National Bison Range.
*** Established with bison from the National Bison Range in 2006–2007.
**** Yellowstone bison are of two distinct but closely related types (Halbert and Derr 2007b, Gardipee 2007).

**Table 3. Numerical status of plains bison conservation herds in North America**

Delaney P. Boyd, *Conservation of North American Bison: Status and Recommendations*, Table 5.1, (University of Calgary, April 2003).

| Herd | Location | Jurisdiction | Managing Authority | Population | Trend |
|---|---|---|---|---|---|
| **UNITED STATES** | | | | | |
| Badlands National Park | SD | Federal | US National Park Service* | 750 | Stable |
| Theodore Roosevelt National Park | ND | Federal | US National Park Service | 850 | Stable |
| Wind Cave National Park | SD | Federal | US National Park Service | 375 | Stable |
| Grand Teton National Park/National Elk Refuge | WY | Federal/State | US National Park Service; US Fish and Wildlife Service; WY Game and Fish Dept.* | 700 | Increasing |
| Yellowstone National Park | WY/MT | Federal/State | US NPS; USFS; USDA APHIS; MT Dept. of Livestock; MT Fish, Wildlife and Parks*[a] | 4000 | Stable |
| Fort Niobrara National Wildlife Refuge | NE | Federal | US Fish and Wildlife Service | 352 | Stable |
| National Bison Range | MT | Federal | US Fish and Wildlife Service | 400 | Stable |
| Neal Smith National Wildlife Refuge | IA | Federal | US Fish and Wildlife Service | 35 | Stable |
| Sullys Hill National Game Preserve | ND | Federal | US Fish and Wildlife Service | 37 | Stable |
| Wichita Mountains National Wildlife Refuge | OK | Federal | US Fish and Wildlife Service | 565 | Stable |
| Fermi National Accelerator Laboratory | IL | Federal | Department of Energy | 32 | Stable |
| Land Between the Lakes National Recreation Area | KY | Federal | USDA, Forest Service | 130 | Decreasing |
| Chitina | AK | State | Alaska Department of Fish and Game | 38 | Stable |
| Copper River | AK | State | Alaska Department of Fish and Game | 108 | Stable or Increasing |
| Delta Junction | AK | State | Alaska Department of Fish and Game | 360 | Stable |
| Farewell Lake | AK | State | Alaska Department of Fish and Game | 400 | Increasing |
| House Rock Wildlife Area | AZ | State | Arizona Game and Fish Department* | 217 | Increasing |
| Raymond Wildlife Area | AZ | State | Arizona Game and Fish Department | 72 | Stable |
| Antelope Island State Park | UT | State | Utah Department of Natural Resources, Division of Parks and Recreation | 600 | Stable |
| Blue Mounds State Park | MN | State | Minnesota Department of Natural Resources, Division of Parks and Recreation | 56 | Stable |
| Finney Game Refuge | KS | State | Kansas Department of Wildlife and Parks | 120 | Stable |
| Maxwell Wildlife Refuge | KS | State | Kansas Department of Wildlife and Parks | 230 | Stable |
| Prairie State Park | MO | State | Missouri Department of Natural Resources | 76 | Stable |
| Fort Robinson State Park | NE | State | Nebraska Game and Parks | 500 | Stable |
| Wildcat Hills State Recreation Area | NE | State | Nebraska Game and Parks | 10 | Stable |
| Custer State Park | SD | State | South Dakota Game Fish and Parks Department | 1100 | Stable |
| Caprock Canyons State Park/Texas State Bison Herd | TX | State | Texas Parks and Wildlife Department | 40 | Increasing |
| Henry Mountains | UT | State | Utah Division of Wildlife Resources | 279 | Stable |
| Sandhill Wildlife Area | WI | State | Wisconsin Department of Natural Resources | 15 | Stable |
| Bear River State Park | WY | State | Wyoming State Parks and Historic Sites | 8 | Stable |
| Hot Springs State Park | WY | State | Wyoming State Parks and Historic Sites | 11 | Stable |
| Konza Prairie Biological Station | KS | State/Foundation | Kansas State University, Division of Biology; The Nature Conservancy | 275 | Stable |
| Santa Catalina Island | CA | Foundation | Catalina Island Conservancy | 225 | Increasing |
| Cross Ranch Nature Preserve | ND | Foundation | The Nature Conservancy | 140 | Increasing |
| Medano-Zapata Ranch | CO | Foundation | The Nature Conservancy | 1500 | Decreasing |
| Niobrara Valley Preserve | NE | Foundation | The Nature Conservancy | 473 | Increasing |
| Ordway Prairie Preserve | SD | Foundation | The Nature Conservancy | 255 | Stable |
| Tallgrass Prairie Preserve | OK | Foundation | The Nature Conservancy | 1500 | Increasing |
| Clymer Meadow Preserve | TX | Foundation/Private | The Nature Conservancy; Private rancher | 320 | Stable |
| Smoky Valley Ranch | KS | Foundation | The Nature Conservancy | 45 | Stable |
| Daniels Park | CO | Municipal | Denver Parks and Recreation | 26 | Stable |
| Genesee Park | CO | Municipal | Denver Parks and Recreation | 26 | Stable |
| **CANADA** | | | | | |
| Camp Wainwright | AB | Federal | Department of National Defence | 16 | Stable |
| Elk Island National Park | AB | Federal | Parks Canada Agency | 430 | Stable |
| Prince Albert National Park | SK | Federal | Parks Canada Agency | 310 | Increasing |
| Riding Mountain National Park | MB | Federal | Parks Canada Agency | 33 | Increasing |
| Waterton Lakes National Park | AB | Federal | Parks Canada Agency | 27 | Stable |
| Primrose Lake Air Weapons Range (Cold Lake) | AB/SK | Federal/Provincial | Department of National Defence; Saskatchewan Environment, Fish and Wildlife Branch | 100 | Increasing |
| Pink Mountain | BC | Provincial | British Columbia Ministry of Water, Land and Air Protection* | 1000 | Stable |
| Buffalo Pound Provincial Park | SK | Provincial | Saskatchewan Environment, Parks Branch | 33 | Stable |

* Title of agency with managing authority is corrected.

a. The Record of Decision for the Bison Management Plan for the State of Montana and Yellowstone National Park includes the managing authorities of the U.S. Department of the Interior (National Park Service), the U.S. Department of Agriculture (Forest Service and Animal and Plant Health Inspection Service), and the State of Montana (Department of Livestock and Fish, Wildlife & Parks).

**Table 4. Plains Bison Conservation Herd Status Summary Tables**

Delaney P. Boyd, *Conservation of North American Bison: Status and Recommendations*, Appendix 1, (University of Calgary, April 2003).

| Herd | Location | Jurisdiction | Managing Authority | Population | Trend |
|---|---|---|---|---|---|
| **UNITED STATES** | | | | | |
| Badlands National Park | SD | Federal | US National Park Service* | 750 | Stable |
| Theodore Roosevelt National Park | ND | Federal | US National Park Service | 850 | Stable |
| Wind Cave National Park | SD | Federal | US National Park Service | 375 | Stable |
| Grand Teton National Park/National Elk Refuge | WY | Federal/State | US National Park Service; US Fish and Wildlife Service; WY Game and Fish Dept.* | 700 | Increasing |
| Yellowstone National Park | WY/MT | Federal/State | US NPS; USFS; USDA APHIS; MT Dept. of Livestock; MT Fish, Wildlife and Parks*[a] | 4000 | Stable |
| Fort Niobrara National Wildlife Refuge | NE | Federal | US Fish and Wildlife Service | 352 | Stable |
| National Bison Range | MT | Federal | US Fish and Wildlife Service | 400 | Stable |
| Neal Smith National Wildlife Refuge | IA | Federal | US Fish and Wildlife Service | 35 | Stable |
| Sullys Hill National Game Preserve | ND | Federal | US Fish and Wildlife Service | 37 | Stable |
| Wichita Mountains National Wildlife Refuge | OK | Federal | US Fish and Wildlife Service | 565 | Stable |
| Fermi National Accelerator Laboratory | IL | Federal | Department of Energy | 32 | Stable |
| Land Between the Lakes National Recreation Area | KY | Federal | USDA, Forest Service | 130 | Decreasing |
| Chitina | AK | State | Alaska Department of Fish and Game | 38 | Stable |
| Copper River | AK | State | Alaska Department of Fish and Game | 108 | Stable or Increasing |
| Delta Junction | AK | State | Alaska Department of Fish and Game | 360 | Stable |
| Farewell Lake | AK | State | Alaska Department of Fish and Game | 400 | Increasing |
| House Rock Wildlife Area | AZ | State | Arizona Game and Fish Department* | 217 | Increasing |
| Raymond Wildlife Area | AZ | State | Arizona Game and Fish Department | 72 | Stable |
| Antelope Island State Park | UT | State | Utah Department of Natural Resources, Division of Parks and Recreation | 600 | Stable |
| Blue Mounds State Park | MN | State | Minnesota Department of Natural Resources, Division of Parks and Recreation | 56 | Stable |
| Finney Game Refuge | KS | State | Kansas Department of Wildlife and Parks | 120 | Stable |
| Maxwell Wildlife Refuge | KS | State | Kansas Department of Wildlife and Parks | 230 | Stable |
| Prairie State Park | MO | State | Missouri Department of Natural Resources | 76 | Stable |
| Fort Robinson State Park | NE | State | Nebraska Game and Parks | 500 | Stable |
| Wildcat Hills State Recreation Area | NE | State | Nebraska Game and Parks | 10 | Stable |
| Custer State Park | SD | State | South Dakota Game Fish and Parks Department | 1100 | Stable |
| Caprock Canyons State Park/Texas State Bison Herd | TX | State | Texas Parks and Wildlife Department | 40 | Increasing |
| Henry Mountains | UT | State | Utah Division of Wildlife Resources | 279 | Stable |
| Sandhill Wildlife Area | WI | State | Wisconsin Department of Natural Resources | 15 | Stable |
| Bear River State Park | WY | State | Wyoming State Parks and Historic Sites | 8 | Stable |
| Hot Springs State Park | WY | State | Wyoming State Parks and Historic Sites | 11 | Stable |
| Konza Prairie Biological Station | KS | State/Foundation | Kansas State University, Division of Biology; The Nature Conservancy | 275 | Stable |
| Santa Catalina Island | CA | Foundation | Catalina Island Conservancy | 225 | Increasing |
| Cross Ranch Nature Preserve | ND | Foundation | The Nature Conservancy | 140 | Increasing |
| Medano-Zapata Ranch | CO | Foundation | The Nature Conservancy | 1500 | Decreasing |
| Niobrara Valley Preserve | NE | Foundation | The Nature Conservancy | 473 | Increasing |
| Ordway Prairie Preserve | SD | Foundation | The Nature Conservancy | 255 | Stable |
| Tallgrass Prairie Preserve | OK | Foundation | The Nature Conservancy | 1500 | Increasing |
| Clymer Meadow Preserve | TX | Foundation/Private | The Nature Conservancy; Private rancher | 320 | Stable |
| Smoky Valley Ranch | KS | Foundation | The Nature Conservancy | 45 | Stable |
| Daniels Park | CO | Municipal | Denver Parks and Recreation | 26 | Stable |
| Genesee Park | CO | Municipal | Denver Parks and Recreation | 26 | Stable |
| **CANADA** | | | | | |
| Camp Wainwright | AB | Federal | Department of National Defence | 16 | Stable |
| Elk Island National Park | AB | Federal | Parks Canada Agency | 430 | Stable |
| Prince Albert National Park | SK | Federal | Parks Canada Agency | 310 | Increasing |
| Riding Mountain National Park | MB | Federal | Parks Canada Agency | 33 | Increasing |
| Waterton Lakes National Park ) | AB | Federal | Parks Canada Agency | 27 | Stable |
| Primrose Lake Air Weapons Range (Cold Lake) | AB/SK | Federal/Provincial | Department of National Defence; Saskatchewan Environment, Fish and Wildlife Branch | 100 | Increasing |
| Pink Mountain | BC | Provincial | British Columbia Ministry of Water, Land and Air Protection* | 1000 | Stable |
| Buffalo Pound Provincial Park | SK | Provincial | Saskatchewan Environment, Parks Branch | 33 | Stable |

* Title of agency with managing authority is corrected.

** NA indicates the data was not available in Boyd's survey.

*** The trend for the Smoky Valley Ranch is stable in Table 5.1, while Appendix 1 indicates the trend is increasing.

a. The Record of Decision for the Bison Management Plan for the State of Montana and Yellowstone National Park includes the managing authorities of th e U.S. Department of the Interior (National Park Service),the U.S. Department of Agriculture (Forest Service and Animal and Plant Health Inspection Service), and the State of Montana (Department of Livestock and Fish, Wildlife & Parks).

**Table 5. Plains Bison Conservation Herd Status Summary Tables**

Delaney P. Boyd, *Conservation of North American Bison: Status and Recommendations*, Appendix 1, (University of Calgary, April 2003).

| Herd | Male:Female | Original Range? | Range area (km²) | Expansion potential | # founders | Origin | Genetics Management |
|---|---|---|---|---|---|---|---|
| **UNITED STATES** | | | | | | | |
| Badlands National Park | 1 to 1 | Yes | 259.2 | Yes – Active | 53 | Theodore Roosevelt National Park, Fort Niobrara NWR, private | DOI/TAMU study underway |
| Theodore Roosevelt National Park | 1 to 2 | Yes | 97.48 + 186.82 | None/None | 29 | Fort Niobrara NWR | TAMU study underway |
| Wind Cave National Park | 1 to 1 | Yes | 114.41 | Yes – Active | 20 | New York Zoo, Yellowstone National Park | TAMU study underway |
| Grand Teton National Park/National Elk Refuge | 1 to 1.2 | Yes | 750 | None | 16 | Theodore Roosevelt National Park, Yellowstone National Park | DOI/TAMU study underway |
| Yellowstone National Park | 1 to 1 | Yes | 9315 | None | 46 | 25 native, 3 Goodnight, 18 Allard | TAMU study underway |
| Fort Niobrara National Wildlife Refuge | 1 to 1 | Yes | 56.7 | Yes | 21 | Private, Yellowstone NP, Custer State Park, NBR | FWS study underway |
| National Bison Range | 1 to 1.2 | Yes | 74.93 | None | 38 | Private | FWS study underway |
| Neal Smith National Wildlife Refuge | 1 to 1 | Yes | 2.84 | Yes | 32 | NBR, Fort Niobrara NWR, Wichita Mountains NWR | FWS study underway |
| Sullys Hill National Game Preserve | 1 to 2 | Yes | 3.65 | None | 6 | Portland City Park, Oregon (1903) | None |
| Wichita Mountains National Wildlife Refuge | 1 to 1 | Yes | 174.19 | None | 15 | Fort Niobrara NWR, New York Zoo | FWS study underway |
| Fermi National Accelerator Laboratory | 1 to 10 | Yes | 0.28 | None | 12 | Private | Bull replacement |
| Land Between the Lakes National Recreation Area | 1 to 10 | Yes | 2.84 + 0.73 | Yes/None | ?/? | Theodore Roosevelt National Park | Bull replacement |
| Chitina | NA | No | 259 | Limited by winter range | 35 | Delta Junction AK (originally from National Bison Range) | None |
| Copper River | NA | No | 1036 | Limited by winter range | 17 | Delta Junction AK (originally from National Bison Range) | None |
| Delta Junction | 1 to 1.5 | No | 1087.8 | None | 22 | National Bison Range | None |
| Farewell Lake | NA | No | 7770 | Yes – Active | 38 | Delta Junction AK (originally from National Bison Range) | None |
| House Rock Wildlife Area | 1 to 1 | No | 243 | Yes | Unknown | Yellowstone National Park | Bull replacement |
| Raymond Wildlife Area | 1 to 1 | No | 60.75 | Yes | ~100 | House Rock Wildlife Area | Bull replacement |
| Antelope Island State Park | 1 to 5 | Peripheral | 113.4 | None | 12 | Private | Frequent introductions to improve diversity, selection to conserve rare allele |
| Blue Mounds State Park | NA | Yes | 2.59 | None | 3 | ? | Bull replacement |
| Finney Game Refuge | 1 to 7 | Yes | 14.86 | None | 11? | Wichita Mountains National Wildlife Refuge, Private | Bull replacement |
| Maxwell Wildlife Refuge | 1 to 3 | Yes | 9.11 | Yes – Active | 10 | Wichita Mountains National Wildlife Refuge | Bull replacement |
| Prairie State Park | 1 to 1.5 | Yes | 15.64 | Yes | 16 | Fort Niobrara NWR, Wichita Mountains NWR, Private | None |
| Fort Robinson State Park | 1 to 16 | Yes | 36.45 | Yes | ~28 | National Bison Range | Movement of animals among three separated herds |
| Wildcat Hills State Recreation Area | 1 to 1.5 | Yes | 1.46 | None | 5 | Private, Fort Niobrara NWR | None |
| Custer State Park | 1 to 7 | Yes | 287.55 | None | 36 + 60* | Private, Tribal, Wind Cave National Park | Selection for blood groups, bull replacement |
| Caprock Canyons State Park/Texas State Bison Herd | 1 to 10 | Yes | 1.34 | None | 32? | Goodnight | Managing to maintain unique diversity |
| Henry Mountains | 1 to 1.75 | Yes | 2590 | Yes | ~37–45 | Yellowstone National Park | None |
| Sandhill Wildlife Area | 1 to 1.5 | Peripheral | 1.01 | Yes | ~5 | State game farm | None |
| Bear River State Park | 1 to 8 | Yes | 0.2 | None | 8 | Hot Springs State Park | Trades with Hot Springs State Park |
| Hot Springs State Park | 1 to 4.5 | Yes | 2.84 | None | 16 | Yellowstone National Park, Kansas Botanical Gardens | Bull replacement, trades with Bear River State Park |
| Konza Prairie Biological Station | 1 to 1.7 | Yes | 10.04 | None | 48 | Fort Riley, Maxwell State Park, Private | Augmentation to supplement genetics |
| Santa Catalina Island | 1 to 2.5 | No | 129.5 | None | 24 | Private | None |
| Cross Ranch Nature Preserve | 1 to 2 | Yes | 12.39 | Yes – Active | 15 | Private (originally from Custer State Park) | Bulls culled at 6–8 years, bull replacement |
| Medano-Zapata Ranch | 1 to 5 | Yes | 182.25 | Yes | 20–100 | Private | Bull replacement |
| Niobrara Valley Preserve | 1 to 10 | Yes | 30.38 + 18.76 | None/Yes – Active | 55/132 | Private | Bull replacement |
| Ordway Prairie Preserve | 1 to 6 | Yes | 12.72 | Yes | <20 | Custer State Park, Private | Bull replacement, quality bull selection |
| Tallgrass Prairie Preserve | 1 to 2.3 | Yes | 58.32 | Yes – Active | 300 | Private | Bull replacement, quality bull selection |
| Clymer Meadow Preserve | NA | Yes | 4.86 | None | 40 | Private, Tallgrass Prairie Preserve | ? |
| Smoky Valley Ranch | 1 to 15 | Yes | 12.6 | Yes | NA | Private | None |
| Daniels Park | 1 to 12 | Yes | 3.24 | None | 7 | Genesse Park (originally from Yellowstone National Park) | Bull replacement, heifer trades with Genesee Park herd |
| Genesee Park | 1 to 12 | Yes | 2.03 | Yes | 7 | Yellowstone National Park | Bull replacement, heifer trades with Daniels Park herd |
| CANADA | | | | | | | |
| Camp Wainwright | 1 to 2 | Yes | 0.65 | Yes | 4 | Elk Island National Park | Bull replacement |
| Elk Island National Park | 1 to 1 | Yes | 140 | None | 50 | Pablo–Allard | None |
| Prince Albert National Park | NA | Yes | 500 | Yes – Active | 4 to 10 | Elk Island National Park | Opportunistic sampling to determine genetic diversity |
| Riding Mountain National Park | NA | Yes | 5 | None | ? | Elk Island National Park | Bull replacement |
| Waterton Lakes National Park | 1 to 2 | Yes | 2.02 | Yes – Active | 6 | Elk Island National Park | Bull replacement |
| Primrose Lake Air Weapons Range (Cold Lake) | NA | No | 10360 | Yes – Active | 17 | Elk Island National Park | None |
| Pink Mountain | NA | No | 2000 | Yes – Active | 41 | Elk Island National Park | None |
| Buffalo Pound Provincial Park | 1 to 10 | Yes | 1.92 | None | 10 | Elk Island National Park | Bull replacement, quality bull selection |

United States total original range: 14348.7 square kilometers (3,545,640 acres)
United States total peripheral range: 114.41 square kilometers (28,271 acres)
United States total outside original range: 10586.05 square kilometers (2,615,869 acres)

Canada total original range: 649.59 square kilometers (160,517 acres)
Canada total outside original range: 12360 square kilometers (3,054,222 acres)

*36 bison from Scotty Philip's herd, 60 from Pine Ridge Indian Reservation herd (source: https://gfp.sd.gov/csp-history/)

**Table 6. Plains Bison Conservation Herd Status Summary Tables**

Delaney P. Boyd, *Conservation of North American Bison: Status and Recommendations*, Appendix 1, (University of Calgary, April 2003).

| Herd | Selectively breed? | Genetic testing? | Hybrids with cattle? | Inbreeding signs? | Genetic defects? | Unique factors? | Regular augmentation? |
|---|---|---|---|---|---|---|---|
| **UNITED STATES** | | | | | | | |
| Badlands National Park | No | Yes | No | Yes | Yes | Unknown | No |
| Theodore Roosevelt National Park | No | Yes | No | No | No | No | No |
| Wind Cave National Park | No | Yes | No | No | No | Unknown | No |
| Grand Teton National Park/National Elk Refuge | No | Yes | No | No | No | Unknown | No |
| Yellowstone National Park | No | Yes | No | No | No | High diversity | No |
| Fort Niobrara National Wildlife Refuge | No | Yes | Yes | No | No | Unknown | No |
| National Bison Range | No | Yes | Yes | No | No | Unknown | No |
| Neal Smith National Wildlife Refuge | No | Yes | No | No | No | Unknown | Yes, within FWS Refuges |
| Sullys Hill National Game Preserve | No | No | Unknown | No | Unknown | Unknown | Yes |
| Wichita Mountains National Wildlife Refuge | No | Yes | No | No | No | Unknown | No |
| Fermi National Accelerator Laboratory | No | No | Unknown | No | Unknown | Unknown | Yes |
| Land Between the Lakes National Recreation Area | No | No | Unknown | No | Unknown | Unknown | Yes |
| Chitina | No | No | Unknown | Unknown | Unknown | Unknown | No |
| Copper River | No | No | Unknown | Unknown | Unknown | Three white calves in 24 years | No |
| Delta Junction | No | No | Unknown | No | Unknown | Unknown | Yes, escaped domestic bison have joined the herd |
| Farewell Lake | No | No | Unknown | No | Unknown | Unknown | No |
| House Rock Wildlife Area | No | No | Unknown | Unknown | Unknown | Unknown | Yes |
| Raymond Wildlife Area | No | No | Unknown | Unknown | Unknown | Unknown | Yes |
| Antelope Island State Park | No | Yes | Yes | None now, historically yes | No | Rare allele | Yes |
| Blue Mounds State Park | No | No | Unknown | Unknown | Unknown | Unknown | Yes |
| Finney Game Refuge | No | Yes | Yes | No | No | No | Yes |
| Maxwell Wildlife Refuge | No | Yes | Yes | No | No | Unknown | Yes |
| Prairie State Park | No | No | Unknown | Unknown | Unknown | Unknown | No |
| Fort Robinson State Park | No | No | Unknown | No | No | Unknown | No |
| Wildcat Hills State Recreation Area | No | No | Unknown | No | Unknown | Unknown | Trades with Fort Robinson State Park |
| Custer State Park | No | Yes | Yes | No | No | Hemoglobin ratio (80/20) | No |
| Caprock Canyons State Park/Texas State Bison Herd | Yes | Yes | Yes | No | No | Yes, diversity | Planned |
| Henry Mountains | No | No | No | No | No | Unknown | No |
| Sandhill Wildlife Area | No | No | Unknown | No | Unknown | Unknown | Yes |
| Bear River State Park | No | No | Unknown | No | Unknown | Unknown | Yes |
| Hot Springs State Park | No | No | Unknown | No | Unknown | Unknown | Yes |
| Konza Prairie Biological Station | No | No | Unknown | No | Rabbit-hocked legs in past | Unknown | Yes |
| Santa Catalina Island | No | No | Unknown | Possible | Unknown | Unknown | No |
| Cross Ranch Nature Preserve | No | No | Unknown | No | No | Unknown | Yes |
| Medano-Zapata Ranch | No | No | Unknown | No | Unknown | Unknown | Yes |
| Niobrara Valley Preserve | No | No | Unknown | No | Unknown | Unknown | Yes, within TNC herds |
| Ordway Prairie Preserve | No | No | Unknown | No | Unknown | Unknown | Yes |
| Tallgrass Prairie Preserve | No | No | Unknown | No | Unknown | Unknown | Yes |
| Clymer Meadow Preserve | ? | ? | ? | ? | ? | ? | ? |
| Smoky Valley Ranch | No | No | Unknown | No | Unknown | Unknown | No |
| Daniels Park | No | No | Unknown | No | Unknown | Unknown | Yes |
| Genesee Park | No | No | Unknown | No | Unknown | Unknown | Yes |
| **CANADA** | | | | | | | |
| Camp Wainwright | No | No | Unknown | No | No | Unknown | Yes |
| Elk Island National Park | No | Yes | No | No | No | No | No |
| Prince Albert National Park | No | In progress | Unknown | No | Unknown | Unknown | No |
| Riding Mountain National Park | No | No | Unknown | No | No | Unknown | Yes |
| Waterton Lakes National Park | No | No | Unknown | No | No | Unknown | Yes |
| Primrose Lake Air Weapons Range (Cold Lake) | No | No | Unknown | Unknown | Unknown | Unknown | No |
| Pink Mountain | No | No | Unknown | No | Unknown | Unknown | No |
| Buffalo Pound Provincial Park | No | No | Unknown | No | Unknown | Unknown | Yes |

## Table 7.A. Plains Bison Conservation Herd Status Summary Tables

Delaney P. Boyd, *Conservation of North American Bison: Status and Recommendations*, Appendix 1, (University of Calgary, April 2003).

| Herd | Range management | Fencing | Predation |
|---|---|---|---|
| **UNITED STATES** | | | |
| Badlands National Park | Open | Perimeter | Mountain lions |
| Theodore Roosevelt National Park | Open | Perimeter | Mountain lions |
| Wind Cave National Park | Open | Perimeter | None |
| Grand Teton National Park/National Elk Refuge | Open | None | Wolves and grizzly bears |
| Yellowstone National Park | Open | None | Wolves and grizzly bears |
| Fort Niobrara National Wildlife Refuge | 17-unit pasture rotation every 4–7 days | Perimeter and cross | Coyotes |
| National Bison Range | Rotational | Perimeter and cross | Unknown |
| Neal Smith National Wildlife Refuge | Open | Perimeter | None |
| Sullys Hill National Game Preserve | Open | Perimeter | None |
| Wichita Mountains National Wildlife Refuge | Three pastures | Perimeter and cross | Coyotes |
| Fermi National Accelerator Laboratory | Fenced pasture | Perimeter and cross | None |
| Land Between the Lakes National Recreation Area | Open/Pastures | Perimeter/Perimeter and cross | None |
| Chitina | Open | None | Wolves and grizzly bears |
| Copper River | Open | None | Wolves and grizzly bears |
| Delta Junction | Open | None | Wolves and grizzly bears |
| Farewell Lake | Open | None | Wolves and grizzly bears |
| House Rock Wildlife Area | Open | Only on BLM boundary | None |
| Raymond Wildlife Area | Open | Perimeter | None |
| Antelope Island State Park | Open | None | Coyotes |
| Blue Mounds State Park | Rotated through pastures | Perimeter and cross | None |
| Finney Game Refuge | Rotation through 3 pastures | Perimeter and cross | None |
| Maxwell Wildlife Refuge | Open | Perimeter | None |
| Prairie State Park | Rotated through 4 pastures, mature bulls separate | Perimeter and electric cross | None |
| Fort Robinson State Park | Three pastures | Perimeter and cross | None |
| Wildcat Hills State Recreation Area | Open | Perimeter | None |
| Custer State Park | Some pasture rotation | Perimeter and cross | Mountain lions |
| Caprock Canyons State Park/Texas State Bison Herd | Two pastures, males and females | Perimeter and cross | None |
| Henry Mountains | Open | None | Mountain lions |
| Sandhill Wildlife Area | Open, except as required for management of other species | Perimeter and cross with gates open | None |
| Bear River State Park | Open | Perimeter | None |
| Hot Springs State Park | Open | Perimeter | None |
| Konza Prairie Biological Station | Rotated by burn regimes | Perimeter and cross (with gates open) | None |
| Santa Catalina Island | Open | Cross fencing for other purposes | None |
| Cross Ranch Nature Preserve | Two pastures | Perimeter and cross | None |
| Medano-Zapata Ranch | Open | Perimeter | Coyotes, mountain lions, black bears, bobcats |
| Niobrara Valley Preserve | Open | Perimeter | None |
| Ordway Prairie Preserve | Open | Perimeter | Coyotes |
| Tallgrass Prairie Preserve | Open | Perimeter | None |
| Clymer Meadow Preserve | Rotated through pastures | Perimeter and cross | None |
| Smoky Valley Ranch | Open | Perimeter | None |
| Daniels Park | Some rotation during dry seasons | Perimeter and cross | Mountain lions. Black bears, coyotes |
| Genesee Park | Some rotation during dry seasons | Perimeter and cross | Mountain lions, black bears, coyotes |
| **CANADA** | | | |
| Camp Wainwright | Pasture rotation | Perimeter and cross | None |
| Elk Island National Park | Open | Perimeter | None |
| Prince Albert National Park | Open | None | Wolves |
| Riding Mountain National Park | Winter-summer rotation through two pastures | Perimeter and cross | None |
| Waterton Lakes National Park | Winter-summer rotation through two pastures | Perimeter and cross | None |
| Primrose Lake Air Weapons Range (Cold Lake) | Open | None | Wolves and grizzly bears |
| Pink Mountain | Open | None | Wolves and grizzly bears |
| Buffalo Pound Provincial Park | Two pastures with no rotation | Perimeter and cross | None |

## Table 7.B. Plains Bison Conservation Herd Status Summary Tables

Delaney P. Boyd, *Conservation of North American Bison: Status and Recommendations*, Appendix 1, (University of Calgary, April 2003).

| Herd | Supplemental feed? | Round-ups |
|---|---|---|
| **UNITED STATES** | | |
| Badlands National Park | No | Opportunistic when carrying capacity reaches 1/3 |
| Theodore Roosevelt National Park | No | Every 3 years |
| Wind Cave National Park | No | Annual |
| Grand Teton National Park/National Elk Refuge | Yes, 70 days in winter | No |
| Yellowstone National Park | No | Periodic trappings |
| Fort Niobrara National Wildlife Refuge | No | Annual |
| National Bison Range | No | Annual |
| Neal Smith National Wildlife Refuge | No | Annual |
| Sullys Hill National Game Preserve | Yes, winter | No |
| Wichita Mountains National Wildlife Refuge | No | Annual |
| Fermi National Accelerator Laboratory | Yes, winter | Annual |
| Land Between the Lakes National Recreation Area | No/No | Annual |
| Chitina | No | No |
| Copper River | No | No |
| Delta Junction | Fall/winter forage is grown to deter the herd from moving into agricultural areas | No |
| Farewell Lake | No | No |
| House Rock Wildlife Area | No feed. Water is provided by pipeline | No |
| Raymond Wildlife Area | No | No |
| Antelope Island State Park | No | Annual |
| Blue Mounds State Park | Yes, winter | Annual |
| Finney Game Refuge | Yes, winter and drought | Annual |
| Maxwell Wildlife Refuge | Yes | Annual |
| Prairie State Park | Yes, if hard winter | Annual |
| Fort Robinson State Park | Yes, if snow is deep | Annual |
| Wildcat Hills State Recreation Area | Yes, winter | Every 2 years |
| Custer State Park | No | Twice annually |
| Caprock Canyons State Park/Texas State Bison Herd | Yes | Annual |
| Henry Mountains | No | No |
| Sandhill Wildlife Area | Yes, winter | Annual |
| Bear River State Park | Yes | 2–3 times annually |
| Hot Springs State Park | Yes | 2–3 times annually |
| Konza Prairie Biological Station | No | Annual |
| Santa Catalina Island | No | Every 2 years |
| Cross Ranch Nature Preserve | No | Annual |
| Medano-Zapata Ranch | No | Annual |
| Niobrara Valley Preserve | No | Annual |
| Ordway Prairie Preserve | Yes, if hard winter | Annual |
| Tallgrass Prairie Preserve | No | Annual |
| Clymer Meadow Preserve | ? | Yes |
| Smoky Valley Ranch | No | Yes |
| Daniels Park | Yes, 6 months/year | Annual |
| Genesee Park | Yes, 6 months/year | Annual |
| **CANADA** | | |
| Camp Wainwright | Yes, winter | Annual |
| Elk Island National Park | No | Annual |
| Prince Albert National Park | No | No |
| Riding Mountain National Park | No | Annual |
| Waterton Lakes National Park | Yes, if harsh winter | Every 2 years |
| Primrose Lake Air Weapons Range (Cold Lake) | No | No |
| Pink Mountain | No | No |
| Buffalo Pound Provincial Park | Yes, winter | Annual |

**Table 7.C. Plains Bison Conservation Herd Status Summary Tables**

Delaney P. Boyd, *Conservation of North American Bison: Status and Recommendations*, Appendix 1, (University of Calgary, April 2003).

| Herd | Culling | Disposal |
|---|---|---|
| **UNITED STATES** | | |
| Badlands National Park | Random, opportunistic | MOU with native tribe |
| Theodore Roosevelt National Park | Selection by age class | Bureau of Indian Affairs brokers animals to tribes |
| Wind Cave National Park | Selection by age class | Dispersal to Native tribes, and state and federal agencies at cost |
| Grand Teton National Park/National Elk Refuge | Not since 1996, except hunting on state lands | Hunting on state lands only; population control measures currently in litigation |
| Yellowstone National Park | Opportunistic selection for disease management | Shipped live to Native tribes for slaughter |
| Fort Niobrara National Wildlife Refuge | Selection by age class, weight, appearance, condition, health, reproductive success | Live sales, donations |
| National Bison Range | Random selection by age class, health | Live sales, transfers to native tribes |
| Neal Smith National Wildlife Refuge | Selection for genetics, appearance | ? |
| Sullys Hill National Game Preserve | Selection by age class | Sales to non-profit groups at cost |
| Wichita Mountains National Wildlife Refuge | Selection by age class; random selection for calves, injured | Live sales, ITBC for cost |
| Fermi National Accelerator Laboratory | All calves | Live sales |
| Land Between the Lakes National Recreation Area | All calves, animals that calve late. Injured, appearance | Live sales, sealed bids |
| Chitina | No culling | Hunting |
| Copper River | No culling | Hunting |
| Delta Junction | No culling | Hunting |
| Farewell Lake | No culling | Hunting |
| House Rock Wildlife Area | No culling. Hunters make selection decisions | Hunting |
| Raymond Wildlife Area | Hunters make selection decisions | Hunting |
| Antelope Island State Park | Selection by age class | Live sales, hunting |
| Blue Mounds State Park | Selection by age class | Live sales |
| Finney Game Refuge | Selection by age class, condition, conformation, appearance | Live sales |
| Maxwell Wildlife Refuge | Selection for conformation, animals that produce early spring calves | Private sales, slaughter for special events, trades with government herds |
| Prairie State Park | Selection by age class | Live sales |
| Fort Robinson State Park | Selection by age class, appearance, conformation | Live sales, slaughter as meat for restaurant |
| Wildcat Hills State Recreation Area | All calves, old bulls, age class, selection by bull size and appearance | Live sales, slaughter as meat for restaurant |
| Custer State Park | Selection by age class, fertility, weight | Live sales, sealed bids, CSP meat company contract, hunting |
| Caprock Canyons State Park/Texas State Bison Herd | No culling | NA |
| Henry Mountains | Random through hunting permits | Hunting |
| Sandhill Wildlife Area | Selection by age class | Exchanges, donations |
| Bear River State Park | All calves | Live sales |
| Hot Springs State Park | Selection by age class, calves, temperament | Live sales |
| Konza Prairie Biological Station | Selection by age class, favour newly introduced bulls to allow for change in breeding dominance | Live sales |
| Santa Catalina Island | No system | Shipped to mainland on pre-arranged contracts |
| Cross Ranch Nature Preserve | Selection by age class, health, appearance | Live sales, field cull |
| Medano-Zapata Ranch | Selection by age class | Private sales, video auctions |
| Niobrara Valley Preserve | Selection by age class | Live sales, individual sales, sealed bids, hunting |
| Ordway Prairie Preserve | Selection by age class | Live sales, private sales |
| Tallgrass Prairie Preserve | Selection to mimic historic predators, deformed | Live sales, sealed bids, private sales |
| Clymer Meadow Preserve | ? | ? |
| Smoky Valley Ranch | Criteria under development | Under development |
| Daniels Park | Selection by age class | Live sales |
| Genesee Park | Selection by age class | Live sales |
| **CANADA** | | |
| Camp Wainwright | Selection to avoid inbreeding | Live sales |
| Elk Island National Park | Selection by age class | Live sales, conservation reintroduction projects |
| Prince Albert National Park | No culling | Some hunting by Natives outside the park |
| Riding Mountain National Park | Selection by age class | Live sales |
| Waterton Lakes National Park | Random, opportunistic | Live sales |
| Primrose Lake Air Weapons Range (Cold Lake) | No culling | Hunting |
| Pink Mountain | No culling | Hunting |
| Buffalo Pound Provincial Park | All calves, selection by age class | Private sales |

**Table 8. Plains Bison Conservation Herd Status Summary Tables**

Delaney P. Boyd, *Conservation of North American Bison: Status and Recommendations*, Appendix 1, (University of Calgary, April 2003).

| Herd | Disease presence | Disease testing | Vaccination | Parasite treatment |
|---|---|---|---|---|
| **UNITED STATES** | | | | |
| Badlands National Park | None | During round-ups | brucellosis | As required by vet |
| Theodore Roosevelt National Park | None | All animals during round-ups | No | No |
| Wind Cave National Park | None | All animals during round-ups | No | No |
| Grand Teton National Park/National Elk Refuge | Brucellosis, Bovine Viral Diarrhea | Opportunistic | No | No |
| Yellowstone National Park | Brucellosis | Opportunistic | No, Under consideration | No |
| Fort Niobrara National Wildlife Refuge | None | Sale animals | hemorrhagic septicaemia, blackleg, malignant edema | No |
| National Bison Range | Johne's | Annually plus symptomatic animals | No | No |
| Neal Smith National Wildlife Refuge | None | All animals during round-ups | No | No |
| Sullys Hill National Game Preserve | None | Yes, all animals annually | as required by state vet | as required by state vet |
| Wichita Mountains National Wildlife Refuge | None | Sale animals | sale animals | Every few years |
| Fermi National Accelerator Laboratory | None | Annually | brucellosis | Yes, annually |
| Land Between the Lakes National Recreation Area | None | Sale animals | 7-way on sale animals | Yes |
| Chitina | None | No | No | No |
| Copper River | None | No | No | No |
| Delta Junction | Parainfluenza 3 | Yes, blood samples from hunters | No | No |
| Farewell Lake | None | No | No | No |
| House Rock Wildlife Area | None | Opportunistic from samples collected by hunters | No | No |
| Raymond Wildlife Area | None | Yes, blood samples from hunters | No | No |
| Antelope Island State Park | None | Sale animals | brucellosis | Yes |
| Blue Mounds State Park | None | TB, annually | No | ? |
| Finney Game Refuge | None | Sale animals | brucellosis on sale animals | No |
| Maxwell Wildlife Refuge | None | Sale animals | No | No |
| Prairie State Park | None | All animals during round-ups | as required by state vet | as required by state vet |
| Fort Robinson State Park | None | Sale animals | brucellosis | No |
| Wildcat Hills State Recreation Area | None | Yes | No | No |
| Custer State Park | None | Sale animals | brucellosis, 7-way, pink eye | Calves wormed |
| Caprock Canyons State Park/Texas State Bison Herd | None | Yes, all animals annually | Yes, all animals annually | Yes, all animals annually |
| Henry Mountains | None | Opportunistic from samples collected by hunters | No | If outbreak detected |
| Sandhill Wildlife Area | None | Visual inspection annually | No | Yes |
| Bear River State Park | None | No | Yes, on remaining animals | Yes, remaining animals annually |
| Hot Springs State Park | None | No | Yes, brucellosis on remaining animals | Yes |
| Konza Prairie Biological Station | None | Sale animals | brucellosis | No |
| Santa Catalina Island | None | All animals during round-ups | sale animals | No |
| Cross Ranch Nature Preserve | None | Sale animals | brucellosis | Annual testing, no treatment required to date |
| Medano-Zapata Ranch | None | Sale animals for brucellosis and TB | brucellosis | Yes |
| Niobrara Valley Preserve | None | Sale animals | brucellosis | Yes |
| Ordway Prairie Preserve | None | Sale animals | brucellosis | Yes |
| Tallgrass Prairie Preserve | None | Subsample for anaplasmosis (1999–2000) | Yes | Yes |
| Clymer Meadow Preserve | None | Yes | Yes | As needed |
| Smoky Valley Ranch | None | Yes | Yes | As needed |
| Daniels Park | None | Sale animals | 8-way | Sale animals treated |
| Genesee Park | None | Sale animals | 8-way | Sale animals treated |
| **CANADA** | | | | |
| Camp Wainwright | None | Yes, biannually | Yes | Yes |
| Elk Island National Park | BVD episode in 96–97 (treated) | Annually for TB and brucellosis, 25% of herd | Yes | On surplus animals |
| Prince Albert National Park | One case of BVD (1997) (treated) | Opportunistic | No | No |
| Riding Mountain National Park | None | Yes, annually | Yes | No |
| Waterton Lakes National Park | None | Whole herd every 5 years | No | No |
| Primrose Lake Air Weapons Range (Cold Lake) | Unknown | No | No | No |
| Pink Mountain | None | Yes, blood samples from hunters | No | No |
| Buffalo Pound Provincial Park | None | Yes on sale animals | Yes | Yes, all animals |

**Table 9. Threats and limits for wild plains bison in the Northern Great Plains Ecoregion**
James A. Bailey & Natalie A. Bailey, *Petition to list plains bison as threatened under the ESA*, (June 19, 2009).

Each cell with an entry indicates a factor threatening or limiting genetic diversity in the foreseeable future; and/or limiting ecological effectiveness of bison. (2000 bison is a standard for maintaining genetic diversity and allowing continued evolution in a diverse environment. 500 sq. miles of range is a standard for maintaining genetic diversity and allowing ecological effectiveness of bison in grassland ecosystems.)

| Herd | Population | Range | | | Anthropogenic Selection | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bison Herd** | **Population <2000 bison** | **Range <500 sq. miles** | **Expand Potential?** | **Cattle Hybrids?** | **Roundups** | **Selective Culling** | **No Predators** | **Pasture Rotation** | **Suppl. Feed** | **Sex Ratio <1M:2F** | **Vaccinations** | **Priority in St CWCS[3]** |
| Badlands | 750 | 100 | | | Yes | Yes | | | | | Yes | No |
| Blue M SP | 56[1] | 1 | No | ? | Yes | Yes | X | X | Yes | ? | | No |
| Cross R. | 140 | 5 | | ? | Yes | Yes | X | X | | | Yes | No |
| Custer SP | 1100 | 111 | No | Yes | Yes | Yes | | X | | 1:07 | Yes | No |
| Ft. Niobr. | 352 | 22 | | Yes | Yes | Yes | | X | | | Yes | |
| Ft. Robin. | 500 | 14 | | ? | Yes | Yes | X | X | Yes | 1:16 | Yes | |
| Hot Spr. | 11 | 1 | No | ? | Yes | Yes | X | | Yes | 1:04 | Yes | No |
| Niobrara V | 473 | 19 | | ? | Yes | Yes | X | | | 1:10 | Yes | |
| Ordway P | 255 | 5 | | ? | Yes | Yes | | | Yes | 1:06 | Yes | No |
| Sully's H. | 37[1] | 2 | No | ? | | Yes | X | | Yes | | | No |
| T Roos NP | 850[2] | 110[2] | No[2] | | Yes | Yes | | | | | | No |
| Wildcat H | 10[1] | <1 | No | ? | Yes | Yes | X | | Yes | | | |
| Wind C NP | 375 | 44 | | | Yes | Yes | X | | | | | No |

1 Herd initiated with < 15 founders.

2 Theodore Roosevelt National Park: There are 2 units of range; 38 sq. miles with 250 bison and 72 sq. miles with 600 bison.
No potential for expansion under current policies; but TRNP is surrounded by much public land.

3 Comprehensive Wildlife Conservation Strategy for the state in which the herd is located.
No priority indicates the state has no plans or program for restoring wild bison.

**Table 10. Threats and limits for wild plains bison in the Southern Great Plains Ecoregion**
James A. Bailey & Natalie A. Bailey, *Petition to list plains bison as threatened under the ESA,* (June 19, 2009).

Each cell with an entry indicates a factor threatening or limiting genetic diversity in the foreseeable future; and/or limiting ecological effectiveness of bison. (2000 bison is a standard for maintaining genetic diversity and allowing continued evolution in a diverse environment. 500 sq. miles of range is a standard for maintaining genetic diversity and allowing ecological effectiveness of bison in grassland ecosystems.)

| Herd | Population | Range | Anthropogenic Selection | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bison Herd** | **Population <2000 bison** | **Range <500 sq. miles** | **Expand Potential?** | **Cattle Hybrids?** | **Roundups** | **Selective Culling** | **No Predators** | **Pasture Rotation** | **Suppl. Feed** | **Sex Ratio <1M:2F** | **Vaccinations** | **Priority in St CWCS[3]** |
| Caprock | 40 | <1 | No | Yes | Yes | | X | X | Yes | 1:10 | Yes | No |
| Clymer M. | 320 | 2 | No | ? | Yes | ? | X | X | ? | ? | Yes | No |
| Finney GR | 20 [1] | 6 | No | Yes | Yes | Yes | X | X | Yes | 1:7 | | No |
| Konza Pr. | 275 | 4 | No | ? | Yes | Yes | X | X | | | Yes | No |
| Maxwell R | 230 [1] | 4 | | Yes | Yes | Yes | X | | Yes | 1:3 | | No |
| Prairie SP | 76 | 6 | | ? | Yes | Yes | X | X | Yes | | Yes | No |
| Smokey V. | 45 | 5 | | ? | Yes | Yes [2] | X | | | 1:15 | Yes | No |
| Tallgrass P | 1500 | 23 | | ? | Yes | Yes | X | | | | Yes | No |
| Wichita M | 565 | 67 | No | | Yes | Yes | | X | | | | No |

[1] Herd initiated with < 15 founders.

[2] Smokey Valley Ranch: reports no selective culling in Boyd (2003), but based on herd sex ratio, this cell was checked.

[3] Comprehensive Wildlife Conservation Strategy for the state in which the herd is located.
No priority indicates the state has no plans or program for restoring wild bison.

**Table 11. Threats and limits for wild plains bison in the Rocky Mountain Ecoregion**
James A. Bailey & Natalie A. Bailey, *Petition to list plains bison as threatened under the ESA*, (June 19, 2009).

Each cell with an entry indicates a factor threatening or limiting genetic diversity in the foreseeable future; and/or limiting ecological effectiveness of bison. (2000 bison is a standard for maintaining genetic diversity and allowing continued evolution in a diverse environment. 500 sq. miles of range is a standard for maintaining genetic diversity and allowing ecological effectiveness of bison in grassland ecosystems.)

| Herd | Population | Range | Anthropogenic Selection | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bison Herd** | **Population <2000 bison** | **Range <500 sq. miles** | **Expand Potential?** | **Cattle Hybrids?** | **Roundups** | **Selective Culling** | **No Predators** | **Pasture Rotation** | **Suppl. Feed** | **Sex Ratio <1M:2F** | **Vaccinations** | **Priority in St CWCS [4]** |
| Daniels P. | 26 [1] | 1 | No | ? | Yes | Yes | | Yes | Yes | 1:12 | Yes | No |
| Genesee | 26 [1] | 1 | | ? | Yes | Yes | | Yes | Yes | 1:12 | Yes | No |
| Gr. Teton | 700 | 290 | No | | | | | | Yes | | | No |
| M/Zapata | 1500 [2] | 70 | | ? | Yes | Yes | | | | 1:5 | Yes | No |
| Nat B. Rge | 400 [3] | 29 | No | Yes | Yes | Yes | ? | Yes | | | | |
| YNP | * | | 1/ | | | 1/ | | | 1/ | | | |

[1] 1 Herd initiated with <15 founders.

[2] Medano/Zapata Ranch herd objective is 1100.

[3] National Bison Range herd is listed as a "display herd" in Montana law.

4 Comprehensive Wildlife Conservation Strategy for the state in which the herd is located.
No priority indicates the state has no plans or programs for restoring wild bison.

* Yellowstone NP: Late winter 2009 census is 2900 bison, with 2 subpopulations, needing up to 2000 bison each for genetic security.

1/ Yellowstone NP herd: Expansion limited by Montana brucellosis risk management
In some years many animals have been culled for brucellosis risk management.
In some years up to 200 bison are held and fed during winter.
The Park herd is managed by MT Dept. of Livestock when in Montana.

**Table 12. Threats and limits for wild plains bison in the Great Basin/Colorado Plateau Ecoregion**
James A. Bailey & Natalie A. Bailey, *Petition to list plains bison as threatened under the ESA,* (June 19, 2009).

Each cell with an entry indicates a factor threatening or limiting genetic diversity in the foreseeable future; and/or limiting ecological effectiveness of bison. (2000 bison is a standard for maintaining genetic diversity and allowing continued evolution in a diverse environment. 500 sq. miles of range is a standard for maintaining genetic diversity and allowing ecological effectiveness of bison in grassland ecosystems.)

| Herd | Population | Range | | Anthropogenic Selection | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bison Herd** | **Population <2000 bison** | **Range <500 sq. miles** | **Expand Potential?** | **Cattle Hybrids?** | **Roundups** | **Selective Culling** | **No Predators** | **Pasture Rotation** | **Suppl. Feed** | **Sex Ratio <1M:2F** | **Vaccinations** | **Priority in St CWCS [5]** |
| Antelope I | 600 [1] | 44 [2] | No | Yes | Yes | Yes | | | | 1:05 | Yes | No |
| Bear R. SP | 8 [1] | 1 | No | ? | Yes | Yes | X | | Yes | 1:08 | Yes | No |
| Henry Mts | 279 | 469 [3] | | | | | | | | | | No |
| House R. | 217 | 94 [4] | | ? | | | X | | | | | |
| Raymond | 72 | 23 [4] | | ? | | | X | | | | | |
| Book Cliffs | new | new | new | | | | | | | | | No |

[1] Herd initiated with <15 founders.

[2] Antelope Island: peripheral to native range.

[3] Henry Mountains: Range size from Utah Div. of Wildlife Resources, differs from Boyd (2003).

[4] House Rock and Raymond Wildlife Areas: not native bison range.

[5] Comprehensive Wildlife Conservation Strategy for the state in which the herd is located.
No priority indicates the state has no plans or program for restoring wild bison.

[3] Comprehensive Wildlife Conservation Strategy for the state in which the herd is located.

**8. Executive summary of factors threatening or endangering Yellowstone bison in the wild.**

Much of what we could have learned about bison was rapidly wiped out as the migratory species was driven to extinction throughout nearly all of their indigenous range in North America in the 19th century.

To paraphrase Kenneth P. Cannon (2001), much of what we "think" we know about bison is based on anecdotal, historic records from Americans of European descent that were "not collected in a rigorous or systematic manner," and modern studies of bison living in small, isolated populations representing but "a fraction" of the migratory species' indigenous range and variation.

PHOTO: Anna Day

Until holistic approaches piecing together oral, traditional, and ecological knowledge come to light what we think we know about bison, and what we think was lost, will remain beyond our understanding.

**A number of human-made factors threaten or endanger Yellowstone bison in the wild.**

The biological elements of representation, redundancy, and resiliency scientists say is necessary to prevent extinction and ensure the persistence of species in the wild (Shaffer & Stein 2000) is not present or is impaired for Yellowstone bison in the ecosystem they depend on for survival.

Threats to the persistence of Yellowstone bison as a wild species exist throughout their indigenous range and habitat in the bioregion.

The most evident factors jeopardizing bison's persistence as a wild species include:

- Habitat loss and fragmentation from agriculture, livestock production, and other intensive human land uses.
- Loss of long distance migration corridors.
- Loss of habitat connectivity.
- Loss of large migratory herds.
- Isolation of self-sustaining wild populations, if any remain.
- Loss of natural interchange between self-sustaining wild populations, if any remain.
- Loss of variation and diversity of wild traits and characteristics.
- Infringing on and weakening natural selection through manager's use of a preponderance of artificial selection processes.
- Domestication through manager's use of livestock management and veterinary practices.
- The legacy of crossbreeding bison and cattle, hybridization, and introgression of cattle genes in the bison genome.

- Loss of genetically intact bison populations, if any remain.
- Introducing cattle and sheep, and the diseases cattle and sheep carry.
- The lack of legal protection.
- Inadequate or nonexistent State and federal regulatory mechanisms.
- Rapid climate change, the harmful effects of climate change on bison, and the availability and nutritional quality of native plants bison depend on for survival and reproduction in the wild.

**The distinct population segment of Yellowstone bison is discrete, significant, and unique to the wild species to which they belong.**

The best available evidence indicates Yellowstone bison meet the U.S. Fish & Wildlife Service's distinct population segment criteria: is discrete, significant, and unique to the wild species to which they belong.

- Yellowstone bison represent the only surviving natural occurrence of the wild migratory species in the contiguous 48 States.

- Yellowstone bison persist in an ecological setting unusual and unique to the wild species to which they belong.

- Yellowstone bison are physically and geographically isolated from other wild bison populations, if any remain.

- The biological and ecological significance of Yellowstone bison is distinguished by the unique migrations, foraging strategies, and genetically distinct subpopulation structure of the Northern and Central herds.

- The loss of Yellowstone bison would result in a significant gap in the range of wild bison in North America.

**The distinct population segment of Yellowstone bison is threatened or endangered throughout their indigenous range.**

The best available evidence indicates the distinct population segment of Yellowstone bison's biological status in relation to the Endangered Species Act is threatened or endangered throughout the migratory species' range and habitat in the bioregion.

All of the Endangered Species Act's five factors threaten or endanger Yellowstone bison in the wild.

These five factors operate additively, synergistically, and cumulatively, any one of which jeopardize the ability of Yellowstone bison to adapt as a migratory wildlife species and persist in the wild as a self-sustaining population.

In properly determining Yellowstone bison's biological status, the U.S. Fish & Wildlife Service must critically examine all of the factors detailed herein in the agency's Species Status Assessment Framework.

**FACTOR 8.A.**

**The destruction and curtailment of the migratory species' indigenous range and habitat threatens or endangers Yellowstone bison in the wild.**

• The westward expansion of European American settlers destroyed the continental migrations of bison populations throughout their North American range. The country's only representative wild bison population remaining in their indigenous range and habitat is at risk of being destroyed in the Yellowstone ecosystem.

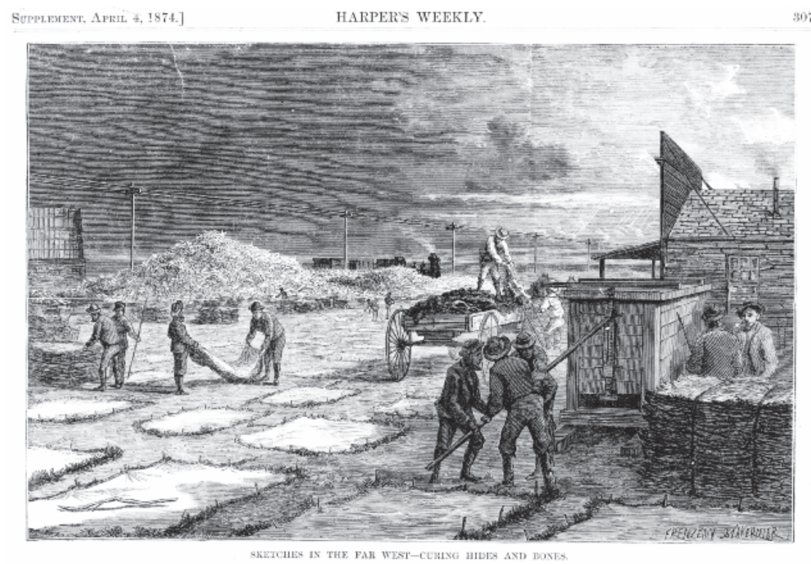



ILLUSTRATION: Sketches in the far West - curing hides and bones (Freneny & Tavernier 1874, Library of Congress)

• The appropriation of land for human use is destroying, fragmenting, and reducing Yellowstone bison's habitat and range. Various governments prohibit Yellowstone bison from migrating to millions of acres of National public trust lands. Consequently, the migratory population's ecological and geographic representation is impaired and significantly diminished in the bioregion.

• The States of Montana, Idaho, and Wyoming confine and reduce the range of migratory Yellowstone bison, and reduce and eradicate the wild species roaming their range and habitat on National public trust lands.

• Yellowstone National Park has created an artificial population sinkhole limiting the distribution and connectivity of Yellowstone bison to their range in the ecosystem. Yellowstone National Park can no longer be considered a protected area for wild bison.

• No self-sustaining bison populations exist in the wild on more than 145 million acres of National Forest habitat in the Western United States.

• Under State of Montana imposed "tolerance zones," the range of Yellowstone bison is limited and restricted, and the migratory population is reduced by government trapping and hunting on National Forest habitat in Region 1.

• Introducing cattle limits and reduces the range of migratory bison, and is degrading habitat in the ecosystem bison depend on for survival.

• Yellowstone bison are extinct in four out of five landscapes on the Custer Gallatin, and the agency's cattle grazing program is degrading bison's National Forest range and habitat.

• The Custer Gallatin National Forest is permitting barriers that disrupt habitat connectivity for migratory bison roaming their home range.

• Bison have lost all long-distance migration routes in the Greater Yellowstone bioregion.

• The Custer Gallatin National Forest's land management plan provisions for bison limit and reduce Yellowstone bison's range and habitat.

• The State of Wyoming manages for the extirpation of migratory bison on National Forest habitat in Region 2.

• The State of Idaho manages for the eradication of migratory bison on National Forest habitat in Region 4, and elsewhere.

• Bison are a species of concern in Montana due to human threats to their habitat, restricted distribution, and management actions reducing the only population found in the wild: the distinct population segment of Yellowstone bison.

• Few opportunities exist to naturally restore Yellowstone bison in the wild because National public trust lands in the range of bison are appropriated for grazing cattle. The lack of protections and provisions for conserving Yellowstone bison's range and habitat is a threat to restoring the wild species on National public trust lands in the ecosystem and bioregion.

**FACTOR 8.B.**

**Domestication, artificial selection, and overutilization for commercial purposes endangers the genetic integrity and natural selection of wild bison. Consequently, intact bison populations may be extinct.**

• Natural selection and the genetic integrity of wild bison is endangered by domestication and artificial selection.

• Domestication processes in current management are artificially selecting against wild bison.

• Management of bison conservation herds is domesticating the wild species. Metapopulation management is not restoring the migratory species in the wild, and presents a risk and threat to bison.

• Bison are at risk of genomic extinction as a consequence of domestication and artificial selection, an artifact of ranchers breeding cattle and bison in confinement to exploit bison's attributes for commercial purposes.

• Domestication of bison as livestock, a commercial activity, is not compatible with natural selection, evolutionary adaptation, and restoring bison as a wildlife species.

• Regulatory quarantine has not led to restoring bison in the wild. Managers have not investigated if genetic diversity is lost, and the rate and extent of loss, in the source population of Yellowstone bison undergoing regulatory quarantine.

• Yellowstone National Park's 50-year bison quarantine program includes transfer for commercial purposes and has not led to restoring self-sustaining bison populations in the wild.

• Proximity of domestic cattle, sheep, and ranched bison is a risk to bison roaming wild in the Yellowstone ecosystem.

**FACTOR 8.C.**

**Disease management threatens or endangers Yellowstone bison in the wild.**

• Disease management is a threat to Yellowstone bison in the wild.

• State and federal livestock management and veterinary policy is a threat to Yellowstone bison in the wild.

• Yellowstone National Park's disease management actions threaten or endanger Yellowstone bison in the wild.

• Disease management is a threat to Yellowstone bison's genetically distinct subpopulations.

• State and federal disease management actions threaten genetic variation, disease resistance, and evolutionary adaptation of Yellowstone bison in the wild.

PHOTO: Jim Peaco

• The State of Montana's and Yellowstone National Park's bison management plan is not based on the best available science.

• The State of Montana's statutory scheme (Mont. Code Ann. § 81-2-120) is a threat to Yellowstone bison in the wild.

• The Montana Dept. of Livestock is not enforcing and Montana cattle ranchers are not complying with Designated Surveillance Area rules.

• In the Designated Surveillance Area, Montana manages wild elk populations to prevent commingling with cattle.

• Designated Surveillance Area management of cattle, bison biology, scavengers, and environmental conditions reduce and prevent disease transmission to cattle in Yellowstone bison's range.

• Eliminating Yellowstone bison from their home range precipitates a cascade of harmful effects on native species and biological diversity. Evidence of management actions harmful effects on Yellowstone bison and bison ecology is not being systematically examined for publication.

• Displacing bison as a native food source undermines the recovery of grizzly bears.

• Displacing bison, a keystone species and ecological engineer, depletes biological diversity in the ecosystem.

**FACTOR 8.D.**

**The inadequacy of existing State and federal regulatory mechanisms threatens or endangers Yellowstone bison in the wild.**

• The conservation status of bison is "Near Threatened" with few populations "functioning as wild" in North America.

• Inadequate or nonexistent State and federal regulatory mechanisms threaten or endanger Yellowstone bison in the wild.

• The State of Montana's and Yellowstone National Park's bison management plan is an inadequate regulatory mechanism because it is not based on the best available science.

• State and federal livestock management and veterinary policy is a threat to Yellowstone bison in the wild.

• The States' statutory framework threaten or endanger Yellowstone bison in the wild.

• There is no regulatory mechanism in place ensuring Yellowstone bison persist as a self-sustaining population on National Forests in the bioregion.

• Bison are a critically imperiled species in the State of Idaho. Under Idaho law, migratory Yellowstone bison are eradicated.

• The State of Wyoming manages for the extirpation of limited numbers of migratory Yellowstone bison in restricted areas. In enforcing Wyoming law, Yellowstone bison are eradicated.

• Despite credible and relevant scientific evidence raising substantial concern about Yellowstone bison's ability to persist as a viable population on the National Forest, the Regional Forester denied bison met the criteria for listing as a species of conservation concern in Region 1.

• Bison are a species of concern in Montana. Despite the designation, the Custer Gallatin has adopted the State's intolerant regulatory framework for Yellowstone bison on National Forest lands in Montana.

• The Custer Gallatin has erected or permitted barriers thwarting Yellowstone bison's natural migrations on the National Forest. These barriers disrupt habitat connectivity the National Forest planning rule requires be maintained or restored.

• Ineffective and inadequate regulatory mechanisms on National Forests in the bioregion threaten or endanger Yellowstone bison in the wild.

• The State of Montana abandoned its' duty to restore bison in the wild.

• Nonexistent and inadequate laws threaten or endanger Yellowstone bison in the wild.

• The U.S. Fish & Wildlife Service has a duty to restore threatened or endangered species in the wild.

## FACTOR 8.E.

**A number of human-made factors threaten the persistence of a wild self-sustaining Yellowstone bison population with distinct subpopulation structure.**

• Climate change is a threat to Yellowstone bison in the wild.

• Yellowstone bison's natural generation times limit their ability to adapt body size in response to rapid climate change.

• Climate change could halve the body size of bison in North America by the end of the 21st century.

• Rising temperatures and increasing drought severity drive a decline in bison body size.

• Rising temperatures decrease bison body size, growth rates, and alter life-history characteristics.

• The role and threat of climate change in the declining nutritional value of native plants in Yellowstone bison's range is unknown. A warmer, dryer climate will result in a significant loss in wetlands, and reduce sedge and rush species bison depend on for food.

PHOTO: BFC Archives

• Changes in climate and rainfall patterns cause a reduction or regional shift in bison range.

• Extreme weather patterns drive changes in bison movement patterns.

• Drought reduces grassland ecosystem function and drives a decline in the condition of Yellowstone bison.

• State and federal management actions, winter severity, and snow crusting significantly reduces Yellowstone bison's resiliency to withstand such events, and is a threat to the population in the wild.

• State and federal management actions reducing Yellowstone bison's range and population, and climate-driven shifts in the range of bison outside "protected areas" is a threat to the migratory species.

• Climate change was a factor in the extinction of Bison species in the Pleistocene.

• Few founders, hybridization, population bottleneck and isolation threaten or endanger Yellowstone bison in the wild.

• State and federal manager's use of artificial selection and domestication processes infringe on natural selection, and threaten or endanger the persistence of wild Yellowstone bison.

• Current management threatens or endangers retention of the wild genome and the persistence of Yellowstone bison as a wild population.

• Population viability for Yellowstone bison is unknown.

• State and federal managers are jeopardizing genetic variation in wild Yellowstone bison.

• Yellowstone bison are unlikely to persist in the wild without a minimum of 5,000 or more adults.

• Current management is undermining natural selection of Yellowstone bison. Evidence of effects from the loss in ecological choice (natural selection) for Yellowstone bison is not being systematically examined for publication.

• In restricting the range and habitat for Yellowstone bison to naturally evolve and adapt to rapid climate and environmental change, State and federal managers are placing the distinct population segment at increased risk of extinction in the wild.

• State and federal managers are increasing the risk of inbreeding by confining and limiting migratory range and managing bison in small populations in isolated ranges. Evidence of the risk of inbreeding in Yellowstone bison is not being systematically examined for publication.

• In managing Yellowstone bison for a limited population size in a restricted and isolated range, it is unknown how management is transforming mutation rates and maintenance of adaptive genetic variance.

• State and federal management actions are driving the loss or extinction of Yellowstone bison family groups (generational parent-offspring). Evidence of the extent and rate of loss in Yellowstone bison family groups is not being systematically examined for publication.

• The unknown extent and rate of loss or extinction of family groups (generational parent-offspring) is a threat to Yellowstone bison's adaptive potential and resilience to adverse events in a rapidly changing climate and environment.

• The long-term viability, fitness, and evolutionary potential of wild Yellowstone bison is not secure and at risk of extinction. Under current State and federal management, inbreeding in the Yellowstone bison population may not be evident for a century.

PHOTO: BFC Archives

**8. A. The destruction and curtailment of the migratory species' indigenous range and habitat threatens or endangers Yellowstone bison in the wild.**

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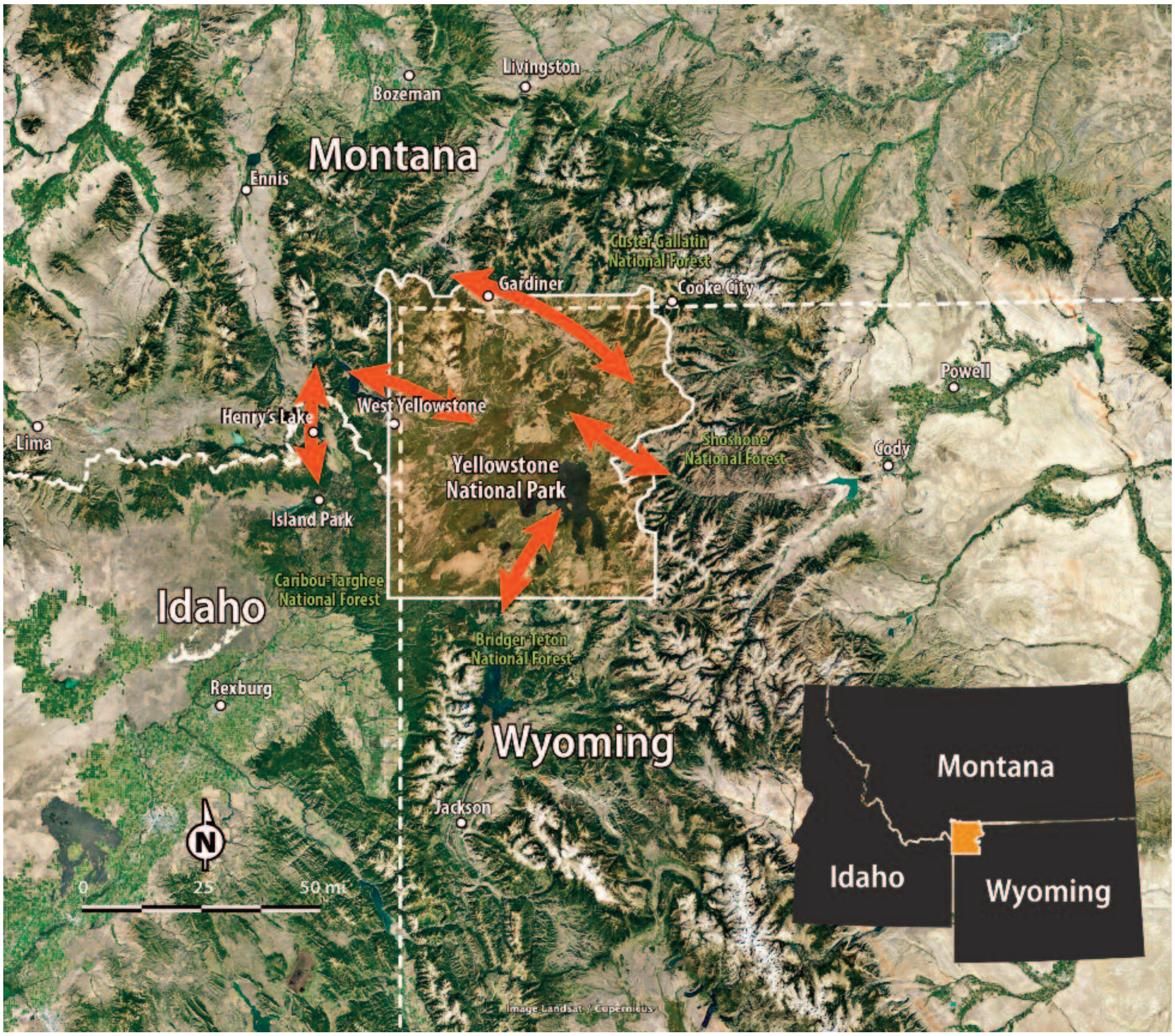


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PHOTO: Darrell Geist

***The westward expansion of European American settlers destroyed the continental migrations of bison populations throughout their North American range. The country's only representative wild bison population remaining in their indigenous range and habitat is at risk of being destroyed in the Yellowstone ecosystem.***

The continental migrations of bison herds across their range and habitat in North America was destroyed over a century ago.

In part, wild bison populations were driven to extinction throughout their North American range "as a consequence of economic growth and development untampered by adequate concern and conservation." 16 U.S.C. § 1531(a)(1).

The once vast variation in geographic distribution and ecological settings bison evolved and adapted to has been reduced to a depauperate condition for the wild species.

The range of bison once spanned over 20 major habitat types or ecoregions in North America "migrating in vast groups across immense latitudinal and elevational gradients." Sanderson et al. 2008 at 256; Geremia et al. 2019 at 1; Bailey's map *Ecoregions of North America*.

"Based on their body mass, bison should have the largest spatial requirements of any North American mammal (Ofstad et al. 2016), yet they are among the most geographically restricted due to current management regimes (Gates et al. 2010)." Ritson 2019 at 16.

ILLUSTRATION: The far west – Shooting buffalo on the line of the Kansas-Pacific Railroad. Frank Leslie illustration 1871, Library of Congress

The vast loss in bison range in North America (>99%) is expected to continue based on future projected loss and fragmentation of habitat in bison's migratory range in the Yellowstone ecosystem. Sanderson et al. 2008 at 255 (Figure 1); Geremia et al. 2019 at 1 ("bison occupy less than 1% of their historic range"); Hansen et al. 2014 at 493 (climate-driven biome shifts are projected in the Greater Yellowstone bioregion), at 498 (effects of change in land use, spread of exotic species, and climate change will be additive and synergistic), at 494 ("a substantial amount of the variation in native species extinction rate was explained by human density" surrounding western National parks, citing a study by Parks & Harcourt 2002); Hansen 2009 at 29 (habitat destruction in the Greater Yellowstone bioregion has occurred primarily in valley bottoms "as a consequence of agricultural and urban development,"), at 34–35 (riparian habitat, corridors, grasslands are at risk from exurban development).

Because of the vast loss in indigenous range, immense population decline, and few populations "functioning as wild," bison are "ecologically extinct" and no longer can fulfill their keystone ecological roles in the wild. Aune, Jørgensen, & Gates 2018 Supplemental Material (Tables 1 and 2); Freese et al. 2007 at 175.

Prior Acts of Congress — the Homesteading Acts, Dawes Act, Indian Appropriations Act of 1889 — fragmented reservation land held in common into private parcels resulting in a significant loss of bison range and habitat, isolated populations, and loss of connectivity between any bison remaining in the wild. Hubbard 2016 at 92–93 (imposed on over 100 reservations, land once commonly held was parceled out to enrolled individuals in a tribe with the remainder deemed "surplus" and sold to settlers); National Archives 1889 (In his last message to Congress, President Grover Cleveland declared "that the Indian Territory be opened for settlement, and there is no doubt but that Congress…will pass the necessary act declaring the unoccupied lands in Indian Territory…open for homestead and pre-emption.").

Allotment also meant "'the grasslands would be broken and fences would be erected,'" with the parceling of Indigenous lands supporting the range of wild bison appropriated for "private homesteads," making "way for an influx of settlers and the increased importation of cattle and other domesticated livestock." Mamers 2020 at 130 (quoting Harvey Locke 2016).

Settler's cattle displaced bison as the migratory species was driven to extinction across their range with 353 million acres of habitat lost to 10 million cattle and 734,000 farms from 1860–1920. Lueck June 2002 at S640 (Table 4).

"Most of the primary region that once contained millions of bison now has either been turned into farmland or is grazed by cattle (Danz, 1997)." Ecoffey 2009 at 14.

Euro-American's long-standing intolerance of bison, and conflict with bison in range appropriated for cattle and other human land uses, continues under the terms of "prevailing social conditions" and "social carrying capacity" expressly obscuring a threat that has never gone away to a revered indigenous species. Plumb et al. 2009 at 2377, 2385; *see also* Cherry et al. 2019 at 553, 554 on the "undesirable levels of population extinction risk and further declines in genetic variability" for the Spurgeon River plains bison population based on a "social carrying capacity threshold" of 430 animals to accommodate agricultural practices and human developments.

The results of a study on the persistence of keystone wildlife species including bison on 746,000 square kilometers (184,340,614 acres) in the Upper Missouri River Basin found that while grassland covered 47% of the landscape, social values (or human intolerance) in Montana, North Dakota, South Dakota, and Wyoming limited "suitable areas as wildlife habitat" for bison to 0.56% of the basin. Rastandeh et al. 2021 at 3, 8 (Table 5), 9 (Table 6).

"A very small area of the region can function as primary habitat for the bison." Rastandeh et al. 2021 at 8. "[H]abitats of the bison could be heavily encroached by human activities (Tables 8, 10; Fig. 4)." Rastandeh et al. 2021 at 18.

> Habitat degradation within socioecological hotspots could have far-reaching consequences for the composition and configuration of wildlife habitats, and consequently biodiversity across the UMRB [Upper Missouri River Basin] (Figs. 7, 8, and 9). We found that habitat loss, habitat subdivision, habitat dispersion, and habitat shrinkage are four consequences of human activities for wildlife habitats in the UMRB; however, the magnitude and spatial extent of these impacts vary among species (Table 9).
>
> The amount of habitat loss ranges from 17.85% in habitats of the bison to 7.89% in habitats of the white-tailed prairie dog (Table 10). We observed the highest changes in the values of CAP and PD in habitats of the bison.

Rastandeh et al. 2021 at 9 (CAP is the Class Area Proportion, quantifying the total area of wildlife habitats and habitat availability across the region, and PD is patch density).

Human developments and government intolerance, the introduction of cattle on private lands, and appropriation of habitat for cattle on National public trust lands is destroying, limiting, and reducing Yellowstone bison's habitat and range.

Bison range and habitat is doubly harmed because grasslands in the Greater Yellowstone bioregion are "underrepresented on public lands" and disproportionally subject to "human development on private lands." Piekielek 2012 at 1.

The additive, synergistic, and cumulative effects of multiple stressors operating on Yellowstone bison habitat and range pose a substantial risk to and raise substantial concern about the migratory species' ability to persist in the wild for the foreseeable future.

> Animal movement is fundamental for ecosystem functioning and species survival, yet the effects of the anthropogenic footprint on animal movements have not been estimated across species. Using a unique GPS-tracking database of 803 individuals across 57 species, we found that movements of mammals in areas with a comparatively high human footprint were on average one-half to one-third the extent of their movements in areas with a low human footprint. We attribute this reduction to behavioral changes of individual animals and to the exclusion of species with long-range movements from areas with higher human impact. Global loss of vagility alters a key ecological trait of animals that affects not only population persistence but also ecosystem processes such as predator-prey interactions, nutrient cycling, and disease transmission.

Tucker et al. 2018 at 466.

"The bison is a land-intensive nomadic species that once roamed over great distances on the North American landscape." Boyd 2003 at 49.

Yellowstone bison migrate up to 100 kilometers (62 miles), "the last truly migratory herd." Geremia et al. 2019 at 1.

> Large-bodied animals are especially vulnerable to the effects of habitat fragmentation because they require a large amount of suitable habitat (Berger and Cunningham 1994). Fragmented populations can be more susceptible to inbreeding pressures, loss of genetic diversity, and extinction (Berger and Cunningham 1994; Mace *et al*. 2001). On the continental scale, natural habitats have been reduced to a fraction of their historical extent (Mace *et al*. 2001). Human population growth and development have led to the appropriation of extensive areas of land within original bison range for natural resource extraction, agriculture, ranching of both cattle and commercial bison, and urban and rural settlement (Johnson *et al*. 1994; Berger and Cunningham 1994; Mace *et al*. 2001). These competing land uses constrain possibilities for preserving or restoring large tracts of habitat for bison recovery.

Boyd 2003 at 49.

Based on Boyd's status review, the total protected area in the indigenous range of bison "conservation" herds is approximately 3,545,640 acres in the United States, and 160,517 acres in Canada. Boyd 2003 at 148–151 (14,348.7 and 649.59 square kilometers respectively).

Total protected area should not be construed as suitable habitat for bison.

For example, the protected area of Yellowstone National Park is 2,301,786 acres but Yellowstone bison habitat is approximately 784,560 acres almost all of which is within the park. Boyd 2003 at 151; Custer Gallatin Final Terrestrial Wildlife Report 2017 at 133.

In Gardiner basin, of 102,501 acres available to bison in government imposed "tolerance zones," current use is 7,136 acres and predicted use is 30,123 acres. In Eagle Creek, a year-round "tolerance" area for bison, current use is 5,417 acres and predicted use is 10,026 acres. In Hebgen basin, of 146,625 acres available to bison in "tolerance zones," current use is 21,795 acres and predicted use is 43,602 acres. Wallen 2012.

However, in government restricted "tolerance zones," potential suitable habitat for Yellowstone bison may be less than half of what biologists project based on the methodology used in mapping habitat. Neto 2018 at 56–64.

Winter range, a vital ecological setting for bison's survival and reproduction, remains largely unprotected.

"Because little thought was given to protecting known winter range for wildlife when the YNP boundaries were developed, much of the winter range for bison lies outside YNP on public and private land." Angliss 2003 at 3.

The focal point of multiple State and federal management actions is on limiting and reducing winter range for bison.

In restricting migrations to winter range, managers are harming bison's ability to adapt to changing environmental conditions and to withstand disturbances and catastrophic events such as snow crusting events which makes foraging impossible. Most "natural mortality occurs during the winter as a result of the combined effects of stress, malnutrition, and physiological condition (Meagher 1973; Green 1994)." Angliss 2003 at 14.

Reducing or decreasing access to forage discourages bison's natural feeding patterns, resulting "in individuals less similar to their wild ancestors," and is an impediment to fulfilling the "large-scale biological interactions bison have as a keystone species (Knapp et al. 1999; Freese et al. 2007; Fuhlendorf et al. 2010)." Ritson 2019 at 80.

Intensive State and federal management regimes restricting Yellowstone bison's natural migrations and range has impaired the conditions necessary for their survival and recovery in the wild.

At minimum, bison inhabit less than 15% of their habitat in two river valleys in the Yellowstone ecosystem (Plumb et al. 2009 at 2377), and the migratory species' distribution across their range is strictly confined by government imposed "tolerance zones" inside Yellowstone National Park and on contiguous National Forest habitats. Interagency Bison Management Plan Zones North 2012 Map; Gov. Bullock 2016 (Erratum).

Government imposed boundaries restricting bison range and habitat inhibits their fitness and adaptability, and contributes to the migratory species' extinction risk in the Yellowstone ecosystem.

Government imposed range restrictions together with habitat loss and fragmentation has reduced Yellowstone bison to an isolated state with a limited and restricted amount of habitat to evolve with no genetic connectivity between bison populations elsewhere in the wild, if any remain.

The U.S. Fish & Wildlife Service must examine and investigate the threat of ongoing government actions confining migrations and restricting access to habitat and the associated loss in ecological settings, range, and distribution of Yellowstone's bison herds in the agency's threats assessment and status review.

***The appropriation of land for human use is destroying, fragmenting, and reducing Yellowstone bison's habitat and range. Various governments prohibit Yellowstone bison from migrating to millions of acres of National public trust lands. Consequently, the migratory population's ecological and geographic representation is impaired and significantly diminished in the bioregion.***

North American bison "had the widest natural range of any North American herbivore, from the arid grasslands of Chihuahua State in northern Mexico, through the grasslands of the Great Plains of the United States and Canada, to the riparian meadows of interior Alaska." Aune, Jørgensen, & Gates 2018 at 5.

The appropriation of land for human land use has destroyed more than 85% of Yellowstone bison's range and habitat while various governments prohibit and exclude the migratory species from dispersing to millions of acres of National public trust lands. As a consequence, the migratory population's ecological and geographic representation is impaired and significantly diminished in the bioregion.

In addition, the ecological phenomenon of long distance migrations for Yellowstone bison is at risk because there is no protected area large enough for restoring and preserving the full range and extent of this vital adaptive capacity to survive changing environmental conditions and withstand catastrophic events in an inhospitable environment created by the government.

What is migration?

> Mertesky et al. make a distinction between migration, localized station-keeping movements, and ranging behaviors; "localized "station-keeping" movements. . . include foraging. . . commuting. . . and territorial defense." Ranging movements include "exploratory movements in search of suitable habitat or exploitable resources." For example, American bison that once circuited the great American plains "in search of fresh prairie grasses" exhibited ranging movements.

Stoellinger et al. 2020 at 85 n. 10 (citations omitted).

> Scholars have addressed the dilemma of conserving the increasingly rare act of migration among abundant populations by classifying migration as an "endangered phenomenon"—a parallel concept similar to endangered species. Lincoln Brower and Stephen Malcolm have defined an "endangered phenomenon" as "a spectacular aspect of the life history of an animal or plant species involving large numbers of individuals that are threatened with impoverishment or demise, the species per se need not be in peril; rather, the phenomenon it exhibits is at stake."

Stoellinger et al. 2020 at 87 (footnotes omitted).

> Migration is the key to survival and reproduction in many populations, because different habitats used throughout the year provide distinct values. Conserving migratory ungulates requires conserving entire year-round ranges. Unsurprisingly, reviews of the ecology and conservation of ungulate migration have repeatedly identified habitat loss on one or more seasonal ranges as one of the leading causes of declines of migratory ungulates around the world, including in the Greater Yellowstone Ecosystem and other parts of the American West.

Stoellinger et al. 2020 at 93–94 (footnotes omitted).

Bison migration is imperiled due to "land use change contributing to range restriction and depopulation." Aune, Jørgensen, & Gates 2018 at 6.

A continuing decline in area, extent and/or quality of habitat for bison is one factor contributing to the wild species "Near Threatened" status. Aune, Jørgensen, & Gates 2018 at 15.

Merrill & Leatherby (Bloomberg L.P. 2018) provide a useful summary of the appropriation of vast ranges of habitat in the 48 contiguous States bison once inhabited and freely roamed:

> Acres of habitat in the 48 contiguous United States: 1.9 billion
> Acres of pasture/range: 654 million

Acres of forest:  538.6 million
Acres of cropland:  391.5 million
Acres of special use areas:  168.6 million
Acres of urban areas:  69.4 million
Acres of miscellaneous areas:  68.9 million

Special use includes national parks, wildlife areas, highways, railroads, and military bases. Miscellaneous includes cemeteries, golf courses, marshes, deserts, and other areas of "low economic value."

In the United States, 2,244,512 acres of land is dedicated to golf courses while 2,637,559 acres of habitat is available for bison populations "functioning as wild." Oshinsky 2009; Aune, Jørgensen, & Gates 2018 Supplemental Material (Table 2).

"There's a single, major occupant on all this land: cows. Between pastures and cropland used to produce feed, 41 percent of U.S. land in the contiguous states revolves around livestock."

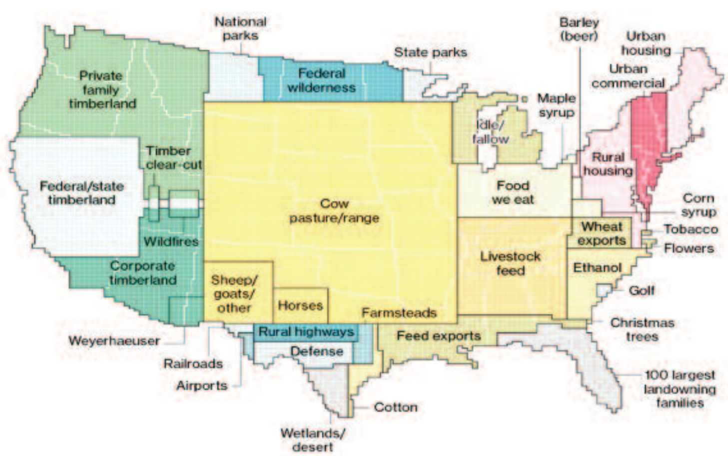
Acres to feed livestock:  781 million
Acres of pasture/range:  654 million
Acres of livestock feed crops:  127 million

Agricultural land takes up about a fifth of the habitat in the 48 contiguous United States. "More than one-third of U.S. land is used for pasture—by far the largest land-use type in the contiguous 48 states."

Acres of croplands:  391.5 million
Acres of livestock feed:  127.4 million
Acres of food we eat:  77.3 million
Acres of other grain/feed exports:  62.8 million
Acres of idle/fallow ag land:  52 million
Acres of ethanol/biodiesel:  38.1 million
Acres of wheat exports:  21.5 million
Acres of cotton:  13.6 million

Acres of wilderness:  64.4 million
Acres of national parks:  29 million
Acres of defense lands:  25 million
Acres of rural highways:  21 million
Acres of state parks:  15.3 million
Acres of farmsteads:  8 million
Acres of airports:  3 million
Acres of railroads:  3 million
Acres of golf courses:  2 million

GRAPHIC: Bloomberg




Merrill & Leatherby (Bloomberg L.P. 2018) online: www.bloomberg.com/graphics/2018-us-land-use/. Sources: U.S. Department of Agriculture, Economic Research Service: Major Uses of Land in the United States, 2012; U.S. Department of the Interior, National Land Cover Database, 2011; U.S. Census Bureau; State governments; stateparks.org; American Farmland Trust; Golf Course Superintendents Association of America;

USDA National Agricultural Statistics Service; USDA Census of Agriculture; U.S. Bureau of Land Management; U.S. Forest Service; Weyerhaeuser Co.; The Land Report magazine.

"Agricultural producers manage more than one-third of the USA's 140 million ha [hectares] of pasture and rangeland, including the largest remaining tract of native rangeland in North America—the Northern Mixedgrass Prairie" containing "25% of the nation's beef cows, sheep, and lambs (NASS 2012), 34% of the nation's cattle on feed (NASS 2012), and significant numbers of dairy cattle and hogs." Derner et al. 2018 at 21 (345,947,534 acres of bison range and habitat converted to agriculture and pasture and range for livestock).

In the Upper Missouri River Basin, an expanse covering 746,000 square kilometers (184,340,614 acres), "respectively 30%, 13%, 11%, and 9% of wheat, soybean, cattle, and corn productions of the United States are supplied in this region (Stoy et al. 2018). Commonplace human activities including settlement development, farming, ranching, grazing, hunting and mining have substantially affected wildlife species, leading to widespread habitat degradation and biodiversity loss over the last two centuries across the region (Samson and Knopf 1994; Jarchow et al. 2020)." Rastandeh et al. 2021 at 3.

> The historic Great Plains of North America consist of grasslands that extend south from Alberta and Saskatchewan, Canada to Northern Mexico and east from the Rocky Mountains to western Indiana and Wisconsin (Chadwick 1995; Berger and Cunningham 1995; Samson and Knopf 1994). The Great Plains grasslands comprise the largest contiguous ecosystem in North America and historically consisted of an area approximately 400 million acres in size (Chadwick 1995; Samson and Knopf 1994). They are often characterized as enduring consistent ecological disturbance (Knopf and Samson 1997) including . . . drought, fire and grazing. . . . Each of these disturbances play a vital role in directing the evolution of the grassland biota (Knopf and Samson 1997). Bison have historically assisted in the shaping of these grasslands with their dynamic patch-type grazing patterns (Knapp and others 1999). Humans have also played major roles in directing this evolution with the significant use of fire by Native People in the past and with the absolute fire suppression and the plowing practices of colonizing Europeans (Kimmerer and Lake 2001).
>
> The prairie ecosystem consists of three sections of which are based almost entirely on climatic factors (Chadwick 1995). Because of the orographic effect on the west side of the Rocky Mountains, a "rain shadow effect" is created immediately to the east of the mountains where there is little moisture and the moisture gradient gradually rises as one travels eastward (Chadwick 1995; Davitt and others 1996). As a result, the grass is shorter in the western areas of the prairie and gradually becomes taller to the east until the grasses were, in pre-settlement times, "as tall as a man on horseback" (Chadwick 1995).

Garrett 2007 at 3–4.

Bison's keystone ecological role in shaping vast and complex grasslands — one of the most imperiled biomes in the world — has "been replaced by fragmented agricultural lands where domestic cattle are the dominant grazers on remnant grasslands. Simultaneously, many obligate grassland species declined" and are also imperiled. Fuhlendorf et al. 2018 at 1, 2.

“More than 50% of native temperate grasslands in North America have been converted to human use (Hoekstra *et al*., 2005).” Elliot & Johnson 2017 at 165.

> The loss of grassland habitat has caused corresponding declines in the populations of grassland-specific species (Samson & Knopf, 1994). Obligate grassland breeding birds, which require grassland for all aspects of their life history (Vickery *et al*., 1999), have experienced declines among the most severe seen for any avian group (North American Bird Conservation Initiative U.S. Committee, 2014).
>
> The issue of habitat loss is further compounded in remnant grasslands by habitat degradation.

Elliot & Johnson 2017 at 165–166.

“Today, 55 grassland species are either threatened or endangered and another 728 are designated as candidates for this status (Samson and Knopf 1994).” Garrett 2007 at 5.

The alarming loss, degradation, and fragmentation of grasslands has local-to-global implications because grassland soils are “considered superior carbon sinks, comparable to some forests (Samson and Knopf 1994; Chadwick 1995).” Garrett 2007 at 5.

Bison’s role in building resiliency in grasslands by storing carbon and nutrients is another unexplored and unmentioned ecological contribution that is undermined by the continuing loss, fragmentation, and degradation of range and habitat for the wild species to roam.

The area of human dominated landscapes continues to expand into bison’s range along with ever increasing levels of housing developments near the “protected areas” of National Parks.

> Area of the conterminous U.S. classified as human dominated in 1992: 2,600,000 $km^2$ (642,473,992 acres)
> Area of the conterminous U.S. classified as human dominated in 2001: 2,680,800 $km^2$ (662,440,107 acres)
> Area of the conterminous U.S. projected as human dominated by 2030: 2,773,000 $km^2$ (685,223,223 acres)
> As of 2000, number of housing units within 1 km of US national parks: 85,000

Theobald 2010 at 999; Shafer 2015 at 272.

In addition to loss of range to agriculture and livestock, the expansion of housing near protected areas is further reducing Yellowstone bison range and habitat.

“Between 1940 and 2000, 28 million housing units were built in the United States within 50 km of protected areas. Seventeen million housing units are predicted to be built within 50 km of protected areas by 2030. In the vicinity of Yellowstone, Glacier, Mount Rainier, and North Cascades national parks, housing growth rates between 1940 and 2000 on non-publicly managed lands have been among the highest adjacent to protected areas nationwide, with rates > 300–400%.” Newmark et al. 2023 at 7.

Human developments on private lands in the Greater Yellowstone biregion is an on-going threat to migratory bison and their habitat.

> [P]ublic lands in the GYE are relatively high in elevation, harsh in climate, and low in primary productivity, whereas the private lands are primarily in valley bottoms and floodplains with longer growing seasons and higher plant productivity (Hansen et al. 2000). Consequently, hot spots for biodiversity and many ungulate winter ranges are largely on private lands (Hansen et al. 2002).

Hansen 2009 at 27.

> Nearly 4,000 homes are added to the 20 counties of Greater Yellowstone each year and natural habitats have been lost to development at a rate of about 60,000 acres (2.2 percent) per year since 1970. Thus, demand for land and resources are increasing while the habitats that allow fish and wildlife to cope with climate change are decreasing.

Hansen 2016 (Bozeman Daily Chronicle, Guest columnist).

For a visual representation of new homes being built in bison's range in Montana (1950–2023 projected), *see* Rasker, Headwaters Economics 2018 at 18–22.

Bison preferentially migrate along valley bottoms but this ecological setting has been appropriated primarily for agricultural and urban development. Hansen 2009 at 29 (citing Gude 2006).

In the Greater Yellowstone bioregion, human population increased 58% from 1970 to 1999, and exurban development in rural lands increased 350%. Hansen 2009 at 28 (citing Gude et al. 2006).


> Human activities often have far-reaching impacts on abiotic and biotic resources and their impacts are not limited within the locations, where people are physically present. Any change in these resources (e.g. soil degradation, water pollution, land cover conversion) can be detrimental to biodiversity (WWF 2020). According to Benítez López et al. 2010, Barbosa et al. 2020, and Mendes et al. 2020, under normal conditions, the environmental impacts of human activities on mammals can spread up to 5 km [>3 miles], if not more, from the origin of impacts.

Rastandeh et al. 2021 at 5.

Ongoing human developments destroying bison range and habitat is also a factor in spreading invasive and non-native plants that threaten the integrity of bison's native forage.

> Invasive plants are able to spread from rural homes and agricultural fields into adjacent natural habitats. The number of documented exotic plants in Yellowstone National Park has increased from 85 in 1986 to more than 200 in 2009 (GYSLC 2009), possibly due in part to human development on surrounding private lands.

Hansen 2009 at 29.

Forwood recorded the first exotic plant species (*Oxalis violacea*) in Yellowstone in 1881. Plant ecologist Don Despain reported finding 86 exotic plants which continue to "arrive and spread in Yellowstone." Whipple 2001 at 336, 337 (citing Despain 1975).

As of 2001, "187 species of exotics (188 taxa) are known to occur or have occurred in the past within the confines of the park, and new taxa are located almost every year" and the "arrival of new exotic plants into Yellowstone associated with vehicles, muddy shoes, equipment, and stock is likely to persist unabated." Whipple 2001 at 337, 338.

Points by which exotic plants are spreading in Yellowstone National Park include 4 million annual visitors using 370 miles of paved roads, with access to 2,200 frontcountry campsites, 300 backcountry campsites, 950 miles of backcountry trails, in addition to 8,000 backcountry stock use nights. Olliff et al. 2001 at 348.

"Exotic plants are substantially impacting the park's natural and cultural resources," and Yellowstone National Park's "Resource Management Plan (NPS 1998) lists exotic plants as one of the major threats to natural resources." Olliff et al. 2001 at 347, 348.

In addition to exotic plants, "nonnative plants that are not listed as noxious, like timothy (*Phleum pratense* L.), may be affecting native biotic communities to a greater degree than those plants deemed "noxious" (Wallace and Macko 1993)." Olliff et al. 2001 at 347.

Over 4,600 acres were treated from 1995–1998 focusing on highly invasive species such as sulfur cinquefoil, leafy spurge, spotted knapweed, oxeye daisy, and hoary cress using chemical, mechanical, and cultural techniques. Olliff et al. 2001 at 347.

The cold-desert environment primarily along the Yellowstone and Lamar River valleys on Yellowstone National Park's northern range, encompassing 198,000 acres, "provides habitat conditions most susceptible to exotic plant invasion and establishment relative to other vegetation zones in the park." Olliff et al. 2001 at 348.

> Many noxious weeds and nonnative plants have become firmly established in YNP because prior attempts at prevention and early detection efforts were ineffective, eradication efforts have failed, or, in the case of some non-natives, past management practices have led to planting and protecting these species. Since the seeds of plants can remain viable for decades (e.g., oxeye daisy seeds have germinated after 39 years; Sheley and Petroff 1999), areas

> where weeds have dispersed seeds must be revisited for control for years, even if no plants are apparent.

Olliff et al. 2001 at 352.

The invasion and expansion of exotic plants disrupts vital ecosystem processes, the nutritional value, availability, and distribution of native forage species for Yellowstone bison.

> Many biologists consider exotic plant establishment to be the largest threat to the integrity of native plant communities of the park. Non-native plants have been demonstrated to negatively impact ecosystem structure and function by altering soil properties and related processes (Lacey et al. 1989, Olson 1999), plant community dynamics and related disturbance regimes (e.g., D'Antonio and Vitousek 1992), and distribution, foraging activity, and abundance of native ungulates (Trammel and Butler 1995, Thompson 1996) and small mammals (Kurz 1995). Geothermal habitats unique to Yellowstone have been altered by exotic plants, potentially compromising the long-term persistence of populations of Ross bentgrass (*Agrostis rossiae Vasey*), a restricted endemic plant found only in a few geothermal environments within the park. Aesthetics and viewsheds of cultural landscapes and historic districts within the park have been altered by the establishment of exotic plant species.

Olliff et al. 2001 at 347.

"Budget limitations require the prioritization of weed species for management purposes, preclude expanded management efforts, and cast doubt on maintaining current activity beyond the short term. Given current levels of monitoring and the structure of the weed management database, no direct measure of success can be made." Olliff et al. 2001 at 357.

As of 2019, 225 exotic plants were recorded in Yellowstone National Park "approximately 15% of the taxa recorded (Whipple unpublished), a 50% increase from what was reported in Hansen et al. (2014)." Wacker 2019 at 64.

Native grass communities are also declining as a consequence of a rapidly changing climate in the Yellowstone ecosystem.

Between 1958–2002, a study of several exclosures on Yellowstone National Park's Northern range found "the mean frequency of grass species decreased in both grazed (−11%) and ungrazed (−28%) areas. Drought-tolerant genera, such as opuntia, phlox, and sedum, increased in both areas. Shrub dominance increased significantly in the absence of grazing, but diversity was not significantly different between ungrazed and grazed areas. Diversity and overall frequency of each lifeform was highest in the mid-1970s to early 1980s, but both decreased significantly at most sites by 2002." Sikkink & Alaback 2006 at 148.

"Fluctuations in climatic factors correlated more significantly with species change than did variations in non-native species or wildlife populations. The most significant environmental factors were spring and summer precipitation and spring and winter temperatures." Sikkink & Alaback 2006 at 148.

Among the results, the study's authors found "[d]rought-tolerant species, such as cactus (*Opuntia* *polyacantha*), phlox (*Phlox hoodii*), and sedum (*Sedum lanceolatum* and *Sedum stenopetalum*) all increased in frequency between 1958 or 1962 and 2002. Cactus increased from 0.0 to 2.95 mean hits; members of the phlox family increased from a mean of 4.5 to 6.2; and mean hits of *Crassulaceae* increased from 1.06 to 1.33. None of the increases between 1958 and 2002 were significant, however, with a two-sample t-test (p>0.05). The average richness for all samples was 9.75 species." Sikkink & Alaback 2006 at 150.

"[O]nly spring precipitation and winter temperature were positively correlated with point movements in species space (Figure 8)" among the environmental variables correlated with community change. Sikkink & Alaback 2006 at 152.

> From 1958 to 2002, the dynamic bunchgrass communities were affected by climatic fluctuation . . .
>
> . . .
>
> The most important influence on the presence of individual species and species dominance at any point in time in YNP, however, appears to be climatic fluctuation. Inside and outside the exclosures, diversity as well as grass and forb species have responded in similar ways through time, indicating that climatic controls on specific species override grazing effects in determining species dominance within these particular communities.
>
> . . .
>
> Path analysis indicates that the most important climatic factors for this time interval were mild spring and winter temperatures and increased moisture early in the growing season. Coughenour et al. (1991) found similar overriding climate controls on composition on the transect lines in YNP. Surprisingly, non-native species are not a significant influence on compositional change in the exclosures or their surrounding areas, although they have dramatically changed other grassland ecosystems (Hobbs 2001) and are a source of concern in other areas of the park (Yellowstone National Park 2005).
>
> . . .
>
> These data suggest that global climate change, which for this region is predicted to result in increasingly prolonged droughts, will create profound challenges for conservation of grassland systems in Yellowstone. Continued monitoring of these exclosures will be critical to determine the resiliency of these systems to increased climate-induced stress and further exotic species invasions, as well as their ability to sustain large populations of ungulates.

Sikkink & Alaback 2006 at 153, 155.

Climate change and "unprecedented" exotic plant invasions are projected to create a "high risk" of "catastrophic" consequences for dry sagebrush communities on Yellowstone bison's Northern range. Wacker 2019 at 65 (citing Bradley 2010, Bradford et al. 2014). The invasion of exotic plants has already reached Yellowstone bison's summer range and territories in the Lamar and Hayden valleys.

In order to anticipate and mitigate the effects of rapidly changing climate, YNP must continue

> to invest in long-term monitoring of plant communities. The dry sagebrush communities of Yellowstone are particularly susceptible to unprecedented invasions by winter annual grasses and forbs, specifically annual wheatgrass (*Eremopyrum triticeum*), cheatgrass (*Bromus tectorum*), and desert alyssum (*Alyssum desertorum*). Having witnessed complete community change in the Gardiner Basin in less than 30 years, it is clear that rapid and large-scale changes in other parts of the northern range are possible. While the arid conditions of the Gardiner Basin combined with a long history of varied land use is not replicated elsewhere in the park, it does illustrate the ability for non-native winter annuals to outcompete most native and even other non-native species in arid and/or drought conditions. Because these dry sagebrush communities are at high risk for catastrophic plant invasions, nine long-term monitoring locations have been established between the park boundary at Beattie Gulch and Mammoth Hot Springs. Figure 1 shows the proportion of desert alyssum in each foliar cover class (an estimation of abundance; follows Daubenmire 1959) at each location. Desert alyssum plus other winter annual species threaten other parts of the park, such as Lamar and Hayden valleys, particularly under the stress of projected climate scenarios of warmer, drier conditions. Only through consistent, continued monitoring will NPS scientists be able to detect the changes and determine ecological thresholds that when crossed, can result in potentially irreparable change to critical habitat.


PHOTO: Jackson Doyel

Wacker 2019 at 65–66.

Available bison habitat and forage will be harmed by rapid climate change and the "increased threat" of "ever-expanding invasive species populations." Wacker 2019 at 66.

Beyond bison's range in Yellowstone National Park, livestock grazing is extensive on bison's National Forest range and habitat in the Greater Yellowstone biorergion. Hansen 2009 at 29.

Livestock grazing is also extensive on bison's indigenous range on private lands in the ecosystem.

Haggerty studied land ownership in the Upper Yellowstone covering 511,000 acres between the boundary of Yellowstone National Park and the southern reaches of Eightmile and Elbow Creek drainages.

"A total of 142,213 acres are in private ownership, distributed among 1,256 owners" with twenty-five landowners controlling over 80,000 acres or 78% of privately held lands. Haggerty 2004 at 64 (footnote omitted).

Approximately 158,905 head of cattle are grazed in Park, Gallatin, and Madison counties. U.S. Dept. of Agriculture 2017.

The introduction of cattle and cattle diseases such as brucellosis to bison and elk has contributed to government management actions directed at restricting the natural range and migrations of Yellowstone bison.

Cumulative effects from the loss, fragmentation, and degradation of bison habitat from continuing human developments on private lands must be examined together with ongoing State and federal management actions limiting and reducing Yellowstone bison's range and migrations on National Forest and National Park lands.

> Land use intensification exerts influences on wildlife both in and near sites of logging, agriculture, and human settlements as well as in the remaining natural parts of an ecosystem. Perhaps the most obvious repercussions are loss, fragmentation, and degradation of habitat. Conversion of natural habitats to agriculture or other intensive human land uses causes these areas to become inhospitable for many native species. Community diversity declines as habitat area is reduced. Smaller habitats can support fewer individuals within a population, hence rates of extinction increase with habitat loss. The spatial pattern of habitat also influences biodiversity potential.
>
> . . .
>
> Hansen and DeFries (2007) outlined four general mechanisms through which land use change on private lands may impact biodiversity on public lands (Table 1). Land use may: (1) destroy natural habitats and reduce the effective size of the larger ecosystem which can: simplify the trophic structure as species with large home ranges are extirpated; cause the area of the ecosystem to fall below that needed to maintain natural disturbance regimes; and reduce species richness due to loss of habitat area; (2) alter characteristics of the air, water, and natural disturbances moving through the public lands; (3) eliminate or isolate seasonal habitats, migration habitats, or habitats that support source populations; and (4) increase human activity along public land boundaries, resulting in the introduction of invasive species, increased hunting and poaching, and higher incidence of wildlife disturbance.

Hansen 2009 at 29, 30.

All four mechanisms of habitat loss outlined by Hansen & DeFries are reducing the range and habitat of Yellowstone bison which is exacerbated by:

- Government jurisdictions imposing and enforcing boundary lines beyond which bison cannot range and are killed or excluded, thereby reducing the effective size of the ecosystem.
- Government management actions confining bison's range, migrations, and dispersal cutoff and undermine bison's keystone ecological roles, thereby limiting ecological flows in the ecosystem.
- Government management actions restricting bison's migrations and connectivity to habitat is expanding the loss of vital habitat and corridors to sustain the population in the wild.

• Ongoing government trapping for slaughter operations leaves fewer migrants on contiguous National Forest lands where bison are hunted or subject to government management actions harassing bison and prohibiting them altogether from roaming National Forest range and habitat.

These government-driven disturbances targeting Yellowstone bison occur during winter and spring when bison's physical condition and nutritional state is at its' most vulnerable.

Ongoing government imposed stressors on bison's access to habitat in the wild interact with other threats from a number of factors examined herein, e.g., restricting bison's ability to disperse beyond government "tolerance" zones together with loss of long distance migration corridors and loss of connectivity to habitat weakens Yellowstone bison's ability to withstand and survive catastrophic events and adapt to rapidly changing environmental conditions.

Government-designed constraints and government-driven mechanisms limiting bison's range threaten bison's ability to escape an inhospitable climate or environment in search of forage.

Additionally, habitat in "protected areas" in which government jurisdictions confine bison's natural migrations may be made unsuitable by climate change or climate variability such as a severe prolonged drought.

Meanwhile, habitat loss on private lands continues to encroach on bison's range in "protected areas" in the Yellowstone ecosystem.

Habitats identified as at risk include grasslands and sage steppe comprising 35% of the Greater Yellowstone bioregion. Key threats include exurban and urban development, agriculture, livestock grazing, alteration of fire regime, exotic species, and conifer encroachment. Hansen 2009 at 33 (Table 3).

A study of protected lands in the northern Rocky Mountains "in providing protection for habitat connectivity" found "[l]ow elevation and non-forest habitats are at highest risk of human-induced habitat loss and fragmentation" across 74.6 million acres of habitat in Montana and northern Idaho. Cushman et al. 2012 at 873.

Low elevation grasslands and valley bottoms bison prefer are not protected and vulnerable to further encroachment and loss of connectivity from human developments marching across the ecosystem.

> Protected lands in the northern Rocky Mountains are concentrated in higher elevation forested mountains. Our analysis shows that species associated with lower elevations and non-forest habitats are poorly protected by the network of federally owned lands. In addition, the vast majority of recent and expected future land use change and habitat loss is concentrated in the lower elevations (see Hansen & Rotella, 2002; Hansen et al., 2002). All major human population centres are concentrated in the lower elevation portions of the study area, and future expansion of residential, urban and industrial land use will be focused in these portions of the study area (but see Huston, 2005). In addition, the transportation network in the study area is concentrated in lower elevations, with most highways and railroads running along the bottom of major valleys between mountain ranges. Thus, current and future human land use impacts on habitat connectivity are concentrated in the lower

> elevation portions of the study area, making species associated with these conditions particularly vulnerable. Climate change is also likely to reduce the area and increase the fragmentation of low elevation forest habitats, as lower tree line moves upwards in elevation (Grace et al., 2002). Thus, there is a confluence of stressors on species associated with low elevation habitats, which also are least protected by the existing protected lands network.
>
> The second major implication of our findings is that different categories of protected lands provide dramatically different degrees of protection of dispersal habitat. The lowest category of protection (Category I, all federal lands) provides at least moderate protection for all hypothetical species considered in this study and a high degree of protection for species associated with higher elevations. However, roughly half of the species were poorly protected by Category II protected lands (Wilderness, National Parks and Roadless Areas), and no species were well protected by Category II protected lands. This shows that the multiple-use matrix that comprises the majority of federal lands is immensely important to regional population connectivity for most species. Thus, managers must not assume that existing strict protection of Wilderness areas and National Parks will be sufficient. This is particularly true for those species associated with lower elevations. No species were well protected by Category III protected lands, indicating that roadless areas are a critical element in the conservation effectiveness of the strictly protected lands. If roadless lands are released from strict protection and incorporated into the multiple-use matrix, no species would be well protected, and most species would be poorly protected by strictly protected land designations.

Cushman et al. 2012 at 881.

A study of the Upper Yellowstone River Basin encompassing 1,828,579 acres found "early-season grassland growth, which represents a critical resource for ungulates, is primarily limited to private lands north" of Yellowstone National Park. Piekielek 2012 at 61.

"[T]he full spectrum of wildland grassland productivity within the study-area is now represented on private-lands under mixed land uses." Piekielek 2012 at 108.

The best available evidence points to continuing loss and fragmentation of bison range from expanding human developments with bison migration corridors among the most heavily impacted habitats.

Harmful effects for the foreseeable future for Yellowstone bison include long-term loss of connectivity to habitat, loss of gene flow, reduced viability, and an increased risk of extinction from rapid climate change and inhospitable climate variation such as severe prolonged drought and snow crusting events.

"[F]ragmentation due to land use reduces connectivity of habitats that is essential to species shifting range under change climate." Hansen 2009 at 34.

> We found that the measured biodiversity responses, including riparian habitat, elk winter range, migration corridors, and eight other land cover, habitat, and biodiversity indices, are likely to undergo substantial conversion (between 5% and 40%) to exurban development by 2020. Future habitat conversion to exurban development outside the region's nature

> reserves is likely to impact wildlife populations within the reserves. Existing growth management policies will provide minimal protection to biodiversity in this region.
>
> . . .
>
> We found that future habitat conversion to exurban development outside the region's nature reserves will probably impact wildlife populations within the reserves. Highly productive lands where biodiversity is concentrated, including riparian areas, aspen stands, and bird hotspots, are underrepresented within reserves and highly impacted by exurban development. These habitats are population source areas for some species and their loss would probably increase the risk of extinction within protected areas (Hansen and Rotella 2002). Potential mammal migration corridors are likely to be vital resources for the ungulates and other large mammals that occur within the parks, and were forecasted to be among the most heavily impacted by exurban development (24%). Loss of these corridors would probably reduce gene flow and decrease long-term viability of species isolated within the protected areas of the GYE (Noss 1983, 1987, Noss and Harris 1986).

Gude et al. 2007 at 1004, 1015.

The U.S. Fish & Wildlife Service must examine and investigate the cumulative effects of forage degradation, habitat loss and fragmentation, loss of corridors and connectivity to habitat, together with government actions restricting the ecological diversity and settings for Yellowstone bison in the agency's threats assessment and status review. All of these factors are striking against a vital adaptive capability of Yellowstone bison: migration and dispersal to survive and reproduce in a rapidly changing climate and environment.

> Range can be taken directly, via agriculture, development (infrastructure, fossil fuels), or grazing livestock; fencing works indirectly, by barring access.
>
> . . .
>
> Mass migrations usually extend beyond protected areas, which are simply too small to contain them. Hence, agriculture and development outside of parks often threaten migrations (Campbell & Borner 1995, Kahurananga & Silkiluwasha 1997, Homewood et al. 2001). Lack of adequate protection within parks also poses problems (Newmark 1987).
>
> . . .
>
> Migrants' abilities to adapt to changing environmental conditions are likely exacerbated by other anthropogenic threats, such as habitat loss and fragmentation (Jetz et al. 2007).

Harris et al 2009 at 68.

"Long distance migrations by ungulate species often surpass the boundaries of preservation areas where conflicts with various publics lead to management actions that can threaten populations." Geremia et al. Feb. 2011 at 1.

The biological consequences of State and federal managers killing migratory Yellowstone bison generation after generation and decade after decade has yet to be investigated.

Even so, the ongoing killing of Yellowstone bison must be examined because the systemic loss of migrants together with continued habitat loss and fragmentation of remaining corridors is a threat to bison retaining this vital adaptive capacity and evolved behavior.

> We demonstrate that collective migratory strategies evolve under a wide range of ecological scenarios, even when social encounters are rare. Although collective migration appears to be a shared navigational process, populations typically consist of small proportions of individuals actively acquiring directional information from their environment, whereas the majorities use a socially facilitated movement behavior. Because many migratory species face severe threat through anthropogenic influences, we also explore the microevolutionary response of migratory strategies to environmental pressures. We predict a gradual decline of migration due to increasing habitat destruction and argue that much greater restoration is required to recover lost behaviors (i.e., a strong hysteresis effect). Our results provide insights into both the proximate and ultimate factors that underlie evolved migratory behavior in nature.
>
> . . .
>
> Anthropogenic pressures can significantly influence population density, as seen in the steep decline of American bison (*Bison bison*), and even result in extinction . . .
>
> In migratory species, as habitat fragmentation increases, individuals have to travel disproportionately larger distances to reach suitable habitats [because of, for example, a reduced frequency of encountering stop-over or refueling sites] and thus to accumulate migratory benefits.
>
> We find that, in habitats that fragment, the resulting ability of the population to migrate reduces relatively gradually (Fig. 4*B*, solid line). At high levels of habitat fragmentation, no individuals evolve to be leaders, and therefore, the population loses its migratory ability. Even after restoring the habitat, however, a population's migratory ability does not recover at the same habitat quality at which it declined; i.e., it shows strong hysteresis, or memory, effects (Fig. 4*B*, dotted line). In highly fragmented habitats, a small mutation in $\omega_{gi}$ that mildly alters the information use does not improve the individual's fitness; it requires large mutations in $\omega_{gi}$, exceeding a threshold, to sufficiently enhance the information use and thus migratory benefits that exceed the costs incurred (in $\omega_{gi}$). Large mutations, however, typically do not occur on relatively short ecological time scales. Upon substantial habitat restoration, the required threshold change in the information use reduces and can be reached by mutations occurring on ecological time scales and hence migratory ability is reestablished (*SI Appendix H*).
>
> . . .
>
> Our model predicts that individuals who invest in acquiring information about the migratory direction from environmental cues are readily exploited by others who adopt a socially facilitated movement behavior. For a wide range of biological assumptions, these two

coexisting strategies result in collective migration with fission–fusion process. Furthermore, even when interactions among organisms are very sparse and would typically be considered insignificant, we find that social interactions play an important (and perhaps hitherto unknown) role.

Collective migration occurs also when all individuals of a population evolve to use both the migratory directional information and social cues. Migrating groups in these evolved populations preserve their group composition over relatively long time scales. However, this strategy is expected to occur only when the costs of gradient information use and sociality are both negligibly small in comparison with the benefits of migration. We also emphasize general predictions of our model, that the ecology of species, represented by population density, habitat structure, costs, and benefits of migration, determines whether populations will evolve to a resident, a solitary migratory, or a collective migratory strategy.

. . .

Climate change and habitat destruction can dramatically alter the migratory patterns; for example, migratory species may become resident [e.g., blackcaps (*Sylvia atricapilla*);], or lost migration can reappear [e.g., eastern house finch (*Carpodacus mexicanus*);]. Using our model, we predict a gradual decline of migratory behavior because of habitat destruction, but, owing to relatively short time scale of these changes, the reestablishment of lost behaviors will require substantially greater restoration. Our study shows that the time scales of ecological changes play a crucial role in determining the response of migratory species.

Guttal & Couzin 2010 at 16172, 16173, 16175, 16176 (endnotes and references omitted).

Insofar as changes in land use bring more humans into conflict with bison, loss and fragmentation of habitat on private lands reinforces the geo-political "tolerance zones" State and federal managers have imposed reducing and eliminating bison from their range and habitat on millions of acres of National public trust lands.

The forecast for more human development and ongoing government intolerance represents a threat to large migratory mammals like Yellowstone bison.

In the absence of measures to preserve wildlife corridors and connectivity to habitat, the passage of time is certain to complicate and potentially eclipse opportunities to conserve the migratory species in the bioregion,

PHOTO: BFC Archives

the iconic long-distance migrations Yellowstone bison are known for, and the wild species' ability to adapt to and withstand current and predicted stressors on the horizon.

Ongoing appropriation of land for human use and the introduction of livestock into Yellowstone bison's range and habitat is a systemic threat to the migratory species' ability to disperse and recover from inhospitable environmental conditions and intensive State and federal management actions.

Substantial loss of range, habitat degradation and fragmentation, loss of corridors, and connectivity to habitat are cumulative stressors striking against the resiliency of Yellowstone bison in the ecosystem.

Because continuing habitat loss and fragmentation of corridors to human developments and ongoing government intolerance is significantly reducing the margin of safety for Yellowstone bison to escape and survive an inhospitable environment, the U.S. Fish & Wildlife Service must examine and investigate these systemic stressors in the agency's threats assessment and status review.

***The States of Montana, Idaho, and Wyoming confine and reduce the range of migratory Yellowstone bison, and reduce and eradicate the wild species roaming their range and habitat on National public trust lands.***

> "If the public gets used to the idea that bison, like elk and deer, should be free to roam on federal lands managed by the Forest Service and Bureau of Land Management, then it may lead to a reduction in the amount of public lands forage allotted to livestock. That's what the ranchers really fear."

Zontek 2003 at 182 (quoting an anonymous Wyoming Fish & Game official) (endnote omitted).

The States' view "protected areas" such as parks as enclosures to confine and limit the migratory range of Yellowstone bison. Hence, the States' regulatory mechanisms calling for the killing of bison in their range is best understood as enforcement of the enclosure.

The hostile regulatory position of the States must therefore be examined and investigated as one of several mechanisms of government and human intolerance threatening or endangering Yellowstone bison roaming their home range and habitat.

The States' regulatory mechanisms jeopardize the potential for sustaining bison's natural patterns and processes over meaningful evolutionary time scales in the Yellowstone ecosystem.

PHOTO: BFC Archives

The States' regulatory framework also undermines the potential for the persistence of a self-sustaining population of wild bison with a distinct population structure on National public trust lands in the Yellowstone ecosystem.

State and federal management actions restricting bison from accessing their range also impairs Yellowstone bison's keystone ecological role in providing for grassland ecosystem function and diversity of native insect, plant, bird, amphibian, and animal species.

The enforcement of regulatory codes in Montana, Idaho, and Wyoming eliminates Yellowstone bison diversity and limits and reduces the geographic representation and ecological settings of the wild species on National Forests across three Regions.

Together, the laws and policies of Montana, Idaho, and Wyoming calling for the eradication and elimination of migratory bison in their natural range and habitat is a significant and ongoing threat to the persistence of Yellowstone bison as a wild species.

While the States have a duty to manage wildlife as a public trust for the benefit of future generations, the States' collective actions against Yellowstone bison make plain government power is not being exercised "as a trust for the benefit of the people." Nie et al. 2017 at 806 (quoting *Geer v. Connecticut*, 161 U.S. 519 (1896)).

In acting in concert with and in deference to the States in confining the natural range of Yellowstone bison, the National Park Service and U.S. Forest Service are contributing to the loss of habitat for Yellowstone bison on National public trust lands.

Human intolerance as imposed by the government is limiting and reducing the natural distribution, abundance, and migrations of Yellowstone bison in their range and is a persistent threat and stressor on the wild species for the foreseeable future.

In confining and restricting Yellowstone bison's natural range, State and federal managers are reducing the size of the ecosystem and undermining the migratory species' nutritional condition, fitness, and keystone ecological roles. In turn, the ecosystem is degrading as a consequence of the government enclosing bison in so-called tolerance zones.

> There are 2 management implications related to ungulates having indirect effects on aboveground production. First, changing the natural migratory patterns of ungulates by herding or fencing may lessen, break, or reverse the positive feedback between herbivores and their forage. Second, because grazers can indirectly influence their food supply, a grassland's carrying capacity can be modified by the ungulates themselves.

Frank 1998 at 414.

> These findings also have several implications for the management of ungulate populations. First, they indicate a potentially tenuous nutritional status of grazing animals in the wild. Second, they identify minerals that may be particularly important supplements for wild populations. And third, the results emphasize the importance of seasonal migration of ungulates for maintaining the animals' nutritional condition and suggest potential deficiencies for animals whose migratory movements are restricted.

Frank 1998 at 412.

By statute, Yellowstone bison migrating onto National Forest habitat in Region 2 in Wyoming are managed in limited numbers in restricted areas for extirpation. Wyoming Game & Fish Department 2008 entire; Wyo. Stat. Ann. § 23-1-302(a)(xxvii) (2022).

The outcome of enforcing Wyoming law and placing the native species under Wyoming livestock board authority reduces bison genetic diversity and habitat to virtually zero on the Shoshone National Forest in Wyoming.

By statute, Yellowstone bison migrating onto Caribou-Targhee National Forest habitat in Region 4 and elsewhere in Idaho are eradicated as a matter of law despite their critically imperiled status in the State. Idaho Code § 25-618(1) (2021); Adams & Dood 2011 at 108.

The regulatory framework for eliminating Yellowstone bison from their range and habitat in Montana is defined in the State's and Yellowstone National Park's bison management plan in separately released decisions. The plan is a product of a negotiated settlement between Montana and Yellowstone National Park. The settlement is the result of a lawsuit Montana filed against Yellowstone National Park based on Mont. Code Ann. § 81-2-120. The statute became law in 1995 and displaced Montana Fish, Wildlife & Parks management of bison. The statute authorizes the Montana Dept. of Livestock to take bison wherever they roam. The statute is void of any provision for conserving bison in their range and habitat in the wild. The statute grants Montana's veterinarian and the Department of Livestock broad authority to use veterinary management (trap, slaughter, quarantine, vaccinate) and livestock agents to destroy or harass wild bison migrating into the State. The Interagency Bison Management Plan is the Governor-approved plan the statute calls for.

"There are no court orders covering the issuance of" the Record of Decision agreed to by the State of Montana and Yellowstone National Park. U.S. Dept. of the Interior & U.S. Dept. of Agriculture Record of Decision 2000 at 38 (IV. Findings A. Compliance with Court Orders); *see also* Montana Dept. of Livestock and Montana Fish, Wildlife & Parks 2000 at 1–3 (providing a rationale and context for the decision). The voluntary agreement is entered into by memorandum.

Yellowstone bison movements are intensely monitored by State and federal agents. Interagency Bison Management Plan Members 2022 at 4–5.

"Bison movements toward park boundaries prompt government agencies to assume a state of readiness. The National Park Service informs state agencies when transgressions appear imminent." Lulka 1998 at 79.

Bison are confined in government delineated "tolerance" zones.

In Zone 1, Yellowstone National Park traps bison for slaughter and quarantine. In Zone 2, bison are hunted on or harassed from National Forest habitat, including calving grounds, in government-led hazing operations. Bison migrations transgressing Zone 3 boundaries result in lethal management actions or removal by other means. Interagency Bison Management Plan 2022 at 8–10; U.S. Dept. of the Interior & U.S. Dept. of Agriculture Record of Decision 2000 at 26 ("Zone 3 is the area where bison that leave Zone 2 will be subject to lethal removal.").

State and federal government intolerance of bison roaming their home range has been ongoing for decades.

"The ability of Yellowstone's bison to define their own biogeography" and conserve natural variation in the ecosystem has been met with government opposition and intolerance as reflected in National Park Service management actions dating to the late 1970s and mid-1980s:

> Sporadic movements beyond park boundaries were observed during this period. An arsenal of non-lethal boundary control weapons were administered by the Park Service to restrict bison migrations. Methods included hazing by helicopters, herding by park personnel, installation of cattleguards, construction of fences along known travel routes, playing tape-recorded wolf howls, use of noise-making devices such as "cracker shells", firing of rubber bullets, and baiting bison with hay among others.

Lulka 1998 at 86.


PHOTO: Darrell Geist

The foundation for Montana's policy was laid with passage of Mont. Code Ann. § 81-2-120 which placed migratory bison under the primary authority of the Dept. of Livestock and the State veterinarian. Montana's bison policy was officially incorporated as the policy of the National Park Service and the U.S. Forest Service in 2000. Montana Dept. of Livestock and Montana Fish, Wildlife & Parks 2000; U.S. Dept. of the Interior & U.S. Dept. of Agriculture 2000.

As foreseen by some, the coordination of State and federal government agencies has "broadened the comprehensiveness of bison management and increased the efficiency with which bison are removed from the landscape." Lulka 1998 at 106–107.

The evidence demonstrates Montana's and Yellowstone National Park's bison management plan is not based on the best available science. Arbitrary provisions, much like the objective below that has been in place since 2000, strictly confine and limit Yellowstone bison's migrations and range.

> Clearly define a boundary line beyond which bison will not be tolerated.

Interagency Bison Management Plan Members 2022 at 2.

The boundary line is enforced to "haze or shoot bison on private land or crossing out of zones in boundary areas," as part of the government's objective to "[p]rotect livestock from the risk of brucellosis." U.S. Dept. of the Interior & U.S. Dept. of Agriculture 2000 Vol. 1 at 221 (Table 11: Methods Each Alternative Uses to Ensure Each Agreed-Upon Objective Is Met).

Despite significant changes in State and federal policies and rules benefitting cattle ranchers in the tri-state region, State and federal managers have failed to propose any measure in response to the changed circumstances favoring the natural range of bison in the wild similar to elk.

For detailed evidence and analysis of how Montana permits wild elk to freely range while wild bison's range is restricted and the Yellowstone population is subject to arbitrary government actions, *see* factor 8.C.

Furthermore, under the objective that management actions be "based on factual information, with the recognition that the scientific database is changing," the government's assumed carrying capacity of 3,000 bison is also not validated by evidence. U.S. Dept. of the Interior & U.S. Dept. of Agriculture 2000 Vol. 1 at 223 (Table 11: Methods Each Alternative Uses to Ensure Each Agreed-Upon Objective Is Met); see also Plumb et al. 2009 at 2384 (assuming a wide variation in "food-limited carrying capacity" of 2,400 bison in the Northern herd and 3,800 bison in the Central herd in Yellowstone National Park alone).

PHOTO: Darrell Geist

Even when migratory bison have won new ground to range under current management, in each instance, the gain has come with a rollback.

For example, in Hebgen basin Montana Governor Steve Bullock rolled back "tolerance" for bison on the south side of the Madison River, the South Fork, and habitat westward including National Forest habitat. Gov. Bullock 2016 (Erratum); Custer Gallatin Final Permitted Livestock Grazing Report 2017 at 100–102 (Grazing Allotments – Bison Management Zones Figures D6, D7, and D8).

After a forest fire in 2008, migratory bison, including matriarch-led groups, were frequently seen in burned lodgepole pine habitat south and west along the Madison River corridor. Geist & Mease pers. observations.

The ecological benefit of having bison in a fire-adapted forest habitat burned by natural fire was negated in an erratum subjecting the Central herd to government harassment, a more limited summer season, and a limit on bison numbers in Hebgen basin. Gov. Bullock 2016 (Erratum).

In Gardiner basin, the ink had hardly dried on manager's decision to expand habitat for bison when the Montana Dept. of Livestock sought and got changes to rollback provisions benefitting bison. Montana Dept. of Livestock 2013 (maintaining an "actionable" zone to haze bison and reduce "the opportunity for bison to breach the tolerance zone boundaries by employing management actions" within Zone 2, an area that supposedly expanded "tolerance" for bison in the basin).

Clearly, the cattle industry, with backing from State governments in Montana, Idaho, and Wyoming has successfully restricted the range and habitat of Yellowstone bison.

Yet, remarkably, the harmful outcomes of eradicating bison and confining migrations and undermining their biological contributions to the ecosystem in their home range has not been examined and investigated as a threat or endangerment to the persistence of the wild species and the ecosystem on which they depend. The U.S. Fish & Wildlife Service must do so in the agency's threats assessment and status review.

For Yellowstone bison, coordinated State and federal agency actions have increased the efficiency of managing for the wild species' extirpation in their range and habitat as defined in the State codes of Montana, Idaho, and Wyoming.

The enforcement of State codes is a hostile and systemic factor driving the loss of Yellowstone bison's range and habitat for the foreseeable future and must be examined and investigated as a threat to the population's resiliency and representation in the ecosystem.

***Yellowstone National Park has created an artificial population sinkhole limiting the distribution and connectivity of Yellowstone bison to their range in the ecosystem. Yellowstone National Park can no longer be considered a protected area for wild bison.***

Bison are the "only wild animal in the United States that is not allowed to live as a wild animal—live outside parks and refuges—anywhere in its original range." Lott 2002 at 201.

Acres of habitat in the Greater Yellowstone bioregion: 22,000,000
Acres of available bison habitat in Yellowstone National Park: 784,560

In the Greater Yellowstone bioregion:
- 63% is public land covering two national parks, five national forests, three national wildlife refuges, Bureau of Land Management holdings, and state lands.
- 32% is privately owned.
- 5% is Tribal land.

Shafer 2015 at 258; Custer Gallatin Final Terrestrial Wildlife Report 2017 at 133.

Despite ample authority provided by the U.S. Congress, the Organic Act and National Park Service regulations are ineffective in mitigating the threat of Yellowstone National Park as an artificial bison population sink for Yellowstone bison roaming their range and habitat, and the harmful cascading effects on bison and the ecosystem in their range.

784,560 acres of bison habitat is available in Yellowstone National Park primarily located in Wyoming, and covering portions of Montana and Idaho. Custer Gallatin Final Terrestrial Wildlife Report 2017 at 133.

Bison range recovery is precluded by intense and on-going government interventions across several State and federal jurisdictions. Geremia et al. Feb. 2011 at 1.

Yellowstone National Park has operated a bison trap at Stephens Creek since 1996, the largest source of bison mortality in the ecosystem. Yellowstone National Park 2016 at 12; White et al. 2011 at 1329 (Table 4); Geremia 2022 at 7–8 (Table A3).

PHOTO: BFC Archives

In establishing a trap in the bison's range within the park, Yellowstone National Park has created an artificial population sinkhole limiting bison herd diversity, distribution, and connectivity to their range in the ecosystem.

Because of ongoing management actions targeting the migratory species for government trapping and slaughter, Yellowstone National

Park can no longer be considered a protected area for wild bison.

Bison biologists recognize management is a threat to bison, and their attendant loss degrades the native species' beneficial ecological roles in the ecosystem. But State and federal managers turn a blind eye to the evidence before them.

> Limiting bison abundance to lower numbers will likely reduce (but not eliminate) the frequency of large-scale migrations into Montana, but could also hamper the conservation of this unique population of wild, free-ranging bison by adversely affecting the population's resiliency to respond to environmental challenges, genetic diversity, and the ecological role of bison in the ecosystem through the creation of landscape heterozygosity, nutrient redistribution, competition with other ungulates, prey for carnivores, habitat creation for grassland birds and other species, provision of carcasses for scavengers, stimulation of primary production, and opened access to vegetation through snow cover.

Geremia et al. Feb. 2011 at 7 (endnotes omitted).

Both subpopulations have suffered significant and disproportionate losses as a result of Yellowstone National Park's trapping for slaughter operations in the bison's home range. Halbert et al. 2012 at 368 (57% of the Northern herd killed in 1996–1997); Halbert 2003 at 131 (manager's assume killing is genetically random with "no real impact" on the bison population's genetic constitution), at 148–149 (disproportionate killing may result in loss of genetic variation in subpopulations and the bison population), at 151–152 (evidence of nonrandom killing of a "disconcerting number" of bison "parent-offspring pairs and family groups."); Geremia 2022 at 5–6 (Recording the decimation of the genetically distinct subpopulation of Central herd bison with a loss in number of 3,553 to 847 from 2005 to 2017).

From 2008 to the present, the number of Central herd bison has been far below conservation biology thresholds "to avoid inbreeding depression and maintain genetic variation." Geremia 2022 at 5–6 (Table A1); Hedrick 2009 at 419.

Yellowstone bison's range and habitat in the protected area of Yellowstone National Park has been turned into an artificial population sinkhole from which the Central bison herd has yet to recover.

Ongoing management actions threatening the persistence of genetically distinct subpopulations undercuts Yellowstone National Park as a protected area for Yellowstone bison.

***No self-sustaining bison populations exist in the wild on more than 145 million acres of National Forest habitat in the Western United States.***

There is no wild bison population anchored by National Forest habitat and range in the Western United States.

Despite being the trustee for 145 million acres of habitat in the Western Region alone, "[n]o self-sustaining herds of wild plains bison exist on National Forest System lands." U.S. Forest Service Region 2 Regional TES Species Program Leader Warren 2011.

Acres of National Forest: 192,922,127
Acres of National Forest in the Western Region: 145,184,376
Acres of National Forest in Region 1: 25,550,270
Acres of National Forest in Region 2: 22,051,028
Acres of National Forest in Region 4: 31,885,607
Acres of National Forest on the Custer Gallatin: 3,039,325
Acres of National Forest on the Shoshone: 2,439,093
Acres of National Forest on the Caribou-Targhee: 2,624,739
Acres of suitable bison habitat on the Custer Gallatin in Montana-imposed “tolerance zones”: 293,151
Acres of suitable habitat bison are predicted to use on the Custer Gallatin in Montana-imposed “tolerance zones”: 83,751

U.S. Forest Service 2015 (Table 1 and Table 3); Custer Gallatin Final Terrestrial Wildlife Report 2017 at 1, 134; Wallen 2012 (acres of habitat bison are predicted to use on the Custer Gallatin includes some private lands).

***Under State of Montana imposed “tolerance zones,” the range of Yellowstone bison is limited and restricted, and the migratory population is reduced by government trapping and hunting on National Forest habitat in Region 1.***

In spite of its’ public trust duty, the Custer Gallatin has let State forces usurp federal authority and undermined the provision of bison habitat and connectivity to range on the National Forest.

The State of Montana imposes and enforces “tolerance zones” for bison migrating to range and habitat on the Custer Gallatin.

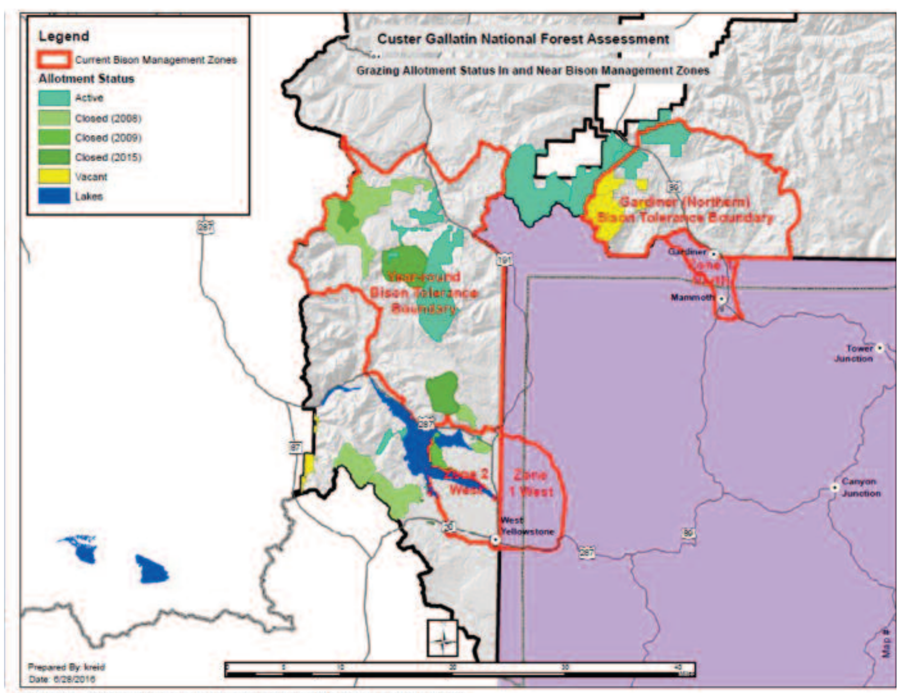


Figure D-6. General location of allotments in or near bison management zones

The Custer Gallatin incorporated the State’s “tolerance zones” excluding bison from substantial portions of their National Forest range and habitat in its’ land management plan. Custer Gallatin National Forest Land Management Plan 2022 at 57–58.

Located in Region 1, the Custer Gallatin includes 3,039,325 acres of National Forest System lands (Federal) and 384,270 acres of non-Federal (private, state and tribal lands). Custer Gallatin Final Land Status and Ownership, Land Uses, and Access Patterns Report 2017 at 3.

On habitat contiguous to Yellowstone National Park, bison are currently using or predicted to use 83,751 acres on the Custer Gallatin National Forest and some private lands. Wallen 2012.

In Gardiner basin, of 102,501 acres available to bison in "tolerance zones," current use is 7,136 acres and predicted use is 30,123 acres. In Eagle Creek, a year-round "tolerance" area for bison, current use is 5,417 acres and predicted use is 10,026 acres. In Hebgen basin, of 146,625 acres available to bison in "tolerance zones," current use is 21,795 acres and predicted use is 43,602 acres. Wallen 2012.

Management actions reduce current and predicted habitat use in both basins, e.g., the State of Montana harasses bison migrating south of the Madison River and westward to the South Fork in Hebgen basin, and biological facts, i.e., during winter, few bison climb to the top of hydrological divides in Gardiner basin. Bison that attempt to or do move beyond Gardiner basin breach the government's drop-dead zone.

PHOTO: Darrell Geist

In addition, the government has reduced "the opportunity for bison to breach the tolerance zone boundaries by employing management actions at the most efficient trigger points in consideration of overall conditions and risks." Montana Dept. of Livestock 2013.

While habitat counted above on the Custer Gallatin is available in the Upper Gallatin River (Jourdonnais 2006) few if any bison naturally roam there after being extirpated by government management actions in the 1990s. Geist & Mease pers. observations; White et al. 2018 at 11.

The re-appearance of bison in the Upper Gallatin coincided with major crown fires in the Yellowstone region in 1988. Geremia & Cunningham 2018 at 8 (identifying a migration route bison likely used during the mid-1990s to reach the headwaters of the Gallatin River).

In addition, from 1995–2010, the Montana Dept. of Livestock shot or trapped for slaughter 1,482 bison migrating into Hebgen basin, a habitat comprised primarily of National Forest land. White et al. 2011 at 1329.

The National Forest permitted the livestock agency to trap migratory bison on Horse Butte peninsula — the Central herd's calving grounds and wintering habitat — for shipment to slaughter. The National Forest originally permitted the Horse Butte bison trap in 1998 and renewed the Montana Dept. of Livestock's special use permit for another 10 years in 2009. Gallatin National Forest Jan. 13, 2009 entire.

State and federal managers are reviewing additional traps in bison's current range, including sites on the Custer Gallatin National Forest. Reid 2018 entire.

In spite of its' legal authority from the U.S. Congress to manage for species diversity and viability under the National Forest Management Act of 1976, the Custer Gallatin cooperates with the State of Montana in restricting or limiting the range of bison on National Forest lands in several ways.

In its' revised forest plan process, the Custer Gallatin confirmed the agency's compliance with Montana's regulatory intolerance by foregoing analysis of habitat bison once occupied:

> Given current constraints on bison tolerance, there is no expectation that bison would be re-established outside of the landscapes that are adjacent to Yellowstone National Park. Therefore, habitat was assessed only for the Madison, Gallatin and Beartooth landscape.

Custer Gallatin Final Terrestrial Wildlife Report 2017 at 134.

The Custer Gallatin admits there is an expectation government intolerance will continue to operate on Yellowstone bison — confining movements and limiting access to their National Forest habitat and range for the foreseeable future.

It is axiomatic that the less habitat available for bison to adapt and evolve, the greater the risk to native species and ecological processes. Committee of Scientists 1999 at 147.

According to the Committee of Scientists, the core elements of ecological sustainability depend on the diversity of plant and animal communities and the productive capacity of ecological systems. "Biological diversity and ecological productivity, in turn, depend on the viability of individual species. Diversity is sustained only when species persist." Committee of Scientists 1999 at 176.

Human intolerance imposed in government management actions is limiting and reducing the natural distribution, abundance, and migrations of bison in their current range and is a persistent threat and stressor foreseen on the Custer Gallatin National Forest.

In coordinating with Montana in limiting and reducing bison range, the Custer Gallatin is placing the wild species at increased risk of local extinction on the National Forest and in the State.

***Introducing cattle limits and reduces the range of migratory bison, and is degrading habitat in the ecosystem bison depend on for survival.***

The introduction of cattle into Yellowstone bison's range degrades bison habitat, and limits and reduces the native species' range.

In introducing cattle into bison's range, the cattle industry is also displacing and excluding bison from their home range and habitat.

In addition to displacing bison from their indigenous range across hundreds of millions of acres of National public trust lands in the Western United States, where permitted, cattle and sheep degrade the native species' habitat, soils, and water quality.

> Livestock are the principal cause of soil erosion and stream degradation. (Jones 2000; Belsky et al, 1999).
>
> Livestock are the most pervasive cause of riparian damage. Up to 80% of Western streams have been damaged by livestock. (Belsky, et al. 1990).

> Most harm to archeological resources is from livestock and from ranch access roads, fences, tanks and other ground disturbing range developments. (Osborn et al. 1987; Broadhead 1999).
>
> Removes wild competitors for forage. (Moskowitz and Romaniello 2002, Table A-2).
>
> Considerable harm to wildlife results from the pervasive competition for forage and removal of cover by livestock. (Fleischner 1994).
>
> Considerable harm to threatened and endangered species results from the pervasive competition for forage and removal of cover by livestock. (Fleischner 1994, Flather et al. 1994; Czech and Kraussman 1997).
>
> Herbicides are the main tool used to control weeds that are spread by livestock operations. Many noxious weeds are spread by livestock operations. (Belsky and Gelbard 2000, Reisner 2013).
>
> Grazing is often the land use most in conflict with wildlife habitat needs and necessitates fencing. (Fleischner 1994).
>
> Grazing is the [principal] cause of the growth of highly flammable thickets in western ponderosa pine forests, and for invasion of rangelands by pinion, juniper and other woody shrubs. Wildland fire management includes thinning of thickets and prescribed fires to reduce fuel loads. (Belsky and Blumenthal 1995).

Glaser et al. 2015 at 32–33 (Appendix A) BLM Budget Items Potentially Containing Indirect Costs of Grazing BLM, (Table A2) USFS Budget Items Potentially Containing Indirect Costs of Grazing Program, *see also* other government agencies' contributions to grazing livestock on National public trust lands at 34–35.

Furthermore, cattle introduced into bison range reduce the biological diversity bison create in the wild as a keystone species and ecological engineer.

Introduced cattle — an on-going source of conflict and subsequent killing of native bison — are widely permitted and distributed across the bison's range on National Forests in the Western United States.

One representative National Forest in the bison's range, the Custer Gallatin, is speckled with 36,000 head of cattle with one-third of the forest's habitat allocated for grazing livestock.

**Custer Gallatin National Forest**

> Acres of National Forest in Region 1: 25,550,270
> Acres of National Forest on the Custer Gallatin: 3,039,325
> Acres of primary range for grazing livestock: 666,233
> Acres allotted for grazing livestock: 1,117,456
> Percent of the Custer Gallatin allocated for grazing livestock: 36.7
> Percent of the Pine Savanna forest allocated for grazing livestock: 93

Percent of the Montane forest allocated for grazing livestock: 22
Number of permitted grazing allotments: 216/199 active
Number of permitted cattle: 36,259
Number of permitted horses: 548
Number of permitted domestic bison: 400
Number of permitted Animal Unit Months: 202,187
An Animal Unit Month: 780 pounds dry weight forage for a 1,000-pound cow for one month
Cost per Animal Unit Month: $1.35
Miles of fencing on active livestock grazing allotments: 2,775
Number of dugouts, guzzlers, ponds, reservoirs, storage tanks, and troughs on active livestock grazing allotments: 1,849
Number of proper functioning riparian habitats within grazing allotments: 184
Number of functional-at-risk riparian habitats within grazing allotments: 70
Number of nonfunctional riparian habitats within grazing allotments: 7

U.S. Forest Service 2015 (Table 3); Custer Gallatin Final Permitted Livestock Grazing Report 2017 at 42, 7, 1, 49, 15, 18, 20, 19; Custer Gallatin Grazing Allotments (Pine Savanna) Map and Custer Gallatin Grazing Allotments (Montane) Map Feb. 16, 2017; U.S. Dept. of Agriculture, Forest Service 2022.

Under the State of Montana's and Yellowstone National Park's bison management plan, government managers require the killing of bison migrating in their range to prevent any temporal and spatial contact with cattle. As a result, the Custer Gallatin's cattle grazing program is an additional threat to bison range because introducing cattle results in the loss, reduction, and displacement of the native species from their National Forest range and habitat.

The Custer Gallatin permits numerous livestock grazing allotments throughout bison's range. Custer Gallatin Grazing Allotments (Pine Savanna) Map (Feb. 16, 2017); Custer Gallatin Grazing Allotments (Montane) Map (Feb. 16, 2017); Auttelet et al. 2015 at 6 (Figure 1.1). As a result, native bison have been displaced from substantial portions of their National Forest range and habitat.


PHOTO: Darrell Geist

Since the 1990s, the Custer Gallatin's claimed authority to modify livestock grazing permits and accommodate bison has been used once. Custer Gallatin Final Permitted Livestock Grazing Report 2017 at 115.

This one exception demonstrates the lack of regulatory mechanisms or actionable policy addressing the National Forest Management Act's mandate to provide for diversity of plant and animal communities including native bison. Nie 2018 at 16–19 (citing § 219.9 of the 2012 National Forest planning rule and its' implementation).

Bison diversity cannot be sustained without access to habitat in their home range. "Diversity is sustained only when species persist." Committee of Scientists 1999 at 176.

Preferentially managing for livestock displaces bison on National Forests resulting in a loss of a key grizzly bear food at the same time it brings grizzly bears into potential conflict with livestock resulting in dead bears. Mattson 2017 at 16; Haroldson & Frey 2011–2017.

For grizzly bears and bison, the U.S. Forest Service's livestock grazing program is a leading source of conflict.

In a six-year period, 62 of 260 human-caused Yellowstone grizzly bears deaths involved management removals due to livestock depredation. Haroldson & Frey 2011-2017. Three additional cubs were also lost due to grizzly bear-livestock conflicts. On National Forests, 30 of 62 human-caused grizzly bear deaths were due to conflicts with livestock. Haroldson & Frey 2011-2017.

"[L]ivestock grazing on public lands continues to be a leading source of conflicts between bears and humans (Gunther et al., 2009) and consequently impose mortality risks for grizzly bears (Knight et al. 1988, Gunther et al. 2004, Bridger-Teton National Forest 2010)." Yellowstone Grizzly Coordinating Committee July 2010 at 72.

Displacing bison with domestic livestock limits the "biological suitable" habitat of grizzly bears and the "potential for a self-sustaining population of grizzly bears" in the Greater Yellowstone bioregion.

> Traditional food sources such as bison and elk have been reduced and replaced with domestic livestock such as cattle, sheep, chickens, goats, pigs, and bee hives, which can become anthropogenic sources of prey for grizzly bears.

82 Fed. Reg. 30502, 30510 (June 30, 2017).

In drawing an arbitrary boundary line beyond which bison are killed or excluded on the Custer Gallatin, State and federal managers have also severed an ecological relationship between grizzly bears and native bison that has spanned millennia.

The Yellowstone ecosystem is the only place where the ancient connection between grizzly bears and bison continues to evolve. Mattson 2017 entire.

> Bison and grizzlies were extirpated by European settlers from most of their pre-contact distribution in the western United States between 1800 and 1900, amounting to a 97% decline for grizzly bears and a 99% decline for bison. The joint remnants in Yellowstone constitute a mere 1% of what once existed in the Great Plains, Rocky Mountains, and northern Great Basin, entailing what I speculate to have been an intimate, complex, and important triad of relations involving bears, bison, and native peoples.

Mattson 2017 at 2 (endnotes omitted).

The U.S. Forest Service's livestock grazing program is a detriment and limiting factor for grizzly bears and bison across their range.

Despite its' wildlife species authority, the National Forest lacks an actionable policy to close grazing allotments in support of conserving native bison diversity, habitat, and connectivity to range.

The U.S. Congress mandates National Forests maintain biological diversity and viability which encompasses native species like bison. 16 U.S.C. § 1604(g)(3)(B).

The diversity mandate comes with the requisite power the U.S. Congress has delegated to the U.S. Forest Service to protect wildlife species on National Forests. Schultz et al. 2013 at 8; Nie 2018 at 16 (citing 36 C.F.R. § 219.9) ("Contribute to the recovery of T&E [threatened and endangered] species," "Provide ecosystem & species-specific approach (in context of ecological integrity)," "keep common native species common," and "maintain a viable population of each species of conservation concern in the plan area.").

> In our view, the "complete power" that Congress has over public lands necessarily includes the power to regulate and protect the wildlife living there.

*Kleppe v. New Mexico*, 426 U.S. 529, 540–541 (1976) (footnote omitted).

Within their jurisdictions, the States are entrusted to care for and protect wild animals but the States' police powers exist only "in so far as (their) exercise may be not incompatible with, or restrained by, the rights conveyed to the federal government by the constitution." *Kleppe* at 545 (quoting *Geer v. Connecticut*, 161 U.S. 519, 528 (1896)).

In addition to the U.S. Supreme Court, other federal courts have affirmed federal wildlife authority for land management agencies.

> [T]he Tenth Amendment does not reserve to the State of Wyoming the right to manage wildlife . . . regardless of the circumstances.

*Wyoming v. United States*, 279 F.3d 1214, 1227 (10th Cir. 2002).

> Under the public trust doctrine, the State of Virginia and the United States have the right and the duty to protect and preserve the public's interest in natural wildlife resources. Such right does not derive from ownership of the resources but from a duty owing to the people.

*In re Steuart Transp. Co.*, 495 F. Supp. 38, 40 (E.D. Va. 1980) (citation omitted).

In contrast to widely permitted and distributed cattle in Yellowstone bison's habitat and range, the Custer Gallatin has permitted the trapping of bison for slaughter on Horse Butte — the Central herd's winter range and calving grounds — and erected or permitted barriers that disrupt the wild species' natural migrations and connectivity to habitat and migration corridors in the Yellowstone and Madison river valleys.

In 2015, the Custer Gallatin adopted a "Clean-up Amendment" that gutted a long standing forest plan goal to provide "habitat for viable populations of all indigenous wildlife species and for increasing populations of big game animals." Gallatin National Forest 2015 at II-1.

The standard for managing habitat for viable populations is now limited to species of conservation concern, a designation denied to Yellowstone bison in the Custer Gallatin's new forest plan. U.S. Forest Service Northern Region on April 22, 2021.

The Custer Gallatin's permitted activities threaten bison range, habitat, and diversity in breach of the U.S. Congress's directive in the National Forest Management Act of 1976 to provide for diversity and the National Forest planning rule requirement to provide for habitat connectivity. 16 U.S.C. § 1604(g)(3)(B); 77 Fed. Reg. 21162, 21265 (Apr. 9, 2012).

The U.S. Fish & Wildlife Service must examine and investigate the additive, synergistic, and cumulative effects of the Custer Gallatin allocating resources to cattle that would otherwise sustain Yellowstone bison on the National Forest in the agency's threats assessment and status review.

***Yellowstone bison are extinct in four out of five landscapes on the Custer Gallatin, and the agency's cattle grazing program is degrading bison's National Forest range and habitat.***

Due to government intolerance, Yellowstone bison roam only one part of one of five landscapes on the Custer Gallatin in the Madison, Henrys Lake, Gallatin, Absaroka and Beartooth Mountains. Custer Gallatin Draft Assessment Report of Ecological, Social and Economic Conditions 2016 at 40–41.

> The eastern Custer Gallatin is missing only a few species, such as black-footed ferrets and plains bison.
>
> . . .
>
> Bridger, Bangtail and Crazy Mountains
> This landscape includes most native species but not bison, bighorn sheep or grizzly bears. This area is a potential wildlife corridor between the Greater Yellowstone Ecosystem and other large blocks of wildlife habitat to the north, such as the Northern Continental Divide Ecosystem in northwest Montana.
>
> . . .
>
> Pryor Mountains
> There are no bison or grizzly bears in the area, black bears and deer are abundant. The Pryor landscape represents a transition from the montane to the pine savanna ecosystem and contains a few notable pine savanna species such as eastern red bat, greater sage-grouse and prairie voles.

Custer Gallatin Draft Assessment Report of Ecological, Social and Economic Conditions 2016 at 38, 40, and 41.

On the Custer side of the National Forest, NatureServe ranks bison in South Dakota as S3 vulnerable, at "moderate risk of extirpation in the jurisdiction due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors." NatureServe 2021 at 3.

On the Gallatin side of the National Forest, bison in Montana are subject to livestock agency control under State law that is bereft of provisions ensuring the wild species' viability and access to range to support a self-sustaining population.

> [The Montana Department of Livestock] is granted broad and discretionary authority to

regulate publicly-owned bison that enter Montana from a herd that is infected with a dangerous disease (YNP bison) or whenever those bison jeopardize Montana's compliance with state or federally administered livestock disease control programs including the authority to remove, destroy, take, capture, and hunt the bison (§ 81-2-120(1)-(4) MCA).

Montana Fish, Wildlife & Parks and Montana Dept. of Livestock 2013 at 13.

Yellowstone bison's National Forest range and habitat is allocated for grazing cattle. Allocating bison range to cattle is preventing the native species from occupying four out of five landscapes on the Custer Gallatin. At the same time, the Custer Gallatin's cattle grazing program is degrading bison's National Forest range and habitat.

• 36,259 permitted cattle displace bison from significant portions of their range.

• 2,775 miles of fencing fragment bison range and habitat.

• 70 functional-at-risk riparian habitats, and 7 nonfunctional riparian habitats are found within cattle grazing allotments.

Custer Gallatin Final Permitted Livestock Grazing Report 2017 at 18, 15, 49.

Monitoring data show the Custer Gallatin's grazing program and the introduction of non-native and noxious species is harming riparian ecosystems in the bison's range. Custer Gallatin Final Permitted Livestock Grazing Report 2017 at 69.

**Measurements of riparian vegetation ecosystem indicators (montane units)**
Greenline Average (Range): 30% (9–50) for Relative Frequency Hydric Species.
Cross Section Average (Range): 12% (1–30) for Relative Frequency Hydric Species.

Greenline Average (Range): 41% (8–82) for Relative Cover Hydric Species.
Cross Section Average (Range): 18% (Trace–74) for Relative Cover Hydric Species.

Greenline Average (Range): 22% (2–42) for Relative Frequency Introduced Species.
Cross Section Average (Range): 25% (10–46) for Relative Frequency Introduced Species.

Greenline Average (Range): 15% (Trace–41) for Relative Cover Introduced Species.
Cross Section Average (Range): 20% (3–63) for Relative Cover Introduced Species.

Greenline Average (Range): 1% (Trace–6) for Relative Frequency Noxious Species.
Cross Section Average (Range): 3% (Trace–11) for Relative Frequency Noxious Species.

Greenline Average (Range): 1% (Trace–3) for Relative Cover Noxious Species.
Cross Section Average (Range): 2% (0–9) for Relative Cover Noxious Species.

Custer Gallatin Final Permitted Livestock Grazing Report 2017 at 67.

Along the greenline, native species' relative frequency averaged 74 percent and relative cover

> averaged 82 percent; introduced species' relative frequency averaged 22 percent and relative cover averaged 15 percent. Noxious weeds averaged 1 percent along the greenline. Along the greenline transects, Canada thistle was found in 23 reaches, houndstongue was found in 10, oxeye daisy was found in one and tall buttercup was found in one reach.
>
> Along the cross section, native species' relative frequency averaged 71 percent and relative cover averaged 77 percent; introduced species' relative frequency averaged 25 percent and relative cover averaged 20 percent. Noxious weeds averaged 1 percent within the cross section. Along the cross section, Canada thistle was found in 20 reaches, houndstongue was found in 17, oxeye daisy was found in one and tall buttercup was found in one reach.
>
> . . .
>
> 60 percent of pine savanna watersheds on the Custer Gallatin were rated as functioning at risk [for streambank stability].

Custer Gallatin Final Permitted Livestock Grazing Report 2017 at 70.

> Within the montane units, 72 percent of the survey sites were found to be in proper functioning condition, with 25 percent functioning at risk and 3 percent were rated as non-functional. Within the pine savanna units, 58 percent of the survey sites were found to be in proper functioning condition, with 42 percent functioning at risk and none were rated as non-functional.

Custer Gallatin Final Permitted Livestock Grazing Report 2017 at 49.

***The Custer Gallatin National Forest is permitting barriers that disrupt habitat connectivity for migratory bison roaming their home range.***

Despite ample authority provided by the U.S. Congress, the National Forest System Land Management planning rule is ineffective in providing for Yellowstone bison diversity, viability, and connectivity to their range and habitat.

The Custer Gallatin has erected or permitted barriers to obstruct and thwart Yellowstone bison's natural migrations to National Forest habitat. These barriers disrupt habitat connectivity the National Forest System planning rule requires be maintained or restored. 77 Fed. Reg. 21162, 21265 (Apr. 9, 2012).

> The best opportunity for maintaining species and ecological integrity is to maintain or restore the composition, structure, ecological functions, and habitat connectivity characteristics of the ecosystem. These ecosystem components, in essence, define the coarse-filter approach to conserving biological diversity.

U.S. Forest Service Final Programmatic Environmental Impact Statement 2012 at 126.

"A commitment to restore or maintain landscape connectivity to facilitate movement, migration, and dispersal is a significant addition to the planning rule." Schultz et al. 2013 at 5.

> Notably, the new rule eliminates the requirement for maintaining viable wildlife populations, in contrast to the 1982 rule's viability provision for vertebrates and the provisions of the 2000 rule that would have extended the requirement to other species. Since the agency only commits to maintaining the viability of species of conservation concern, under the 2012 rule the USFS has no obligation to address the decline of any species not listed, proposed, or a candidate under the ESA, unless the responsible official, in this case the Regional Forester, expresses substantial concern about its persistence. Thus, any number of species could pass from secure to endangered status before any federal intervention would be required.

Schultz et al. 2013 at 5.

Despite National Forest planning rule requirements for habitat connectivity (36 C.F.R. § 219.10) and species diversity (36 C.F.R. § 219.9), the Custer Gallatin has approved erecting several barriers in migration corridors to obstruct and thwart bison's access to their range.

> The fence installation will be more or less perpendicular to the river with the goal of preventing bison from moving further downstream.

Gallatin National Forest Decision Memo 2011 at 1 (approving 900 feet of jackleg fencing uphill from both sides of the Yellowstone River, associated gates and "cattle guards" on highway 89 near Yankee Jim Canyon in Gardiner basin).

> The only identified effect to wildlife is to prevent bison from migrating further west, toward the Madison Valley, which is exactly the purpose of the fence.

Custer Gallatin National Forest Decision Memo 2016 at 3 (approving 30 feet of jackleg fencing, gate, and associated "Bison Cattle Guard" on highway 287 in Hebgen basin).

> [T]he Holder is authorized to construct and maintain a bison corridor fence.

Gallatin National Forest Special Use Permit 2009 at 1 (approving 695 feet of electrified fencing, associated gates and "cattle guards" in Gardiner basin).

Unless the Custer Gallatin withdraws its' special use permits, these barriers to landscape connectivity in wildlife corridors will have long-term and harmful impacts on bison's access to their range for the foreseeable future.

While not insurmountable — bison do climb mountains — the barriers are placed in corridors the migratory species favors to access habitat in their range.

PHOTO: BFC Archive

Connectivity is defined under the National Forest planning rule as the "ecological conditions that exist at several spatial and temporal scales that provide landscape linkages that permit the exchange of flow, sediments, and nutrients; the daily and seasonal movements of animals within home ranges, the dispersal and genetic interchange between populations; and the long distance range shifts of species, such as in response to climate change." 77 Fed. Reg. 21162, 21270 (Apr. 9, 2012); 36 C.F.R. § 219.19 (2012).

> There are two primary requirements for habitat connectivity. The first is that suitable habitats are present for species of interest, and the second is that there are no barriers to movement (USDA 2006).

Custer Gallatin Draft Terrestrial Wildlife Report 2016 at 11.

> § 219.8 Sustainability.
> The plan must provide for social, economic, and ecological sustainability within Forest Service authority and consistent with the inherent capability of the plan area, as follows: (a) Ecological sustainability. (1) Ecosystem Integrity. The plan must include plan components, including standards or guidelines, to maintain or restore the ecological integrity of terrestrial and aquatic ecosystems and watersheds in the plan area, including plan components to maintain or restore structure, function, composition, and connectivity.

77 Fed. Reg. 21162, 21264 (Apr. 9, 2012).

The Custer Gallatin's permitting activities directly limit bison's natural migrations and dispersal to ranges. Manager's decisions intentionally disrupt habitat connectivity for bison in contravention of National Forest planning rule requirements.

The National Forest's permitting activities also undermine bison connectivity to habitat, viability and diversity in their range.

> The reason for movement also plays a role in the assessment of habitat connectivity. For example, long-range dispersal movements may contribute to gene flow between populations, genetic rescue of small or isolated populations, and/or colonization of new areas (Parks et al. 2012).
>
> . . .
>
> Given the importance of habitat connectivity for maintaining species viability and associated biological diversity, a great deal of attention has been devoted to identifying potential movement corridors, as well as potential barriers to movement, for terrestrial wildlife species (USDA Forest Service 2006; Hansen 2006; WGA 2008; Cushman et al. 2010; Parks et al. 2012; Haber and Nelson 2015).

Custer Gallatin Draft Terrestrial Wildlife Report 2016 at 12.

Together, the Custer Gallatin's actions and permitting activities are reducing the size of the ecosystem, disrupting ecological flows, and reducing vital habitat for bison to roam on the National Forest. The net result is an increase in the intensity of government actions directed at eliminating bison who are connected to the health and diversity of the ecosystem on which they depend for survival.

Because the Custer Gallatin's actions and permitting activities strike against the representation, resiliency, and redundancy of Yellowstone bison in the ecosystem, the U.S. Fish & Wildlife Service must examine and investigate the biological consequences of the National Forest obstructing and thwarting habitat connectivity in the agency's threats assessment and status review.

***Bison have lost all long-distance migration routes in the Greater Yellowstone bioregion.***

Berger studied the imperiled biological phenomena of long-distance migration and conservatively found all 14 migration routes or corridors have been lost for bison in the twenty-seven-million-acre Greater Yellowstone bioregion since the 19th century. Berger 2004 at 322 (Table 1) (estimating lost routes based "on point counts of discrete winter and summer ranges.").

Among the factors that stand out for loss of major migration routes include "little tolerance for bison outside protected areas," an increase in human population and "associated loss of habitat, especially areas crucial" to wintering ungulates. Berger 2004 at 324.

> 19th century hunters nearly exterminated migratory bison occupying the expansive grasslands of central North America (Dary 1974). Only 2 remnant populations of migratory bison remain, one in Yellowstone National Park in the USA and the other in Wood Buffalo National Park in Canada (Meagher 1973, Van Vuren & Bray 1986, Gates et al. 2001).
>
> . . .
>
> The main causes [in losses of and threats to mass migrations of mammals] are unsustainable hunting and loss of seasonal ranges and/or migration routes through fencing, livestock, agriculture or human settlement.

Harris et al. 2009 at 69, 70.

The consequence of losing all long distance migration corridors together with loss of connectivity to wild bison populations elsewhere has led to the genetic isolation of the Yellowstone bison population. There is no foreseeable action to reverse the genetically isolated condition of Yellowstone bison.

In addition, there is no State or federal management provision for restoring or preserving the biological phenomena of long-distance migration for Yellowstone bison. On the contrary, the government's plan purposely confines bison from reaching vital seasonal ranges.

The key principles for conserving migratory species like bison include "securing seasonal ranges, resource protection, government support and minimizing fences." Harris et al. 2009 at 55.

In Yellowstone, the government has not secured seasonal habitats including winter range for bison.

Yellowstone bison's National Forest range and habitat is allocated for grazing cattle.

State and federal governments cooperate in excluding and prohibiting bison from significant portions of their National Forest range and habitat. The National Forest has also permitted fencing and cattle guards to thwart bison's migrations to seasonal ranges.

All of these government-driven factors have contributed to a deteriorating condition for Yellowstone bison to migrate and obtain resources to support the population's resiliency in an ecosystem that has been significantly reduced by government action.

"[T]errestrial migrations are inherently difficult to protect because of their vast scale and transboundary nature. Indeed, many ungulate migrations worldwide are now at risk (Berger 2004; Harris et al. 2009). Migratory ungulate populations depend on large landscapes to obtain resources, but humans are steadily fragmenting those landscapes and introducing competing land uses. Even the world's largest protected areas cannot fully safeguard migratory herds." Middleton et al. 2020 at 83.

Data from 92 female Yellowstone bison collected from 2004–2017 mapped corridors, stopovers, and winter range. The investigators found:

> • distinct seasonal migration periods, with a minimum migration corridor length of 21 miles and a maximum of 81 miles;
> • a core winter range of 149,397 acres, and a stopover area covering 39,882 acres;
> • a migration corridor area with 57,331 acres of high use, 120,420 acres of medium use, and 392,762 acres of low use.

Kauffman et al. 2020 at 108–109.

Large herds of bison once migrated upwards of "200 miles (322 km) or more to winter range." Tesky 1995 at 5 (citing Banfield 1974).

The prehistoric range of Yellowstone bison reached the Northern Great Plains in present day Livingston, Montana and beyond. Gates et al. 2005 at 79–80 ("occupied continuously by bison for ca. 10,000 years.").

PHOTO: Taliyah Sansa

Like other ungulates who migrate to avoid the stress of winter conditions, the remaining corridors bison must navigate "are increasingly threatened by roads, fencing, subdivisions, and other development." Kauffman et al. 2020 at 1.

> The GYE contains the longest and most diverse ungulate migrations in North America (Berger 2004). These migrations remain largely unprotected, with highways, housing, fencing, and energy extraction sites impeding movements both inside and outside protected areas (Berger 2004, Sawyer et al. 2005)... Solutions require implementing conservation plans far beyond protected area boundaries, such as purchasing conservation easements and reducing surface impacts to public lands, especially during migratory periods. Here and elsewhere, migration corridors can facilitate the movement of large mammal populations.

Harris et al. 2009 at 70.

The loss of all long distance migration routes has far-reaching ecological consequences for Yellowstone bison and the ecosystem they depend on for survival and reproduction.

> Conservationists worry about the persistence of migrations (Wilcove & Wikelski 2008). Some issues are ecological, as mass migrants have positive feedback effects on grassland forage and indirect effects on ecosystem processes (e.g. increasing grassland production and raising nitrogen mineralization) (Caughley 1976, McNaughton et al. 1988, Frank 1998), and therefore losing migrations may result in ecosystem collapse.

Harris et al. 2009 at 56.

> Bison migrations have been lost in most of the species' range, but studies of conservation herds can give us a picture of their ecological impact. Bison feed on dominant grasses, releasing other grasses and forbs from competition. Bison urine amplifies their effects by increasing plant biomass and nitrogen concentration. Bison also facilitate other species; for example, some butterflies prefer the vegetation that grows around bison wallows. Ecologist Chris Geremia and co-authors found that bison in Yellowstone National Park – the only truly migratory bison herd remaining – have an engineering effect on the ecosystem, prolonging the "green wave" through grazing, which stimulates plant growth and delays plant maturation. Together these findings suggest the loss of bison, and their migrations, from North American grasslands has profoundly changed ecosystems.

Stoellinger et al. 2020 at 104 (footnotes omitted).

The loss of all long distance migration routes also has far-reaching biological consequences on Yellowstone bison's ability to survive adverse environmental conditions, e.g., snow-crusting events, and adapt to a rapidly changing climate amidst the widespread loss and fragmentation of range and connectivity to habitat in the ecosystem.

> Across the western United States, many ungulate herds must migrate seasonally to access resources and avoid harsh winter conditions. Because these migration paths cover vast landscapes (in other words migration distances up to 150 miles [241 kilometers]), they are increasingly threatened by roads, fencing, subdivisions, and other development.
>
> . . .
>
> Across the American West, many ungulate herds migrate to exploit key resources that shift seasonally across topographically diverse landscapes (Kauffman and others, 2018). Migration promotes abundant populations by enhancing foraging opportunities and reducing risk of exposure to adverse conditions (Bolger and others, 2008). Evidence of the importance of migration can be found throughout western landscapes as well as more broadly across the globe.

Kauffman et al. 2020 at 1.

Government permitted barriers, government imposed boundaries, and the systemic killing of migrants cumulatively threaten Yellowstone bison's ability to migrate and survive unfavorable or catastrophic events, and inhospitable environmental conditions.

"Princeton ecologist Dr. David Wilcove has classified four common threats to all types of migration: habitat destruction, human-created obstacles, overexploitation, and climate change." Stoellinger 2020 at 108.

Yellowstone bison are facing all four common threats to the persistence of their natural migration patterns in an ecosystem undergoing rapid climate change.

Fences, highways, and homes add to the inhospitable government-created conditions in which migratory bison must disperse to withstand adverse environmental changes in the ecosystem.

> Fencing is a particularly pervasive influence for migratory ungulates in the western U.S. A recent review by McInturff et al. conservatively estimates that the western U.S. contains about one million miles of fencing. Fences impact ungulates in three ways: (1) ungulates choose not to cross the fence, which impedes movement; (2) ungulates spend time and energy looking for a place to cross a fence; and (3) when attempting to cross a fence, an ungulate may snare its legs in the fence wire, become entrapped, and die.

Stoellinger 2020 at 110 (footnote omitted).

> Migration requires free movement across large landscapes, but western landscapes are increasingly fragmented by many types of barriers. Fences are a persistent feature of many habitats; they are often navigable by migrating big game but remain a source of direct mortality (Harrington and Conover, 2006). . . Housing development in the West has a constant and growing effect on migration corridors because subdivisions and other housing are permanent (Kauffman and others, 2018; Monteith and others, 2018).
>
> . . .
>
> Roads are an additional source of mortality, which also constrain connectivity in the western United States (Huijser and others, 2017) and worldwide (Brown and Ross, 1994). . . . Perhaps more importantly, roads—especially those with high traffic—are an increasingly formidable barrier to movement and can truncate migrations or cause loss of migration (Kauffman and others, 2018).

Kauffman et al. 2020 at 3.

Roads are a major hazard bison must navigate to reach seasonal ranges.

High traffic roads such as highways 191 and 287 in Hebgen basin intersect bison's east to west and west to east migrations to winter range and spring calving grounds resulting in a number of collisions with vehicles. Dupree & DiMambro 2012 entire.

Highway 89 in the Gardiner basin is another hazard for bison's safe migration to seasonal ranges.

Yellowstone National Park recorded nearly 100 bison related motor vehicle accidents from 2009–2012. Geremia 2022 at 9 (Table A4).

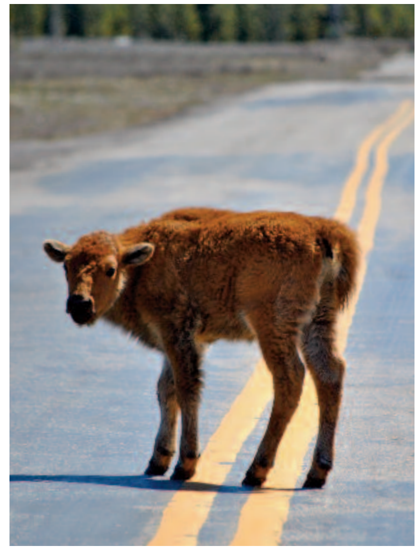


PHOTO: BFC Archives

"Human activities have fragmented landscapes throughout the world, severing historic pathways for migration of many species of large herbivores (Galvin et al. 2008, Hobbs et al. 2008)," including Yellowstone bison. Geremia et al. 2014 at 346–347.

> Road development (Nellemann et al. 2001, Ito et al. 2005, Fox et al. 2009, Holdo et al. 2011), fencing (Fox et al. 2009, Bartlam-Brooks et al. 2011, Li et al. 2012), natural resource extraction (Sawyer et al. 2009), and recreation-based development (Vistnes et al. 2004, Wittmer et al. 2007) now threaten many remaining long-distance migrations (Berger 2004). Furthermore, migratory wildlife may come into conflict with people beyond the boundaries of protected areas because wildlife transmit disease, damage property, or compete with livestock for forage. (Thouless 1995, Plumb et al. 2009, Metzger et al. 2010). Severing migrations has had adverse demographic effects on large herbivores and there is increasing support at regional and global levels to preserve these natural phenomena (Berger 2004). However, the interests of local economies often conflict with conservation goals.

Geremia et al. 2014 at 347.

In severing bison's migrations to vital ranges, the government's plan is a strike against the Yellowstone population's ability to withstand ecosystem-wide changes driven by rapid climate change.

> Climate change engenders longer-term threats. Concerns concentrate on migrants in higher latitudes where the pace and scale of habitat changes and the decoupling of climatic variables over disparate migratory ranges are highest, causing problems with mistimed migrations (Pulido 2007, Robinson et al. 2009). Migrants' abilities to adapt to changing environmental conditions are likely exacerbated by the other anthropogenic threats, such as habitat loss and fragmentation (Jetz et al. 2007).

Harris et al. 2009 at 68.

> Many western U.S. landscapes contain a juxtaposition of mountains and plains or sagebrush basins, wherein the best forage is produced in mountain habitats fed by winter snowmelt and summer precipitation. Thus, many herds migrate into the mountains in spring in search of high-quality forage (Albon and Langvatn, 1992). The mountains become largely inhospitable, however, once winter advances and blankets the high country with snow. All species of ungulates suffer elevated energy costs when forced to move through deep snow (reviewed in Parker and others, 2009). The migratory cycle is complete when animals move out of the high country in early winter and head for low-elevation basins, where snow levels are relatively shallow and some forage remains accessible. Migration is recognized as a

> ubiquitous behavior that allows ungulates to survive and thrive in seasonal landscapes that characterize the American West.

Kauffman et al. 2020 at 1–2.

Knowledge of destination and pathways to winter ranges is not only a survival trait but fundamental to bison's reproduction of offspring.

Female bison "show strong affinity to winter range" with older females more likely to seek out new winter ranges and return in subsequent winters. Tesky 1995 at 5 (citing Meagher 1973, Shaw & Carter 1990).

The vital adaptive trait and knowledge of migration for Yellowstone bison cannot be passed on between generations without intact and protected corridors allowing for dispersal to seasonal ranges in the ecosystem.

Empirical evidence from University of Wyoming scientists demonstrates ungulates including bison "must learn where and when to migrate" from other bison, and seasonal migration is maintained "by passing cultural knowledge across generations." University of Wyoming 2018.

"[T]he importance of learning and cultural transmission to the persistence of ungulate migration has become clearer (Bracis and Mueller 2017), suggesting that corridors are maintained through cumulative herd knowledge that may not be readily re-learned once lost (Jesmer *et al*. 2018)." Middleton et al. 2020 at 86.

According to ecologist Brett R. Jesmer, "ungulates accumulate knowledge of their landscapes over time, and cultural transmission of this knowledge is necessary for migrations to arise and persist." University of Wyoming 2018.

"When migration corridors are lost, we also lose all the knowledge animals had about how to make those journeys, which will likely take many decades or even a century to re-learn," according to Matthew J. Kauffman, Ph.D. "This study clearly indicates that the best way to conserve migration corridors is to protect the landscapes that these corridors depend on today, which will also maintain the cultural knowledge that helps sustain abundant herds." University of Wyoming 2018.

> Increasingly, researchers understand that the detailed knowledge required to make seasonal migrations is best thought of as a form of animal culture, built up through time, and transmitted between generations (Whiten, 2019). Such past experiences may often lead to a diverse portfolio of migratory strategies (Lowrey and others, 2019), which is likely to promote stability and persistence at the population level. This is a cautionary tale for the conservation of migration corridors, because it means that not only must the corridors be kept intact, but the specific animals that retain the knowledge of these journeys must be conserved as well (Brakes and others, 2019). The decades that it will take for the culture of migration to return once lost, suggests that restoring lost migrations is likely to be a nearly impossible task.

Kauffman et al. 2020 at 3.

Yellowstone bison's migrations enable prolonged access to forage and habitat, contributes to population productivity, sustains ecosystem food webs, and benefits species diversity.

However, these life history traits are weakened and severed by loss of long distance migration corridors, loss and fragmentation of range, loss of connectivity to range, and government imposed boundaries restricting the ability of Yellowstone bison to migrate and disperse via corridors.

> Importantly, this foraging advantage may help migrants attain greater nutritional condition (eg body fat levels; Middleton *et al*. 2018) and reproductive success (Hebblewhite *et al*. 2008; Rolandsen *et al*. 2017) than their resident (ie non-migratory) counterparts. These observations support the contention of Fryxell et al. (1988) that ungulate migration underpins population productivity and abundance. In turn, this abundance has broader effects within food webs, such as sustaining large carnivores (Dobson *et al*. 2010) and fueling cross-ecosystem nutrient subsidies; an example of such a subsidy is when carcasses of drowned terrestrial ungulates (wildebeest) provide nutrients for aquatic scavengers or decompose in rivers, thereby releasing carbon, nitrogen, and phosphorus into the environment over time (eg Subalusky *et al*. 2017). For these reasons, reductions in or the complete loss of ungulate migrations is now seen as potentially catastrophic for some ecosystems (Dobson *et al*. 2010; Løvschal *et al*. 2017). Furthermore, studies highlighting ungulate migrations across the steppes, grasslands, and forests of Asia, Europe, and the Americas (Berger 2004; Harris *et al*. 2009; Kauffman *et al*. 2018) demonstrate how this ecological phenomenon – and consequently its broader impacts for populations and ecosystems – may be far more widespread and fundamental than previously recognized.

Middleton et al. 2020 at 84–85.

> While the primary function of a migration route is to provide a connection between summer and winter ranges, the "migratory routes themselves have functional attributes that yield important benefits beyond simple connectivity." New research brings to light the ecological value of migrations suggesting that they underpin robust ungulate populations which, in turn, provides "broader effects within food webs, such as sustaining large carnivores." For this reason, reductions or loss of ungulate migrations may have potentially catastrophic implications for some ecosystems. Thus, migrations have a far more widespread and fundamental impact on ungulate populations themselves and the related ecosystems than have been previously recognized by ecologists, wildlife managers, and the general public.

Stoellinger et al. 2020 at 85–86 (footnotes omitted).

> In the American West, big game ungulates (hereinafter "ungulates") like mule deer, pronghorn, elk, moose, bison, and bighorn sheep often migrate long distances to avoid harsh seasonal climates. Mountain ranges with lush grasses, wildflowers, and shrubs are ideal ungulate habitat in the summer and early fall. But winter in the mountains means deep snowpack of ten feet or more, making the mountains unsuitable year-round habitat. The solution for winter survival is for animals to migrate down to winter ranges in the basins below. These basins offer milder winter conditions and are fairly snow-free, making forage available. However, basins are not ideal summer habitats; they are dry and unproductive in the summer months. As a result, in the spring, the migrating animals follow the spring forage

> green-up, moving back to their lush, mountainous summer ranges. These migrations occur seasonally, year after year to the same habitats, and are critical to ungulate survival and abundance in the American West.

Stoellinger et al. 2020 at 84 (footnotes omitted).

Migration to winter range is at risk because the government's plan and focus of management action is to obstruct, thwart, and kill bison making the trek. Thus, fewer migrants survive the gauntlet of government management actions to return to summer ranges and pass on a trait that enhances the Yellowstone population's persistence in the wild.

PHOTO: BFC Archives

"[E]cologists Blake Lowery and his co-authors specifically note that "[s]easonal migration has evolved as a complex behavior to enhance fitness and results from interactions between individuals (e.g., learned behavior), their genes, and the environment, notably spatiotemporal variation in resources and interspecific threats (e.g., predation. . .)." Stoellinger et al. 2020 at 93 n. 57.

> The winter is a period of limited food resources, nutritional deficit, and declining body condition for many wildlife species in northern temperate landscapes. For migratory ungulates, the winter range has long been viewed as the most limiting seasonal range. During winter, the grasses, forbs, and shrubs that ungulates prefer to eat are generally senescent—holding relatively low nutritional value—and often covered by snow. Many ungulates reduce their forage intake over the winter, effectively fasting, and reduce activity levels, presumably to conserve energy and minimize risks of mortality. Many northern ungulates can lose anywhere from 15-30% of their body mass over winter.

Stoellinger et al. 2020 at 94 (footnotes omitted).

In severing bison's migrations to winter range, State and federal managers are also reducing the capacity of a vital seasonal range to sustain robust herds of Yellowstone bison.

"Scientists have found that the animals that migrate long distances leave their winter ranges earlier than short and medium-distance migrants in the spring, thus alleviating the competition for limited forage on the winter ranges and most likely increasing the landscape's carrying capacity. The more animals within a herd that migrate longer distances, the more animals a particular winter range may be able to support. The inverse is also true: if ungulates no longer migrate, the carrying capacity of the landscape may be diminished and animal populations may decline." Stoellinger et al. 2020 at 100 (footnotes omitted).

Migration between ranges is not only a travel path or route it is a vital habitat unto itself. Stoellinger et al. 2020 at 96 (citing Monteith et al. 2018).

Designated "protected areas," that is, the available habitat Yellowstone bison are permitted to roam under the government's plan may be inadequate for distinct subpopulations to persist under future climate conditions.

A study of migratory elk in the Greater Yellowstone bioregion found the effects of rising temperatures and the stress of drought harmed reproduction due to shorter green up in high-elevation summer ranges. Stoellinger et al. 2020 at 112 (citing Middleton et al. 2013).

It is uncertain how Yellowstone bison will adapt to rapid climate change in altering migration routes or shifting ranges to adapt to the stress of severe prolonged drought, rising temperatures, and other disturbances in the ecosystem.

What is certain is management actions cutting bison off from migrating to winter range together with severe drought on summer ranges would make it difficult for bison to restore the fat reserves necessary for healthy calving.

> After winter subsides, ungulates migrate back to higher elevations to feed on newly emerging grasses, forbs, and shrubs and take cover in forested areas. Migratory ungulates benefit from consuming high-quality forage found in high-elevation summer ranges attributed to cool weather and prolonged snowmelt. This allows some migratory ungulates to attain higher body mass and pregnancy rates compared to their non-migratory counterparts.
>
> Kevin Monteith, et al., note ":[i]n contrast to winter, summer is viewed as a period of nutritional abundance . . . and is considered a critical period for replenishment of reserves lost during winter." One of the most important functions of summer range is to support adult females as they nurse rapidly growing calves or fawns while also building the fat required to support autumn conception and survival over the coming winter.

Stoellinger et al. 2020 at 95–96 (footnotes omitted).

> [I]nvestigations have demonstrated not only that migration corridors, like other seasonal ranges, contain habitats that contribute to the annual nutritional cycle but also that the summer range is critical to the nutrition, reproduction, and overwinter survival of ungulates (eg Middleton *et al*. 2013, 2018). This new appreciation of the summer range compounds the importance of corridors because the loss of a migratory corridor translates into the loss of access to critical resources on the summer range. For these reasons, there is now consensus that conserving ungulate migrations requires conserving year-round ranges.

Middleton et al. 2020 at 85.

> It seems reasonable to assume that the more jurisdictions a species crosses, the more difficult it is to protect. . . Yet even a relatively simple migration can pose tremendous conservation (and political) headaches. In Montana, for example, bison exit Yellowstone National Park during harsh winters. They follow established routes along the Yellowstone and Madison river valleys to lower-elevation sites where less snow cover means easier access to forage. It is a relatively short migration that falls wholly within the borders of Montana, and it is largely confined to lands managed by the federal government and the state of Montana. Yet the bison are hazed back into Yellowstone or killed when they stray outside the park due to fears that they will transmit a bacterial disease, brucellosis, to livestock. The

> option of removing the livestock from the winter range of the bison has not been given serious consideration.

Wilcove & Wikelski 2008 at 3.

"Over the last century, individuals in this population have learned to migrate up to 80 mi (97 km) (Geremia and others, 2019) and can now be considered the last truly migratory herd. The migratory movements of Yellowstone bison are also truncated, however. They are not allowed to move freely outside the park for concerns about human safety, disease transmission, conflicts with domestic livestock, and protection of property (National Park Service, 2020)." Kauffman et al. 2020 at 106.

Migration is an essential life-history trait for bison allowing for adaptation to a rapidly changing ecosystem, and evolutionary resilience in a climate being disrupted on a regional and global scale.

Bison's long-distance migrations, corridor use, and connectivity to habitats in their range need to be proactively managed so these phenomena and ecological processes do not become endangered.

The State of Montana is following and carrying out an unstated goal to eradicate bison's migratory behavior or at least, eradicate bison that attempt the migratory journey, a characteristic that has evolved over thousands of years.

"It would appear that even in Big Sky country, there is no longer room for a remnant of the American bison's grand migration." Wilcove 2008 at 120.

Loss of all long-distance migration routes, government actions disrupting Yellowstone bison's migrations and dispersal to vital ranges, and the systematic killing of migrants who retain the knowledge of migratory pathways are factors the U.S. Fish & Wildlife Service must examine and investigate in the agency's threats assessment and status review.

***The Custer Gallatin National Forest's land management plan provisions for bison limit and reduce Yellowstone bison's range and habitat.***

The Custer Gallatin's land management plan provisions for bison limit and reduce Yellowstone bison's National Forest habitat and range for the foreseeable future. Custer Gallatin National Forest Land Management Plan 2022 at 57–58.

Defining bison through "state-delineated tolerance zones" and "state-approved tolerance zones" (Custer Gallatin National Forest 2018 at 53–54) is incompatible with the Custer Gallatin's authority and duty to manage for bison diversity and habitat connectivity the National Forest Management Act and National Forest planning rule requires.

It is unreasonable for the Custer Gallatin to surrender the National Forest's authority for managing bison and their native habitat to Montana's regulatory intolerance.

Furthermore, the Custer Gallatin's land management plan provisions for bison are unreasonable given the threats and stressors bison are confronted with on National Forest habitat and beyond.

Instead of managing for connectivity to habitats and conserving migration corridors, the Custer Gallatin has permitted barriers to habitat and intentionally disrupted connectivity obstructing and thwarting bison's ability to naturally disperse in their ranges.

Together, the Custer Gallatin's permitting activities and enforcement of "tolerance zones" by the State of Montana on the National Forest cut-off Northern herd bison from migrating to substantial portions of their range, e.g., beyond Gardiner basin, the adjacent Tom Miner basin, and Paradise Valley. Gates et al. 2005 at 79–80 (Yellowstone bison's Northern range extended beyond Livingston, Montana to the Northern Great Plains); Geremia & Cunningham 2018 at 9 ("Migration into Tom Miner Basin is likely"); *see* Montana Fish, Wildlife & Parks and Dept. of Livestock 2013 map at 23 (delineating bison "tolerance zones").

The Custer Gallatin's permitting activities and enforcement of "tolerance zones" by the State of Montana on the National Forest also cut-off Central herd bison from migrating to substantial portions of their range, e.g., in and beyond Hebgen basin. *See* Montana Fish, Wildlife & Parks and Dept. of Livestock 2013 Maps at 22, 25, 36; Gov. Bullock 2016 (Erratum).

Given the stressors and threats bison are likely to experience over the life of the next land management plan, excluding bison from substantial portions of the Custer Gallatin National Forest adds to the extensive loss of bison range and habitat in the Yellowstone ecosystem.

Hence, the U.S. Fish & Wildlife Service must examine and investigate the National Forest's combined permitting activities and government imposed "tolerance zones" as a significant loss and threat to Yellowstone bison's habitat and range for the foreseeable future in the agency's threats assessment and status review.

***The State of Wyoming manages for the extirpation of migratory bison on National Forest habitat in Region 2.***

Acres of National Forest in Region 2: 22,051,028
Acres of National Forest on the Shoshone: 2,439,093

U.S. Forest Service 2015 (Table 3).

By statute, bison migrating onto National Forest lands in Wyoming are managed in limited numbers in restricted areas for extirpation. Wyo. Stat. Ann. § 23-1-302 (2020).

Bison migrations onto the Shoshone National Forest in Region 2 occurred over most of the latter 20th century and became consistent after a major forest fire in 1988. Wyoming Game & Fish Department 2008 at 7, 10–11 (recording bison movements going back to 1966).

From 1988–1997, up to 30 bison including female-led groups were annually observed on the North Fork of the Shoshone River. Bulls were documented in all years (1988–2007). After two seasons of being hunted, only individual bull bison — less than 10 — were observed. Wyoming Game & Fish Department 2008 at 12.

State law calls for bison migrating onto the Shoshone National Forest in Wyoming to be shot by hunters or government authorities. The low numbers Wyoming has set limit and reduce bison's exploratory movements, and do not allow for female-led groups except in the Teton Wilderness.

> In summary, the fundamental recommendation for the Absaroka Bison Management Area is to maintain the current low number and specific distribution of bull bison in the North Absaroka and Washakie Wilderness Areas (no more than 25), and on Shoshone National Forest (SNF) lands along the North Fork of the Shoshone River (no more than 15). In addition, the WGFD may allow up to 25 bison in the Yellowstone River drainage within the Teton Wilderness. The WGFD should not allow cow bison to occupy this management area except in the Yellowstone River drainage within the Teton Wilderness. Removing bison would be accomplished by hunters when possible, or by Department personnel when hunting is not possible.

Wyoming Game & Fish Department 2008 at 3.

Under State law, the migratory species falls under Wyoming livestock board authority who can order Wyoming Game & Fish to kill bison. Wyoming Game & Fish Department 2008 at 15; Wyo. Stat. Ann. § 23-1-302(a)(xxvii) (2020).

Enforcing Wyoming law and placing the native species under livestock authority effectively reduces bison diversity to zero by extirpating them from their range on the Shoshone National Forest through hunting or government action.

In 2011, Region 2 proposed listing bison as a sensitive species, the precursor to today's species of conservation concern under the National Forest planning rule.

> Species of conservation concern are those plant and animal species whose long-term persistence within the plan area is of known conservation concern. The rule requires that species of conservation concern must be "known to occur in the plan area," and that the regional forester identify the species of conservation concern for which "the best available scientific information indicates substantial concern about the species' capability to persist over the long term in the plan area."

U.S. Forest Service, 77 Fed. Reg. 21162, 21175 (Apr. 9, 2012).

On April 1, 2011, Regional Threatened, Endangered, & Sensitive Species Program Leader Nancy Warren recommended bison be listed to "encourage consideration of restoration opportunities in the future" and found that the loss of bison, a keystone species, "may have had cascading effects on grassland ecosystem function and the diversity of native plant and animal species." U.S. Forest Service Region 2 Warren (April 1, 2011).

The regional program leader's rationale in support of recommending bison as a sensitive species referenced the U.S. Fish & Wildlife Service's finding on a petition to list wild plains bison that several National Grasslands and National Forests are of sufficient size and provide suitable habitat that *could* support wild plains bison herds.

On April 7, 2011, Deputy Regional Forester Antoine L. Dixon sent a letter to Forest Supervisors proposing bison be added to the sensitive species list in Region 2. U.S. Forest Service Region 2 Dixon 2011.

On May 2, 2011, Shoshone National Forest's Forest Supervisor Joseph G. Alexander requested bison be removed from the proposed list citing "[e]xisting state management plans may conflict with how the Shoshone would manage for species viability. Until further evaluation of this situation can occur, I respectfully ask for the species to be removed from the list." U.S. Forest Service Region 2 Alexander 2011.

On April 29, 2011, Region 2's TES Species Program Leader withdrew her recommendation writing: "At this time no self-sustaining herds of wild plains bison exist on National Forest System lands. Forests should consider working towards the possibility of restoring wild plains bison where feasible on National Forest System lands in the future." U.S. Forest Service Region 2 Warren (April 29, 2011).

The record shows Region 2 ceded the National Forest's regulatory authority and duty to manage for bison viability and list the sensitive species because of *potential conflict* with Wyoming's "management plans" calling for the extirpation of bison migrating onto the Shoshone National Forest.

***The State of Idaho manages for the eradication of migratory bison on National Forest habitat in Region 4, and elsewhere.***

> Acres of National Forest in Region 4: 31,885,607
> Acres of National Forest on the Caribou-Targhee: 2,624,739

U.S. Forest Service 2015 (Table 3).

By statute, bison migrating onto National Forest lands and elsewhere in Idaho are eradicated.

> It is the purpose of the provisions of this section to provide for the management or eradication of bison . . .

Idaho Code § 25-618(1) (2021).

Bison migrate onto the Caribou-Targhee National Forest in Region 4, into the Henrys Fork basin and Island Park range in Idaho where the species conservation ranking is S1, a "critically imperiled species at high risk because of extreme rarity . . ." Adams & Dood 2011 at 108.

Under Idaho law and Department of Agriculture authority, State and federal officials shoot any bison migrating from the Yellowstone population. Idaho Code § 25-618 (2021).

Based on eyewitness observations and government reports, Idaho law is enforced to eradicate bison migrating onto the Caribou-Targhee National Forest and adjacent habitat — wherever the wild species is found in the State. Associated Press 2012 (two bulls shot near Island Park); Buffalo Field Campaign 2009 (lone bull shot south of Twin Creek); Buffalo Field Campaign 2017 (two bulls shot near Henrys Lake Flats); Montana Fish, Wildlife & Parks and Montana Dept. of Livestock 2013 at 39 ("bison have occasionally migrated into Idaho with the most recent occurrence being July 2012 when two bull bison made the 20 mile trek to Island Park Idaho. Previous to that, the last report of bison traveling into Idaho was in 2009.").

While the State of Idaho acts to eradicate a critically imperiled species, and the Shoshone National Forest acted to prevent listing bison as a species of concern, in Montana, bison are a species of concern due to threats to their habitat, restricted distribution, and management actions that reduce the only migratory population roaming the wild.

***Bison are a species of concern in Montana due to human threats to their habitat, restricted distribution, and management actions reducing the only population in the wild: the distinct population segment of Yellowstone bison.***

> Agency planning policy requires that species identified by states as being at risk be considered as potential Species of Conservation Concern. Forest Service Handbook § 1909.12 (2013).

Nie et al. 2017 at 862 n. 483.

The only wild bison population roaming Montana is the distinct population segment of Yellowstone bison.

In Montana, the migratory species is listed as a "species of concern" and "considered to be 'at risk' due to declining population trends, threats to their habitat, and/or restricted distribution" making wild Yellowstone bison "vulnerable to global extinction or extirpation in the state."

> As of 2010, bison are listed by the Montana Natural Heritage Program (MNHP) and FWP as a "species of concern" (MNHP, 2010; FWP, 2010a). Species of concern "are native Montana animals that are considered to be 'at risk' due to declining population trends, threats to their habitat, and/or restricted distribution" (MNHP, 2010). FWP and MNHP have given bison an S2 state ranking and a G4 global ranking (MNHP, 2010; FWP, 2010a). An S2 status means the species is "at risk because of very limited and/or potentially declining population numbers, range, and/or habitat, making it vulnerable to global extinction or extirpation in the state" (FWP and MNHP, 2010b). The G4 global ranking means that the species is "apparently secure, though it may be quite rare in parts of its range, and/or suspected to be declining" (FWP and MNHP, 2010b). The Montana Comprehensive Fish and Wildlife Conservation Strategy lists bison as Tier 1, which are species in "greatest conservation need. Montana Fish, Wildlife & Parks has a clear obligation to use its resources to implement conservation actions that provide direct benefit to these species, communities, and focus areas" (FWP, 2005, pp.32).

Adams & Dood 2011 at 32.

The ranking of bison as a native species of concern has not spurred the allocation of Fish, Wildlife & Parks resources for conserving the migratory species habitat and range in Montana. On the contrary, the agency has brought in over $2 million dollars in revenue and issued over 1,100 tags to hunt buffalo for "disease control" as authorized by the State Veterinarian and the Dept. of Livestock. Buffalo Field Campaign 2023.

Despite a broad section of the American people who submitted credible and relevant scientific evidence raising substantial concern about bison's ability to persist as a viable, self-sustaining migratory species, Northern Region Regional Forester Leanne M. Marten denied bison met the National Forest's criteria for a species of conservation concern. U.S. Forest Service Marten April 15, 2021.

Other authorities recognize bison as a "species of conservation concern in part because they suffered a severe population bottleneck at the end of the 19th century and now exist in mostly small and isolated populations." Licht 2017 at 83 (citing the "severe population bottleneck" and small, isolated populations of bison which are prone to inbreeding and reductions in fitness).

The U.S. Fish & Wildlife Service must examine and investigate ongoing government actions in Montana, Idaho, and Wyoming to reduce and eradicate the migrations of Yellowstone bison in their range and habitat in the agency's threats assessment and status review.

***Few opportunities exist to naturally restore Yellowstone bison in the wild because National public trust lands in the range of bison are appropriated for grazing cattle. The lack of protections and provisions for conserving Yellowstone bison's range and habitat is a threat to restoring the wild species on National public trust lands in the ecosystem and bioregion.***

The U.S. government is trustee for 640 million acres of the country's 2.27 billion acres. The Bureau of Land Management, U.S. National Park Service, U.S. Forest Service, and U.S. Fish & Wildlife Service administer 606.5 million acres in the public trust. Congressional Research Service 2020 Summary.

But National public trust lands are appropriated for grazing livestock, primarily cattle.

PHOTO: Darrell Geist

Private livestock graze over 103 million acres of National Forest habitat and 168 million acres of Bureau of Land Management habitat in the Western United States. Over 50% of livestock grazed public lands are in "poor or fair condition." Carter et al. 2020 at 46 (citing Fleischner 1994 and U.S. GAO 1988) (endnotes omitted).

Another estimate finds cattle and sheep are permitted to graze 229 million acres of National Forest and Bureau of Land Management habitat primarily in the Western United States. Glaser et al. 2015 at 1, 9 (137.7 of 174.5 million acres of Bureau of Land Management holdings across 11 western States; 92.1 of 141.7 million acres of National Forest holdings in the Western Region).

The combined Animal Unit Months of cattle and sheep permitted on National Forest and Bureau of Land Management habitat ranged from 12,656,540 in 2005 to 15,819,413 in 2010. Glaser et al. 2015 at 13, 8 (an Animal Unit Month or AUM is the amount of forage necessary for sustenance of one animal for one month).

The Bureau of Land Management has issued 17,740 permits for grazing 12,308,350 AUMs in 10 western States. U.S. Dept. of the Interior 2021 at 79.

There is only one population of wild bison anchored to the 245 million acres of National public trust habitat managed by the Bureau of Land Management in 12 Western States. The population size of the Henry

Mountains herd is too small to be considered functioning as wild, and the population size of the wild UTE–Tribal Book Cliffs bison herd is not large enough to be considered sustainable according to the International Union for the Conservation of Nature. Aune, Jørgensen & Gates 2018 Supplemental Material (Tables 1 and 2).

Public Employees for Environmental Responsibility (PEER) obtained public records spanning three decades covering 21,000 grazing allotments in 13 Western States and presented their findings in an interactive online map: mangomap.com/peer/maps.

PEER (2020) found vast areas of land — 40 of 54 million acres of Bureau of Land Management habitat — degraded by cattle, sheep, and other livestock.

"PEER's analysis finds that livestock grazing is the primary culprit behind land degradation." Mohr 2022.

The total acreage of habitat degraded by livestock and failing to meet the Bureau of Land Management's "land-health standards" is more extensive than reported because the agency is not systematically examining the data for publication.

> While standards vary between states and bioregions, they generally measure biological conditions, including soil health, water quality, plant species diversity and the quality of habitat for threatened and endangered species. The standards define the minimum benchmarks land managers need to achieve and maintain in order for landscapes to function and be used sustainably.

Mohr 2022.

A survey of National Forest and Bureau of Land Management habitat in the region overwhelmingly demonstrates National public trust lands in Yellowstone bison's range are allocated for grazing cattle and other livestock.

Yellowstone bison's range and habitat is doubly harmed by State and federal management actions prohibiting access to and managing for the loss of the migratory species on National Forests in the ecosystem, and appropriating bison's National Forest range and habitat for grazing domestic cattle, sheep, and other livestock.

On the Custer Gallatin National Forest, 1,117,456 acres are allocated for grazing cattle and other livestock; 1,302,815 acres of the Shoshone National Forest are allocated for grazing livestock; and 1,018,000 acres of the Caribou-Targhee National Forest are allocated for grazing cattle and sheep.

The National Forest has issued 540 grazing permits covering 1,249,519 of 1,258,300 acres of the Dakota Prairie Grasslands, while two grazing associations run 3,316 head of cattle on 46,594 of 47,600 acres on the Curlew National Grassland.

In the region, 852,778 of 968,194 acres of habitat managed by the Dillon, Montana office of the Bureau of Land Management is allocated for grazing livestock, primarily cattle; 270,039 of 307,309 acres of habitat managed by the Butte, Montana office of the Bureau of Land Management is allocated for grazing livestock; in the Montana/Dakotas, the Bureau of Land Management has permitted 1,210,193 Animal Unit Months for grazing livestock.

Where data is publicly available, the evidence shows grazing cattle and other livestock is degrading grasslands, depleting and harming water quality in bison's range on National public trust lands in the region.

The lack of legal protections and enforceable provisions for conserving Yellowstone bison's range and habitat is a threat to restoring the wild species on National public trust lands in the ecosystem. Legal protections and provisions for Yellowstone bison are essential to naturally restoring the wild species in their range and habitat.

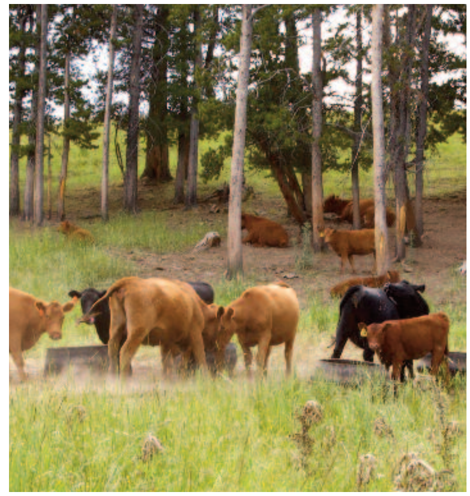


PHOTO: Darrell Geist

The inclusion of Indigenous leadership and inter-governmental cooperation with Indigenous tribes in developing and implementing habitat recovery plans is an indispensable part to naturally restoring wild Yellowstone bison in the ecosystem and bioregion where they are now extinct as a consequence of State and federal government actions and inadequate regulatory mechanisms.

Without substantive measures and provisions securing Yellowstone bison's range and corridors on National public trust lands in the region, loss of range and habitat will continue to operate as a threat to the population's adaptation and persistence in the wild.

The U.S. Fish & Wildlife Service must examine and investigate the additive, synergistic, and cumulative effects of the government allocating Yellowstone bison's range and habitat to cattle and other domestic livestock in the agency's threats assessment and status review.

**Shoshone National Forest**

Acres of National Forest in Region 2: 22,051,028
Acres of National Forest on the Shoshone: 2,439,093
Acres of suitable range for grazing livestock: 375,368
Acres allotted for grazing livestock: 1,302,815
Percent of the Shoshone allocated for grazing livestock: 53.4
Number of permitted grazing allotments: 87
Number of permitted cattle/horse allotments: 79
Number of permitted sheep allotments: 8 (6 vacant/2 active)
Number of permitted Animal Unit Months: 55,930
An Animal Unit Month: 780 pounds dry forage for a 1,000-pound non-lactating cow for one month
Cost per Animal Unit Month: $1.35
Miles of fencing on active livestock grazing allotments: N/A
Number of water developments on active livestock grazing allotments: N/A
Number of watersheds functioning at risk: 16

U.S. Forest Service 2015 (Table 3); Shoshone National Forest Record of Decision for the Land Management

Plan Revision May 6, 2015 at 4; Final Environmental Impact Statement Jan. 2014 Ch. 3 at 79, 411–413, 418–420, 421, 428–430; Final Environmental Impact Statement Jan. 2014 Vol. III Appendix F at 1305–1308. *See also* Shoshone National Forest Final Environmental Impact Statement Map F Lands Generally Suitable for Livestock Grazing, and Map 21 Lands Generally Suitable for Livestock Grazing.

### Caribou-Targhee National Forest

Acres of National Forest in Region 4: 31,885,607
Acres of National Forest on the Caribou-Targhee: 2,624,739
Acres of suitable range for cattle/sheep: 1,146,691
Acres allotted for cattle/sheep: 1,018,000
Acres closed to all grazing: 15,200
Percent of the Caribou-Targhee allocated for cattle/sheep: 38.7
Number of permitted grazing allotments: 122
Number of cattle allotments: 41 (541,200 acres)
Number of sheep allotments: 81 (476,800 acres)
Number of permitted cattle: 71,707
Number of permitted sheep: 37,441
Number of permitted Animal Unit Months: 135,000
An Animal Unit Month: forage for 1,080 pound cow/calf pair or 210 pound Ewe/Lamb
Cost per Animal Unit Month: $1.35
Miles of fencing on livestock grazing allotments: 482
Number of troughs and stock ponds on livestock grazing allotments: 1,103
Miles of pipeline for watering cattle/sheep: 51
Number of wells for watering cattle/sheep: 5

U.S. Forest Service 2015 (Table 3); Caribou-Targhee National Forest Revised Forest Plan Final Environmental Impact Statement Feb. 2003 Vol. I at 2-91, 3-102, 3-104, 3-107, 3-117; Final Environmental Impact Statement Feb. 2003 Vol. II at 4-85, 4-88, 4-90. *See also* Caribou-Targhee National Forest Rangeland Suitability for Livestock Grazing under Alternative 7R Map, and Range Allotment Boundaries Map.

### Curlew National Grassland

Acres of Curlew National Grassland: 47,600
Acres suitable for grazing livestock: 46,594
Acres unsuitable for grazing livestock: 1,006
Percent of the Curlew National Grassland allocated for grazing livestock: 97.8
Number of permitted grazing allotments: 2 Associations
Number of permitted cattle (cow/calf pairs): 3,316
Number of permitted Animal Unit Months: 21,480
Cost per Animal Unit Month: N/A
Acres of native vegetation: 12,000
Percent of Curlew National Grassland comprised of sagebrush: 95
Status of sagebrush: functioning-at-risk
Miles of roads: 76
Miles of streams functioning-at-risk: 5

Miles of fencing required for riparian habitat not currently fenced: 9
Miles of streamside improvements under selected alternative: None
Selected alternative meets properly functioning condition for sagebrush canopy cover in 10 years: No
Acres of grassland farmed and seeded with non-native species: 36,000
Projected annual grazing program cost: $249,300
Projected annual grazing program fair market value: $123,425
Summary of Trends for the Grassland: "Non-native seedlings have simplified species composition, reduced biodiversity, changed species interactions, and in some situations, reduced wildlife habitat quality and forage availability."

Caribou-Targhee National Forest Curlew National Grassland Plan Record of Decision and Final Environmental Impact Statement Feb. 8, 2002 Appendix G at G-6, G-8; Summary of the AMS March 2002 Ch. 2 at 2-3, 2-7, 2–8; Executive Summary March 2002 at 21, 23, 26, and 28.

**Bridger-Teton National Forest**

Acres of National Forest in Region 4: 31,885,607
Acres of National Forest on the Bridger-Teton: 3,383,302
Acres of suitable range for grazing livestock: 908,000
Acres allotted for grazing livestock: 2,164,000
Percent of the Bridger-Teton allocated for grazing livestock: 63.9
Number of permitted cattle in 1924: 51,000
Number of permitted sheep in 1924: 267,000
Number of permitted cattle in 1975: 39,000
Number of permitted sheep in 1975: 86,000
Number of permitted grazing allotments in 1990: 205
Number of permitted cattle in 1990: 40,000
Number of permitted sheep in 1990: 60,000
Number of permitted Animal Unit Months: N/A
Cost per Animal Unit Month: $1.35
Miles of fencing on livestock grazing allotments: N/A
Number of water developments on livestock grazing allotments: N/A
Acres of grazing allotments in unsatisfactory condition: 71,900
Number of watersheds: 65
Number of watersheds functioning at risk: 38
Number of impaired watersheds: 16

U.S. Forest Service 2015 (Table 3); Bridger-Teton National Forest Land and Resource Management Plan 1990 at 39, 86, 91.

**Beaverhead-Deerlodge National Forest**

Acres of National Forest in Region 1: 25,550,270
Acres of National Forest on the Beaverhead-Deerlodge: 3,380,000
Acres of suitable range for grazing cattle/sheep/horse: 846,135

Acres of National Forest allotted for grazing cattle/sheep/horse: 2,410,410
Percent of the Beaverhead-Deerlodge allocated for grazing livestock: 71.3
Number of permitted cattle allotments: 206
Number of permitted sheep allotments: 8
Number of permitted horse allotments: 35
Number of permitted cattle: 50,750
Number of permitted sheep: 15,600
Number of permitted Animal Unit Months: 255,200
An Animal Unit Month: forage to sustain a 1,000-pound animal for one month
Cost per Animal Unit Month for cattle: $1.35
Cost per Animal Unit Month for sheep: $0.27
Miles of fencing on livestock grazing allotments: 2,220
Number of water developments on livestock grazing allotments: 1,223

U.S. Forest Service 2015 (Table 1); Beaverhead-Deerlodge National Forest Land and Resource Management Plan Forest Plan Jan. 2009 at 7; Final Environmental Impact Statement Jan. 2009 at 305–306, 308. *See also* Final Environmental Impact Statement July 2007 Alternative 6 Livestock Grazing Allotments Map; May 2007 Alternative 1 - Existing Condition Livestock Grazing Allotments Map; Jan. 2009 Livestock Grazing Allotments Map; Beaverhead-Deerlodge National Forest and Dakota Prairie National Grasslands Dec. 15, 2022 grazing data.

**Dakota Prairie Grasslands**

Acres of Dakota Prairie Grasslands: 1,258,300
Acres of Grand and Cedar River National Grasslands: 161,700
Acres of Little Missouri National Grassland: 1,026,300
Acres of Sheyenne National Grassland: 70,300
Acres allotted for grazing cattle: 1,249,519
Percent of the Dakota Prairie Grasslands allocated for grazing livestock: 99.3
Number of permitted cattle grazing allotments: 540
Number of permitted cattle: 74,797
Number of permitted Animal Unit Months for cattle: 862,291
An Animal Unit Month: 1,000-pound cow calf pair
Cost per Animal Unit Month for cattle: $1.35
Miles of fencing on livestock grazing allotments: 4,138
Number of water developments on livestock grazing allotments: 3,099

U.S. Forest Service Northern Region, Dakota Prairie Grasslands Land and Resource Management Plan Record of Decision July 31, 2002 at 20, 27–28; Final Environmental Impact Statement Appendix C at C-1; Final Environmental Impact Statement Ch. 2 at 2-1; Beaverhead-Deerlodge National Forest and Dakota Prairie National Grasslands Dec. 15, 2022 grazing data.

**Bureau of Land Management**
**Dillon, Montana**

Acres of surface public lands on the BLM-Dillon: 968,194

Acres allocated for grazing livestock: 852,778
Acres unavailable for grazing livestock: 47,837
Percent of the BLM-Dillon allocated for grazing livestock: 94.75
Number of permitted grazing allotments: 425/268 permittees
Number of permitted Animal Unit Months: 113,219
Cost per Animal Unit Month: $1.35
Number and acreage of allotments in unsatisfactory condition: 128 (542,213 acres)
Acres seeded, plowed, chiseled, contoured, and herbicide sprayed: 85,996
Number of designated noxious weeds found on the BLM-Dillon: 14
Miles of fencing on grazing allotments: 1,468
Miles of pipelines laid for watering livestock: 175
Number of springs developed for watering livestock: 285
Number of reservoirs and stock ponds for watering livestock: 29
Number of guzzlers and wells for watering livestock: 3, 25
Number of cattle guards: 114
Miles of streams functioning-at-risk: 536
Miles of streams not functioning: 215
Percent of riparian areas functioning-at-risk: 59
Percent of riparian areas not functioning: 23

Bureau of Land Management Dillon, Montana Field Office Resource Management Plan and Draft Environmental Impact Statement March 2004 Vol. I at 161, 195, 197, 199, 210, 211, 300; Bureau of Land Management Dillon, Montana Field Office Record of Decision and Approved Resource Management Plan Feb. 2006 at 42. *See also* Resource Management Plan Grazing Availability and Allotments Map, and Resource Management Plan Land Status in the Planning Area Map.

**Bureau of Land Management**
**Butte, Montana**

Acres in the Butte Planning Area: 7,192,349
Acres of surface public lands on the BLM-Butte: 307,309
Acres allocated for grazing livestock: 270,039
Acres unavailable for grazing livestock: 37,000
Percent of the BLM-Butte allocated for grazing livestock: 87.8
Number of permitted grazing allotments: 237
Number of active cattle allotments: 210
Number of active sheep allotments: 3
Number of active horse allotments: 5
Number of permitted cattle AUMs: 24,139
Number of permitted sheep AUMs: 1,286
Number of permitted horse AUMs: 240
Number of permitted domestic bison AUMs: 12
Number of permitted Animal Unit Months: 24,710
Cost per Animal Unit Month: $1.35
Miles of fencing on grazing allotments: N/A
Number of water developments on grazing allotments: N/A

Total acres of crested wheatgrass and weed infestations on grasslands: 135,398
Total acres of crested wheatgrass and weed infestations on shrublands: 19,858
Waterhsheds in the Butte Planning Area where grazing is identified as a primary land use: Blackfoot, Big Hole, Boulder, Gallatin, Jefferson, Shields, Upper Missouri, Upper Clark Fork, Upper Yellowstone
Miles of impaired streams: 77
Miles of streams functioning-at-risk: 101
Watersheds for which no information is available: Blackfoot, Gallatin, Shields
Miles of streams not functioning: 34
Watersheds for which no information is available: Blackfoot, Gallatin, Shields, Upper Clark Fork, Upper Yellowstone

Bureau of Land Management Butte, Montana Field Office Record of Decision and Approved Resource Management Plan April 20, 2009 at 1, 15, 23; Proposed Resource Management Plan and Final Environmental Impact Statement Sept. 1, 2008 Ch. 1 at 2, Ch. 3 at 223–224, 240, 271–272. *See also* Butte Field Office Planning Area Map.

**Bureau of Land Management**
**Montana/Dakotas**

Acres of public lands on BLM Montana/Dakotas: 8,329,004
Miles of streams: 2,500
Acres allocated for grazing livestock: N/A
Acres of grassland bird habitat of international importance: 400,000+
Acres of inventoried and mapped noxious weeds: 192,985
Number of cattle/domestic bison grazing permittees: 4,119
Number of permitted cattle/domestic bison Animal Unit Months: 1,210,193
Number of horse/burro grazing permittees: 163
Number of permitted horse/burro Animal Unit Months: 5,231
Number of sheep/goats grazing permittees: 178
Number of permitted sheep/goats Animal Unit Months: 29,234
Cost per Animal Unit Month: $1.35

Bureau of Land Management Interior Regions 5 and 9 Montana/Dakotas 2018 Annual Report at 3, 10, 11.

**8.B. Domestication, artificial selection, and overutilization for commercial purposes endangers the genetic integrity and natural selection of wild bison. Consequently, genetically intact bison populations may be extinct.**

• Natural selection and the genetic integrity of wild bison is endangered by domestication and artificial selection.

• Domestication processes in current management are artificially selecting against wild bison.

• Management of bison conservation herds is domesticating the wild species. Metapopulation management is not restoring the migratory species in the wild, and presents a risk and threat to bison.

• Bison are at risk of genomic extinction as a consequence of domestication and artificial selection, an artifact of ranchers breeding cattle and bison in confinement to exploit bison's attributes for commercial purposes.

• Domestication of bison as livestock, a commercial activity, is not compatible with natural selection, evolutionary adaptation, and restoring bison as a wildlife species.

• Regulatory quarantine has not led to restoring bison in the wild. Managers have not investigated if genetic diversity is lost, and the rate and extent of loss, in the source population of Yellowstone bison undergoing regulatory quarantine.

• Yellowstone National Park's 50-year bison quarantine program includes transfer for commercial purposes and has not led to restoring self-sustaining bison populations in the wild.

• Proximity of domestic cattle, sheep, and ranched bison is a risk to bison roaming wild in the Yellowstone ecosystem.

***Natural selection and the genetic integrity of wild bison is endangered by domestication and artificial selection.***

"American bison provide a spectacular example of a species that resisted domestication." Folsom 2016 at 3 (footnote omitted).

Colonists, including the Huguenots in Virginia, tried to domesticate bison as early as 1701. Folsom 2016 at 5.

Land speculator George Washington attempted to acquire bison calves to "raise a Breed of them" at his Mount Vernon estate in Virginia. Folsom 2016 at 11.

From *Legacies and Lessons of the History of the Bison*
Andrew C. Isenberg, Temple University

Thomas Jefferson tried but never realized obtaining bison for his animal park at Monticello in the 1770s. Folsom 2016 at 10.

Successful cross-breeding of bison and cattle "by several people of distinction" in Illinois was first reported by Peter Kalm in 1754. Folsom 2016 at 8; American Bison Society 1918 at 30.

There are written accounts from Spanish conquistadors in the 1500s of bison in Aztec ruler Emperor Montezuma's private menagerie — at a time when bison's range was 1,000 miles away from the capital city of the Aztec Empire. Garrett 2007 at 9; Bitto 2016 at 2, 4.

After great cost and effort the French in Lower Louisiana attempted but dropped their plans for domestication because of the difficulties encountered in reducing bison in the wild to captivity. Folsom 2016 at 8.

Bison would often "harm or kill themselves" in transatlantic shipments destined for the menageries of European royalty. Folsom 2016 at 2.

In attempts to obtain bison in Texas during 1779–1780 for the King of Spain, Carlos III, the bison would "kill themselves in anger." Folsom 2016 at 14 (quoting Texas hunter and rancher Carlos Rioja).

Former hide hunter C.J. "Buffalo" Jones, who aspired to perfect a cattle-buffalo hybrid, lost one-fourth of an entire herd who "destroyed itself" while confined in boxcars on a railroad passage from Winnipeg, Manitoba to Kansas City, Kansas. Ogilvie 1979 at 21, 22.

In 1879, members of the Gros Ventre tribe broke down a fence freeing fifty calves caught by Montana plainsman Vic Smith and penned north of the Yellowstone River breaks. Zontek 2003 at 74.

The initial efforts to save bison from extinction were driven in part by ranchers "who wanted to improve their cattle by crossbreeding them with bison, that is, to introduce genes resulting in commercially favourable traits into cattle, such as those for meat quality and quantity, hardiness, feed efficiency, and disease resistance (Boyd 1914; Goodnight 1914)." Hedrick 2010 at 3328.

"From early Virginian settlers, through Governor Bedson and Buffalo Jones to our Canadian Agricultural Experimental Stations, people without number have wanted to breed a "cattalo" (Buffalo Jones coined the word) which would combine the hardiness and winter foraging ability of the buffalo with the beef-bearing stolidity of domestic cattle." Ogilvie 1979 at 62.

> *The object of this experiment is to develop a range beef animal for Western and Northwestern Canada which combines a maximum of the hardy characteristics of the buffalo (bison) and the superior meat qualities of the domestic breeds.*
> Hybridization of Domestic Beef Cattle and Buffalo, A Progress Statement, 1950.

Ogilvie 1979 at 64.

Infertility and sterility resulting from cross breeding bison and cattle caused the Dominion Department of Agriculture in Canada to abandon decades of work to create a new breed of cattalo. Ogilvie 1979 at 63.

> 1. His amenability to domesticity being perfect.
> 2. His economic value being incomparable.
> Having come to this important conclusion, that in the American buffalo we have an animal

> superbly endowed by nature, not by artifice, to fill the bovine requirements of this country, made ready to hand, but his thorough adaptability unperceived or selfishly overlooked, we have now to consider the possibility of realizing our dream: *i.e.*, establishing his destiny as an animal of such utility as is proved he possesses. We can resign the old romance, but we can not risk the reality in so far as that can be preserved and enhanced. The buffalo, as he has been known, will be known no more. Established in the place his destinators would prepare for him, he will be an entirely different-natured—and even nurtured—being from that from which he was forcibly exiled; and, fulfilling the mission proposed for him, he will become greatly modified from the noble monarch of old. This is inevitable and consequent.

Auld, *A Means of Preserving the Purity and Establishing a Career for the American Bison of the Future*, 1890 at 790–791.

Domestication of bison taken from the wild was unsuccessful as a commercial enterprise until the migratory species was driven to near extinction in the late 1800s.

"Three years ago, there were in this country about two hundred and fifty domesticated buffalo, in the possession of about a dozen individuals." Grinnell 1892 at 274.

The remaining bison including Yellowstone bison, have been subject to a series of extensive, widespread, and ongoing artificial selection and domestication processes for 120 years.

> In 1902, when Secretary of the Interior Ethan Allen Hitchcock requested funding from Congress "for the purchase of buffalo and the corralling of them in Yellowstone Park," he pointed out that by keeping them "under government supervision, it is believed that a herd of pure-blooded American bison may be domesticated" (Hitchcock 1902). Yellowstone's acting superintendent Major John Pitcher thought that the small herd of wild bison remaining in Pelican Valley "may possibly die out completely," but he expected that the 17 bison obtained from ranchers could "become very tame" if kept fenced in Lamar Valley. It was his intention "to feed and handle the new herd of buffalo in the same manner that domestic cattle are handled in this country, and . . . to brand them U.S. in such a way that they can always be identified as United States property" (Pitcher 1904).

Franke 2006 at 70.

For a detailed examination of the transition of how bison were managed in Yellowstone National Park during the 20th century, *see* Franke 2005 at 75–99.

Domestication processes and artificial selection threaten natural selection and variation of the wild bison genome. Several of these factors also jeopardize the distinct population segment of Yellowstone bison remaining in the wild:

- Domestication practices and selection for livestock traits such as docility and production of more meat (non-adaptive, impairs natural selection, and reduces the full range of bison's ecological roles, functions, and interactions).
- Intensive management and culling practices (non-random selection, reduces genetic

variation, undermines natural selection and evolutionary adaptation).
- Isolating herds on fenced ranges in small populations that are fed, routinely handled, rounded up, and selectively culled (artificial selection determines which bison reproduce or not).
- Artificially skewing male to female ratios (altering mate choice, undermining sexual selection, shifting breeding strategy, and transforming the evolutionary trajectory of the population).
- Ear-tagging or micro-chipping, and vaccinating bison (handling and marking as property, introducing livestock vaccines weakens natural selection for disease resistant bison).
- Eradicating natural predators (bison's acute senses are reduced, few if any herds evolving with natural predation, and few if any herds evolving from or subject to a preponderance of natural selection processes).
- The legacy of ranchers and the government cross breeding cattle and bison (no evidence it naturally occurs in the wild, genetic integrity is lost, genomic extinction of populations may be one result with uncertain and unknown effects on bison's fitness).
- The introgression of cattle genes resulting from metapopulation management (bison ancestry was disregarded in the founding of "conservation" herds, transfer is likely a factor in the loss or extinction of genetically intact bison populations).
- Metapopulation management to prevent inbreeding and save dwindling genetic diversity could lead to loss of genetic diversity and spread lethal diseases to bison (artificial selection of breeding mates through transfer also undermines natural selection achieved by competition among bulls and female choice).
- The introduction of non-native livestock diseases in the bison's range (which subject bison in the wild to intensive management, harassment from habitat, trapping, handling, quarantining, vaccination, and other domestication practices).

Hedrick 2009 at 412; Bailey 2013 ch. 8 at 133–149; Dratch 2008 at 4–6; Dratch & Gogan 2010 at 9; Freese et al. 2007 at 177; Stroupe et al. 2022 at 1; Hartway et al. 2020 at xi.

"Confinement has been imposed upon bison in order to render the species docile, impotent, and incapable of disrupting the established order." Lulka 1998 at 77.

An acutely accurate observation reflecting how various jurisdictions — including successive managers overseeing the designated protected area of Yellowstone National Park since the 1960s — have institutionalized limiting the range and movements of bison to serve dominant political and economic orders.

Enclosure is a continuous factor in domesticating bison conservation herds including Yellowstone bison because demarcating boundaries and installing barriers limit and reduce bison's long range foraging movements, adaptability to climate change and changing environmental conditions. At the same time, enclosure reinforces "stocking" rates or population "targets" which drives the "surplus" to get rid of in intensively managed populations.

In its' application to Yellowstone bison, managers are domesticating bison by confining the wild species to limited ranges through fencing and management action, and systematically subjecting the migratory species to a number of artificial selection processes because of a cattle-introduced diseased.

The use of livestock and veterinary management on Yellowstone bison is a trend that is expected to continue for the foreseeable future.

Intensively managing Yellowstone bison is domestication and in conflict with the evolutionary processes natural selection favors for the migratory species' long-term fitness in the wild. Bailey 2013 at 78 ("Natural selection, with no or minimal influence by humans, is the benchmark of wildness.").

"[T]here is something "unnatural" about ranges that do not change and populations that do not substantially vary." Lulka 1998 at 126.

Replacing or weakening natural selection with artificial selection is extensive, widespread, and ongoing in management actions targeting Yellowstone bison by way of:

- Limiting ranges.
- Disrupting connectivity to seasonal ranges.
- Reducing herd sizes.
- Trapping bison for slaughter and quarantine.
- Selecting against bison with disease resistance.
- Skewing bull to female ratios.
- Reducing the number of older aged adults.
- Conducting hazing operations harassing bison from their calving grounds.
- Killing bison for exploring their home range.
- Vaccinating trapped bison.
- Experimenting with population control including a chemical sterilant to determine which bison breed or not.

Replacing or weakening natural selection with artificial selection is also extensive, widespread, and ongoing in other bison "conservation" herds as evidenced in:

- Small herd sizes.
- Small herd ranges with little habitat diversity.
- Intensive range/habitat manipulation.
- Provision of artificial waters.
- Provision of supplementary feed during winter or drought.
- Annual roundups and selective culling (Figs. 8.2, 8.3).
- Selection of bulls for breeding.
- Control of breeding season by separating bulls and cows.
- Early, forced weaning of calves.
- Assistance in calving.
- Maintaining stable herds sizes well below ecological carrying capacity.
- Maintaining herds with unnaturally young age distributions.
- Maintaining an unnaturally low bull to cow ratio.
- Culling feisty, excitable, intractable bison.
- Unintentional injuries and deaths of excitable bison during handling (Fig. 8.4).
- Use of vaccinations, vermicides, and antibiotics.
- No effective predators.

Bailey 2013 at 137–139.

Overutilization for commercial purposes and domestication of "conservation" herds is an ongoing threat to bison.

Boyd's status review of the subspecies found overutilization for commercial purposes (hybridization and domestication) an important consideration in listing plains bison under the Endangered Species Act. Boyd 2003 at 93.

Boyd's finding is still relevant and valid today.

> [T]he evolution of bison restoration into an agricultural industry (Hudson 1998; Hughes 1998) raises questions about their genetic diversity and whether their innate characteristics as a wild species will be preserved.
>
> . . .
>
> Management trends, such as feedlot finishing, dehorning, small herd sizes, skewed sex ratios and selection based on characteristics that alter bison behavior, lead some scientists to say bison are being managed as livestock and, therefore, are well on their way to being domesticated (Hudson 1998; Lott 1998; Schneider 1998).

McDonald 2001 at 103, 107.

The bison remaining in North America are dominated by the private commercial market.

"More than 90 percent of the bison in North America today are undergoing domestication." Lott et al. 2002 at 185.

> The vast majority of these bison, about 303,000, are privately owned and managed using domestic and/or commercial livestock husbandry practices (U.S. Department of Agriculture National Agricultural Statistics Service 2019; Statistics Canada 2017). These bison are often managed using artificial selection strategies to promote better growth rates for meat production (Gates et al. 2010; Halbert and Derr 2008), or to favor more docile animals less challenging to handle as livestock. While these bison have important economic, cultural, and nutritional values, many commercial bison herds are not exposed to conditions and natural selection pressures that shaped their ancestors' wild nature.

Hartway et al. 2020 at 1.

The commercial bison population is growing; only 20,000 bison remain in "conservation herds" in North America — a number that has stagnated since the 1930s. Boyd 2003 at 70; Hedrick 2009 at 412.

"Only 1 conservation herd with no known ancestry from cattle has an effective population size of more than 1000." Hedrick 2009 at 411. (Stroupe et al. 2022 found intact bison populations may be genetically extinct, *infra*).

Today, 96% of bison are subject to anthropogenic selection for commodity production. Freese et al. 2007 at 175.

> In addition to small herd size and a lack of gene flow among managed herds, historical events such as severe bottlenecks and cattle-gene introgression in both conservation and commercial herds threaten the integrity and diversity of the bison species genome (Halbert and Derr 2007; Freese et al 2007; Hedrick 2009).
>
> . . .
>
> [S]ince the entire bison species went through a severe bottleneck in the late 1800s, and then again as more conservation herds were founded with few individuals, all bison populations can be assumed to have some level of inbreeding. For example, Hedrick (2009) estimated an approximate level of inbreeding of 0.367 (equal to 2 generations of full-sib mating) in the Texas State Bison Herd. Although the direct effects of inbreeding in bison are unclear, even small amounts of inbreeding have been correlated with the susceptibility to bacterial disease in other wildlife populations (Acevedo-Whitehouse et al. 2003). Overall, historical erosion of genetic variation due to severe bottlenecks, multiple founder events, and inbreeding make preservation of remaining genetic variation through effective management strategies even more imperative to the persistence of bison.

Toldness 2014 at 22.

The U.S. Fish & Wildlife Service must examine and investigate systemic domestication processes and artificial selection practices used in current management and the loss of natural selection as threats to the evolution of wild Yellowstone bison in the agency's threats assessment and status review.

***Domestication processes in current management are artificially selecting against wild bison.***

> When the buffalo disappeared, the old wild Indian disappeared too. There are places set aside for a few surviving buffalo herds in the Dakotas, Wyoming and Montana. There they are watched over by Government rangers and stared at by tourists. If brother buffalo could talk he would say, 'They put me on a reservation like the Indians.' In life and death we and the buffalo have always shared the same fate.

John Fire Lame Deer (Tahca Ushte), Lame Deer & Erdoes 1972 at 270.

> Like the colonized, bison share the low status of an uprooted population in a state of exile. Within the GYE, a multiplicity of borders segment the landscape, defining "safe and unsafe" zones. The park boundary and property lines present a gauntlet which park bison must navigate successfully in order to persist within the borderlands. These borders, physical and metaphysical, demarcate regions in which park bison are the "forbidden." Clearly bison exist in a state of deprivation, as available resources are denied for the purpose of stability.

Lulka 1998 at 77.

> Domestication is the predominant threat to persistence of wild plains bison. If wild plains bison are to persist, we must retain the wild genome in a wild environment. In an "artificial" environment with abundant human controls, the wild genome will deteriorate into something else.

Bailey 2013 at xv.

In endlessly subjecting Yellowstone bison to a number of artificial selection processes managers are risking the loss or extinction of the wild genome.

Intensive State and federal management practices jeopardize Yellowstone bison's genetic variation and fitness, adaptation and resiliency to random environmental changes, and interfere with natural selection processes shaping their evolution in the wild.

"Intensive management of wildlife is expected to impact populations demographically and genetically. For bison, intensive management in small, isolated populations with fixed population sizes and annual removal of surplus animals predicts the erosion of genetic variation over the long term." Toldness 2014 at 20.

For Yellowstone bison, State and federal managers are:

- Restricting the ecological range and natural migrations of bison.
- Reducing herd sizes below the minimum required to prevent inbreeding and maintain genetic diversity.
- Conducting annual trapping operations with disproportionate killings of genetically distinct subpopulations.
- Harassing bison from habitat, including calving grounds, in government hazing operations.
- Permitting fencing and cattle guard schemes to prevent bison migration and dispersal in their home ranges.
- Vaccinating trapped bison.
- Unnaturally skewing breeding male to female ratios.
- Altering the age structure by killing older aged bison.
- Killing entire family lineages (generational parent-offspring).

For detailed evidence and analysis of how management actions jeopardize Yellowstone bison in the wild, *see* factors 8.C. and 8.D.

Domestication must be examined and investigated as a threat because it may be "irreversibly altering the bison gene pool and its morphology, physiology and behavior . . ." Freese et al. 2007 at 177 (citations omitted).

The genetic consequences are similar to "hide hunting, except that instead of stripping off the hide and discarding the meat, bison domestication will strip out the genes that make for good domestic bison and discard the genes that make wild bison wild. . . The essence of domestication is selective breeding: humans deciding which individuals will produce the next generation, and choosing them to produce a next generation that will better serve human goals." Lott et al. 2002 at 197, 198.

> Instead of a natural sex ratio of a bit less than one bull per cow (bulls don't live as long as

> cows in nature), the sex ratio of these herds is altered, perhaps to a ratio of one bull to ten cows.
>
> Such ratios are right if your goal is to produce the maximum number of calves each year from a given amount of range. But while the range will produce more calves, they are likely to be less wild. Natural selection will select animals better suited to their circumstances. A biased sex ratio is a very important circumstance and seems certain to shift the breeding strategy of both males and females. It's likely that when there are lots of cows, bulls that back away from a challenge and spend the time and energy saved finding unattended cows will tend to father more calves. When there are few bulls, cows that aren't coy and don't run about early in estrus inciting competition between bulls will be more sure of being bred each year.
>
> Moreover, selling bison means handling them in corrals. Individuals that attack their handlers are unlikely to have another chance to breed. In these and other ways the animals are being domesticated. Natural selection works and artificial selection works even faster. That's why wild bison behave the way they do, and why domestic bison will behave differently.

Lott et al. 2002 at 198–199.

The U.S. Fish & Wildlife Service must examine and investigate "the degree of replacement of natural selection by artificial selection" (Bailey 2013 at 136) because current management jeopardizes the wild genome in the Yellowstone bison population.

> Artificial selection involves manipulating genetic composition in bison from generation to generation; one direction has been to select animals better adapted to humans and to a captive environment (Lott 1998). According to Geist (1996), bison ranching is nothing more than domestication of a wild animal. It makes no difference, he writes, whether bison are altered deliberately or inadvertently, because ranching makes bison "tractable and a source of products desired by their owner or the marketplace" (1996: 127).
>
> . . .
>
> The healthiest policy to follow as more is learned about genetic variation in bison, according to Trinity University biologist Karen Chambers (1998), is to manage bison herds by avoiding any incidences of nonrandom selection. The compulsion to tinker through selective breeding means that, for each attribute selected, another trait is inescapably lost in the genetic makeup of bison.

McDonald 2001 at 107–108, 109.

The predominate and most significant artificial selection processes operating on bison are management policies selecting against disease and disease resistance, reducing herd sizes in government trapping for slaughter operations, and restricting bison's migratory range and ecological settings in the Yellowstone ecosystem. All of these systemic processes replace natural selection and undermine fitness and adaptation of the wild genome because bison are killed before the values of the fittest individuals are fully realized by natural selection.

Corralling and handling bison over many years and decades for disease management is a systemic factor selecting against wildness "in the Yellowstone bison for generations." Lott 2002 at 111.

PHOTO: Jim Peaco

For detailed evidence and analysis of how State and federal disease management is a threat to wild Yellowstone bison, *see* factors 8.C. and 8.E.

The additive, synergistic, and cumulative harms of using a preponderance of artificial selection and domestication processes on bison remains largely unknown for lack of study.

In repeatedly applying practices leading to domestication of a wild species, managers are institutionalizing policies that are steadily eroding the wild character and traits of Yellowstone bison.

Repeated generation after generation, in time, artificial selection and domestication processes transform bison's behavior, traits, and life history patterns with far-reaching consequences including:

- Inbreeding, with negative effects on survival and reproduction.
- Loss of genetic diversity and ability to evolve and adapt to changing environments.
- Altered body size, smaller or larger, depending upon selection.
- Reduced skull and brain size.
- Diminished dominance behavior.
- Reduced nutritional and energetic efficiencies.
- Reduced maternal behavior, lower milk quality.
- Diminished ease of calving.
- Decline of precociousness in calves.
- Reduced synchrony of breeding and calving.
- Lethargy, less aggressiveness, reduced mobility and agility.
- Diminished disease resistance/accommodation.
- Reduced acuity of senses.
- Diminished ability to survive in the wild.

Bailey 2013 at 141.

"Although the ideal goal of bison conservation is to maintain the bison as a wild species, in contrast to the domesticated state, the realities of the developed landscape and existing human settlement limit opportunities for conserving bison under completely natural conditions." Boyd 2003 at 1–2.

Given the vast loss in wild bison populations, the U.S. Fish & Wildlife Service must examine and investigate the effects of ongoing management policies selecting against wild Yellowstone bison in the agency's threats assessment and status review.

***Management of bison conservation herds is domesticating the wild species. Metapopulation management is not restoring the migratory species in the wild, and presents a risk and threat to bison.***

The wild genome bequeathed by bison's ancestors over thousands of years of evolving natural processes is at risk of extinction.

The best available evidence indicates management is domesticating the wild species, and in the case of Yellowstone's herds, managing for the loss or extinction of the wild bison genome.

Boyd's (2003) status review was the first to comprehensively assess the conservation status of bison in the United States and Canada.

It does not follow that the bison "conservation" herds Boyd surveyed in North America are wild or classified or recognized as wildlife.

> The application of this term assumes that herds managed by governments and conservation organizations are maintained for conservation purposes. Conservation herds may be free-ranging or captive. For this survey, these terms are distinguished based on the absence or presence of a perimeter fence confining a herd's range.
>
> . . .
>
> Currently, there is no other method for objective identification of conservation populations. Therefore, the management of some herds within the scope of this survey may emulate commercial practices. . . As well, the size and management practices of some conservation herds may be similar to some zoo populations. Objective criteria are needed for assessing the conservation value of bison herds, and identifying populations that best support conservation objectives. Resolution of this issue is beyond the scope of this survey.

Boyd 2003 at 4, 5.

> "Bison in zoos are not the same as the bison we observed-frisky, aggressive, shy, social, powerful" (1994:xviii). The bison held in captivity and under the control of humans behaved differently than bison that were relatively free to range the grasslands. Yet, bison are often isolated in small herds on small tracts of land, making them captive animals much like those in a zoo.

McDonald 2001 at 108 (quoting conservation biologists Joel Berger and Carol Cunningham on the behavioral ecology of bison in Badlands National Park).

Loss of the wild species through domestication is a chronic threat for bison conservation herds and the distinct population segment of Yellowstone bison.

Wildness is an endangered characteristic of bison.

All bison conservation herds are either captive or enclosed by boundaries imposed by various governments.

Bison are prohibited from freely roaming a landscape let alone an entire ecosystem or bioregion.

Bison are ecologically and functionally extinct.

Bison are not allowed to fully express the keystone and ecosystem engineering roles they fulfill in providing for grassland ecosystem health and native species diversity.

Bison are precluded from migrating and adapting to changes in the seasons, environmental stressors, and rapid climate change.

Bison are prevented from choosing and determining their seasonal home ranges.

Bison mates are chosen in artificial selection processes.

Bison are so intensively managed U.S. Forest Service workers remove their gut piles. French, Billings Gazette 2023.

Bison are forbidden from being wild.

Even if a herd is managed for conservation purposes how States legally define bison has far-reaching consequences.

Montana recently changed its' legal definition "to specify that a bison previously subject to the per capita fee could never be classified" as a "wild" bison in the State. United Property Owners of Montana 2021 at 3.

For bison to be recognized as "wild," all of the following criteria must be met:

> has not been reduced to captivity;
> has never been subject to the per capita fee under 15-24-921;
> has never been owned by a person; and
> is not the offspring of a bison that has been subject to the per capita fee under 15-24-921.

Montana Code Ann. § 81-1-101(6)(a–d) (2021).

In redefining "wild" bison it is uncertain if any population of bison meets all of the criteria to be recognized as wild in Montana.

In its' application to Yellowstone bison, the transfer of Pablo–Allard owned bison in 1902 saved by Ɫatatí' (Little Peregrine Falcon Robe) casts doubt on whether the Northern range herd or the Yellowstone population meet the criteria to be legally recognized as "wild" under Mont. Code Ann. § 81-1-101 (2021):

• Smith, Salish-Pend d'Oreille Culture Committee 2011 at 15–16 (describing the origin of the Pablo–Allard bison purchased by Yellowstone National Park for transfer on the Northern range);
• Stroupe et al. 2022 at 7 (bison transferred on the Northern range were also purchased from Goodnight who, in addition to Buffalo Jones, cross-bred bison and cattle);
• Wood 2000 at Figure 1 (showing Pablo–Allard purchased 10 bison for $250 each from Samuel Walking Coyote in 1884 and 29 bison from Buffalo Jones in 1883);
• Franke 2006 at 70 (noting Secretary of the Interior Ethan Allen Hitchcock's request for funding from the U.S. Congress "for the purchase of buffalo and the corralling of them in Yellowstone Park"); and
• U.S. Congress 1923 at 46 (distinguishing the "tame" herd of buffalo purchased with a Congressional appropriation of $15,000 from the "wild" herd remaining in Yellowstone).

Bison on the America Prairie Reserve — an ambitious effort to create a 3.5 million acre preserve to restore native species — are classified as livestock and subject to Montana's per head fee ($6.38 in 2021). Huffman 2019 at 35; Montana Dept. of Livestock 2021; Sierra Club 2019 at 3.

In "captive" herds, managers (or owners in the case of nonprofit groups or privately owned businesses who are required by law to pay livestock per capita fees) select a pre-defined space, confining the natural movements of a mammal species with the largest spatial requirements in North America. Ritson 2019 at 1.

> Based on their body mass, bison should have the largest spatial requirements of any North American mammal (Ofstad et al. 2016), yet they are among the most geographically restricted due to current management regimes (Gates et al. 2010). More than half of bison herds managed for conservation are confined to fenced pastures encompassing areas less than 16 km$^2$, which is ~80 times smaller than the expected minimum space use of free-range bison (Bailey 2013). Anthropogenic restrictions like this render bison incapable of responding to seasonal changes in landscape characteristics, including shifts in forage productivity (Merkle et al. 2016), resulting in increasingly intensive use of existing patches (Frank et al. 2016).

Ritson 2019 at 16.

> A continent-wide survey conducted in 2002 found that of the approximately 500,000 plains bison in North America, only 20,000 are managed for conservation purposes and these 'conservation' herds are confined to small geographically isolated herds that are heavily managed to maintain population size (fig. 52).
>
> . . .
>
> Currently, intense land management constrains most bison herds to relatively small, fenced-in areas, restricting natural migratory behavior.

Kauffman et al. 2020 at 106.

In "conservation" herds, managers select bison to range a pre-defined space confining bison's movements and foraging patterns to the limited habitat available based on population "targets" or "stocking" rates.

For example, Badlands National Park manages for a population of 700 bison on 19,500 hectares (48,185 acres); Theodore Roosevelt National Park manages for 200–500 bison in the South Unit and 100–300 bison in the North Unit on 18,400 and 9,600 hectares (45,467 and 23,722 acres) respectively; Wind Cave National Park manages for 350–500 bison on 11,500 hectares (28,417 acres) within a woven-wire boundary fence. Licht 2016 at 138, 139; Licht & Johnson 2018 at 115.

> The three parks rounded up bison in September–November of most years from 1983–2014 for the primary purpose of removing surplus animals. The roundups typically collected most, if not all, of the cow-calf herds; however, bachelor herds and single bulls were generally avoided, as they were difficult and dangerous to handle. Captured adult bulls were typically pushed into the corrals as part of a cow-calf herd. Captured animals were individually pushed into a restraining chute where they were processed. Calves and other un-marked animals were marked with a uniquely-numbered external ear tag and a uniquely-numbered passive microchip injected subcutaneously in the ear.

Licht 2016 at 140.

If bison were to break out of Wind Cave National Park's enclosures in search of water or forage on private land they would be classified as "trespass livestock" in South Dakota. McNeeley et al. 2016 at 156.

Except for a "few recalcitrant bulls," managers on the National Bison Range round up and capture the entire herd. Lott 1991 at 137. Branding of bison calves with the year they were born was eventually phased out, and current management calls for implanting subcutaneous microchips at the base of the ear for bison calves or fixing a metal "brite tag" approved by the U.S. Dept. of Agriculture "as part of the national identification system required for interstate animal transport." Lott 1991 at 138; U.S. Fish & Wildlife Service 2019 at 29.

Ear tags and other identifying markers not only diminish the esthetic value of wild bison but the effects on dominance behavior resulting from deformities (broken and deformed horns) incurred in traps and chutes is uncertain. Bailey 2013 at 139.

In enclosing bison's range in the Yellowstone ecosystem, State and federal managers reduce population size within the capacity of the restricted or enclosed range necessitating further intervention to control and select bison to maintain manager's target population size. Interagency Bison Management Plan Members 2022 at 2 (defining "a boundary line beyond which bison will not be tolerated.").

In enclosing and restricting range and reducing herd sizes in ongoing management actions, State and federal managers are systemically undercutting natural selection of wild bison and their ecological roles, functions, and interactions in the Yellowstone ecosystem.

Domestication is reinforced in repeated management actions designed to undermine migratory behavior, and adaptation of Yellowstone bison to changing seasons and environmental conditions in the ecosystem.

Managing conservation herds in small, isolated populations that are routinely handled to "maintain target population sizes," increases the risk of extinction and decreases the evolutionary pathway for bison to survive in an ever changing environment. Giglio 2018 at 766.

> Each conservation herd is typically maintained at a target population size by removing animals at regular intervals. Population size targets are set to avoid permanent habitat damage and accommodate multiple management objectives on small, isolated reserves (Boyd 2003, Boyd et al. 2010). In these small herds, demographic stochasticity is amplified compared to larger populations and, as a result, small populations are more vulnerable to extinction (Lande 1988, Legendre et al. 1999, Melbourne and Hastings 2008).
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> . . .
>
> In addition to increased extinction risk through demographic stochasticity, small populations are also vulnerable to extinction through inbreeding depression and erosion of genetic variation (Allendorf and Leary 1986, Ralls et al. 1988, Lacy 1997). Management actions that preserve genetic variation and limit the accumulation of inbreeding are important to the long-term persistence of populations.

Giglio et al. 2018 at 766, 767.

> In the long-term, reductions in genetic diversity ultimately decrease the ability of populations or species to evolutionarily adapt to changing or novel environmental conditions (Fisher 1930; Reed and Frankham 2003), such as increased climatic variability or the emergence of novel diseases (Reed et al. 2003; Siddle et al. 2007). Conservation of genetic diversity provides the foundation for adaptive capacity on the evolutionary pathway of bison and is essential for conservation, especially when the existing evolutionary forces of selection may be limited on some DOI [U.S. Department of the Interior] landscapes.

Hartway et al. 2020 at 2–3.

Confining bison in conservation herds to small scale landscapes is also incompatible with the large spatial needs bison require for adapting and evolving as a migratory wildlife species with complex interrelationships in the ecosystems they depend on for survival.

> Our comparison of free-range and captive bison spatial patterns indicates fences may have a larger influence on their space use than local environmental characteristics, manifested by the lack of seasonal variations in space-use. Local characteristics of movement and selection are generally emphasized as major influences of bison spatial distributions (Fortin 2003; Dancose et al. 2011; Merkle et al. 2014; Merkle, Cherry, et al. 2015; Merkle, Sigaud, et al. 2015; Raynor et al. 2017), but understanding the emergent properties of these patterns across the modern landscape is important for bison conservation. Only recently has research begun to address the incompatibility of small scale management for ungulates with large spatial requirements (Meisingset et al. 2018). Our models of home range suggest anthropogenic features heavily impact bison home range sizes. The amount of space available to bison in the study areas we examined was the most important explanatory factor for the size of growing season home ranges. Overall, free-ranging bison used nearly 40 times more space than captive bison during the equivalent season while space use of captive bison

> predictably concurred with their pasture size (i.e., available space). We also found that proximity to roads significantly described trends in annual home ranges. Space use tended to be greater in areas closer to roads on average, which may be related to frequent human disturbances leading to increased bison movement rates (Fortin and Andruskiw 2003). However, due to the large portion of the bison sampled for these models coming from the Henry Mountains, interpretation should proceed with caution.

Ritson 2019 at 25–26.

While bison may continue to exist, domestication is a predominant influence in conservation herds vastly weakening the structure and distribution of bison's complex ecological roles, functions, and relationships as a migratory species.

> [P]ractices deemed necessary to prevent their extinction may have actually removed essential spatial components of their evolutionary history and contributed to their possible ecological extinction (Freese et al. 2007; Sanderson et al. 2008). The vast extents required by bison necessitates a landscape approach to their conservation (Gates et al. 2010).
>
> . . .
>
> Our multi-scale assessment of bison spatio-temporal patterns suggest that fencing may inhibit bison from responding to seasonal landscape variations. While sociopolitical influences preclude bison from returning to their entire historic range and population levels, more space may be necessary to replicate ecologically beneficial behaviors. As innately intensive grazers, bison have a natural tendency to move frequently to avoid overgrazing patches.

Ritson 2019 at 29, 29–30.

In fixing boundaries for wide ranging bison who require vast spatial landscapes to adapt and evolve in a wild environment, what conservation value remains may be at risk from managing for targeted population sizes in geographically isolated ranges.

A "wide ranging species, such as bison, are restricted to suitable habitat but of limited size and isolated from other populations, which negatively affects their conservation in the long-term." Ritson 2019 at 54–55.

The breadth of genetic diversity is also declining and at risk from inbreeding as a consequence of lost connectivity and natural gene flow between wild bison populations.

> Historically large, outcrossing populations that suddenly decline to a few individuals usually experience reduced viability and fecundity, known as inbreeding depression. In many species, lines propagated by continued brother-sister mating . . . tend to become sterile or inviable after several generations. Rapid inbreeding in small populations produces increased homozygosity of (partially) recessive deleterious mutants that are kept rare by selection in large populations, and by chance such mutations may become fixed in a small population despite counteracting selection.

. . .

> Managers of captive populations only recently became aware of the importance of avoiding inbreeding depression in propagating small populations.
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> . . .
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> In small populations, random fluctuation in gene frequencies (random genetic drift) tends to reduce genetic variation, leading eventually to homozygosity and the loss of evolutionary adaptability to environmental changes.
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> . . .
>
> Of course, if an area with fixed boundaries has been established as a natural preserve containing suitable habitat for some species, long-term climatic trends may induce major evolutionary changes in the population, or render the entire preserve unsuitable. This problem is compounded for species that undergo long-distance seasonal migrations and require two or more widely separated patches of suitable habitat.

Lande 1988 at 1456, 1458 (endnotes omitted).

> The loss of genetic diversity due to random genetic drift increases the risk of inbreeding depression, the reduction in fitness in offspring of closely related parents relative to the offspring of unrelated parents (Allendorf et al. 2013). Inbreeding depression has been widely documented among animal species and can result in a broad range of fitness effects, including high infant mortality, skewed sex ratio, reduced adult survival, increased health problems, and infertility (Hedrick and Kalinowski 2000; Hogg et al. 2006; Keller and Waller 2002). The lower survival and reproductive rates typical of inbred individuals in turn lead to declines in population growth rates, thereby increasing the risk of population extirpation (Gilpin and Soulé 1986; Mlot, 2015; Soulé and Mills 1998; Westemeier et al. 1998). Reductions in genetic diversity also ultimately decrease the ability of populations or species to evolutionarily adapt to changing or novel environmental conditions (Fisher 1930; Reed and Frankham 2003), such as increased climatic variability or the emergence of novel diseases (McCallum and Jones 2010; Reed et al. 2003).

Hartway et al. 2020 at 19.

"[I]nevitable genetic changes from random genetic drift and selection in artificial environments may make it difficult for captive strains to be reestablished in the wild. Protection and restoration of natural habitats is the best and cheapest method of preserving the biological diversity and stability of the global ecosystem." Lande 1988 at 1455–1456 (endnotes omitted).

While managers are unlikely to admit or recognize it, the risk of extinction is not only for small bison populations numbering in the hundreds but to populations numbering in the thousands.

> Small populations risk extinction from a variety of genetic and demographic factors,

> including inbreeding depression as well as the fixation of new detrimental mutations.
>
> . . .
>
> [I]t appears that fixation of new, slightly deleterious mutations poses a considerable risk of extinction for populations as large as a few thousand individuals.
>
> . . .
>
> Thus, the risk of extinction from fixation of new mutations with a constant selection coefficient appears comparable to that of only the weakest demographic factor, demographic stochasticity. In contrast, with reasonable variance in selection coefficients, the fixation of new detrimental mutations poses an extinction risk potentially comparable to that of the strongest factor, environmental stochasticity (Table 3).

Lande 1995 at 786, 787, 788.

While the lineages represented in Yellowstone bison exist elsewhere, genetic rescue is unlikely to come from bison populations that are facing extinction or likely experiencing inbreeding as a result of small population size.

The Henry Mountains bison, occupying 1,250 square kilometers (308,881 acres) and primarily founded with bison descended from Yellowstone, provide an example of how managing for small population size risks extinction. Ranglack et al. 2015 at 3, 4; Ritson 2019 at 7.

The geographic isolation and small population size of the Henry Mountains bison ~350 bison has resulted in lower genetic heterozygosity and allelic richness. Ranglack et al. 2015 at 5. "The Henry Mountains bison herd… currently has low levels of heterozygosity due to maintained isolation." Hartway et al. 2020 at 68. In fact, the Henry Mountains herd is close to levels of inbreeding depression found in other bison herds. Hartway et al. 2020 at 15.

"The current management objective for the Henry Mountains bison is to maintain a stable population size by harvesting, with an escapement threshold (Lande et al., 1997) of 325 adults as agreed upon by state and federal agencies and the Henry Mountains Grazing Association (UDWR, 2007)." Ranglack & du Toit 2016 at 550.

The low population size for the Henry Mountains population is unlikely to change for the foreseeable future as "ranchers currently derive no benefits from the bison and have concerns regarding competition between bison and cattle." Ranglack & du Toit 2016 at 549.

Small population size fosters inbreeding and ~350 is "far below the number of bison needed to thwart genetic drift and maintain genetic diversity." Bailey 2013 at 195, 179 ("Herds with fewer than 2000–3000 bison have compromised evolutionary potentials . . .").

350 bison is also far below the number needed "to avoid inbreeding depression and maintain genetic variation." Hedrick 2009 at 419.

Of twenty isolated bison populations that met the criteria to be assessed as wildlife by the International Union for Conservation of Nature, thirteen had 400 or fewer bison. Rogers, Ranglack, & Plumb 2022 (seven of twelve isolated plains bison populations had 400 or fewer bison).

The loss of connectivity between wild bison populations and natural selection of gene flow produced from bull competition and female choice has given risen to yet another artificial selection process: metapopulation management.

"To mitigate the loss of genetic diversity in these isolated populations, previous researchers have suggested restoring effective gene flow among herds and managing DOI [U.S. Department of the Interior] bison herds as a metapopulation." Hartway et al. 2020 at xi.

Managing isolated bison herds as a metapopulation through transfer to prevent inbreeding and loss of genetic diversity is an implicit acknowledgement of a vulnerability for the long-term survival of bison as a wildlife species and recognition that inbreeding is evident in conservation herds.

> The DOI is the primary federal entity responsible for the ongoing recovery and conservation of plains bison in the United States. The DOI oversees the stewardship of ~11,000 plains bison in 19 herds on 4.6 million acres of NPS, US Fish and Wildlife Service (FWS) and Bureau of Land Management (BLM) lands in 12 states (Figure 1.1), making up approximately half of all plains bison managed for conservation in North America. Most of these herds are fenced, have less than 600 individuals, and lack native predators such that herds are subjected to selective removals (e.g.,culling) to maintain herd sizes at or below carrying capacity (DOI 2014). Many herds also show some evidence of low levels of cattle gene introgression from early 19th century cross-breeding with cattle. Despite these constraints, the DOI bison herds are an irreplaceable resource for the long-term recovery of North American plains bison (DOI 2014; Dratch and Gogan 2010).

Hartway et al. 2020 at 1.

However, the irreplaceable source for recovering bison is experiencing a significant loss in genetic diversity according to Hartway's study.

> Results indicate that three bison herds [Grand Teton National Park/National Elk Refuge, Theodore Roosevelt National Park North Unit, Wrangle-St. Elias Copper River] currently have observed heterozygosity levels ($H_o$) close to 0.50, a value identified with an increased risk of inbreeding depression and as a threshold for triggering genetic augmentation.
>
> Results of simulation models for individual bison herds (Chapter 3) project that all herds will lose genetic diversity over the next 200 years under current management conditions without additional gene flow.
>
> . . .
>
> After 200 years under current management conditions eight herds were projected to have heterozygosity levels < 0.50, with mean inbreeding coefficient levels similar to those shown

> to impact the reproduction and survival of bison reported by other studies.
>
> . . .
>
> All herds were predicted to lose genetic diversity (heterozygosity and allelic diversity) over the next 200 years due to small population size insufficient to balance genetic drift with mutation.
>
> . . .
>
> The projected loss in genetic diversity across all herds was mirrored by a projected increase in mean inbreeding coefficients (F) across all herds (Figure 3.3.4).

Hartway et al. 2020 at xi, xii, 28.

Two additional bison herds, Henry Mountains in Utah and a display herd at Chickasaw National Recreation Area in Oklahoma have heterozygosity estimates of ~ 0.55. Hartway et al. 2020 at 15.

A series of bottlenecks, few founders, small population sizes (a consequence of limiting range), and long-term isolation (a consequence of lost habitat and natural connectivity between bison populations) are identified as reasons for very low and decreasing genetic diversity and indicators of inbreeding in bison Hartway surveyed.

For an overview of herd demographics and management data, and a summary of the founding source, numbers, and subsequent transfers of bison in U.S. Dept. of the Interior conservation herds, *see* Hartway et al. 2020 at 9 (Table 2.3.1), at 16 (Table 2.4.1).

In addition, low genetic diversity in the Grand Teton-National Elk Refuge bison "is likely due to multiple founder effects, in which a very small, possibly already inbred herd, went through a bottleneck due to culling to prevent the spread of brucellosis." Hartway et al. 2020 at 15.

> In summary, this study confirms that management of DOI bison herds in isolation promotes the loss of genetic diversity within all herds. More importantly, this study demonstrates that increased herd size and targeted removal strategies can reduce rates of diversity loss, and that adopting a Departmental metapopulation strategy through facilitated periodic movement of modest numbers of bison among DOI herds (i.e., restoring effective gene flow) can substantially reduce the negative impacts of geographic isolation.

Hartway et al. 2020 at xii (acknowledging the isolation of bison conservation herds "promotes" loss of genetic diversity).

But the ability of bison to adapt to a rapidly changing climate and ecosystem is predicated on a population's resiliency – an attribute that is declining and expected to decline for isolated bison populations like Yellowstone.

> Decreases in genetic diversity could ultimately decrease the ability of the herds in this study to adapt to novel or changing environmental conditions (Ralls et al. 2018; White et al. 2015; Willi and Hoffman 2009; Willi et al. 2006). Increasingly, conservation biologists are

> recognizing that the genetic management of populations and species requires not just staving off the worst effects of inbreeding, but also maintaining the evolutionary resiliency of populations and species (Ralls et al. 2018; Weeks et al. 2011). Evolutionary resiliency – the ability to adapt to changing environmental conditions – is proportional to the heterozygosity of a population (Frankham 2015; Ralls et al. 2018), and even small decreases in genetic diversity are predicted to decrease the ability of populations or species to evolutionarily adapt to changing or novel environmental conditions (Fisher 1930; Reed and Frankham 2003), such as increased climatic variability or the emergence of novel diseases (McCallum and Jones 2010; Reed et al. 2003).

Hartway et al. 2020 at 34.

Simply managing bison to prevent genetic extinction does not restore wild populations or self-sustaining migratory populations roaming the wild.

Metapopulation management is another form of artificial selection and an indicator of lost natural selection processes acting on the wild bison genome and lost connectivity between wild bison populations.

Furthermore, healthy bison testing negative for lethal disease such as *Mycoplasma bovis* is likely to complicate or thwart metapopulation management. Register et al. 2018 at 62. "[A] few diseases are difficult to detect such that risk outweighs any potential genetic benefit to the recipient herd." Hartway et al. 2020 at 39.

Metapopulation management to prevent inbreeding may facilitate disease transfer and wipe out the genetic diversity remaining in bison conservation herds reduced to small populations on isolated ranges and intensively managed behind fences or management imposed boundaries.

It does not follow that transferring bison through metapopulation management to save genetic diversity will do so.

Unique bison alleles could be lost, introduced bison may not mate with the resident herd, local adaptation could be lost, outbreeding could occur, retarded growth and development could occur in offspring, pathogens could spread, among the potential negative consequences. Licht 2017 at 90 (citing Berger & Cunningham 1994 and 1995, Champagnon et al. 2012).

Even after 200 years of transferring bison, allelic diversity may still be lost in the entire metapopulation as a consequence, in part, of not increasing population sizes for each herd. Hartway et al. 2020 at 63.

> Another metapopulation management goal identified by herd managers and agency leads was to identify management scenarios that maintained current levels of allelic diversity within the entire metapopulation. Our models indicate that the translocation scenarios modeled in this study alone cannot achieve this goal. Indeed, our models suggest that under some source herd scenarios the entire metapopulation lost allelic diversity faster with translocations between herds than without translocations. This is evidence of genetic swamping, an increased loss or dilution of rare alleles in recipient populations due to a large or constant influx of new alleles (Allendorf et al. 2013). This effect is strongest when eight or more animals are used in translocations, and it is weakest when two to three animals are

> used in translocations. Criteria used to select source herds also affected the degree to which swamping occurs: the effect of swamping decreases when the source herd alternates every translocation or is genetically related to the recipient herd (i.e., when translocations only occur within lineages).

Hartway et al. 2020 at 62.

As reviewed herein, increasing bison population sizes by recovering habitat and range is constrained by factors jeopardizing natural selection and bison's adaptation in the wild including in the Yellowstone ecosystem.

Habitat loss and fragmentation of habitat, including in the Yellowstone ecosystem, is another barrier to recovering bison who require more continuous habitat. Ritson 2019 at 53.

Isolating bison to confined spaces, loss of continuous habitat, and loss of natural connectivity between bison populations are factors driving the risk of extinction for conservation herds including Yellowstone bison.

> Today, most of the range historically occupied by bison has been converted to either agriculture, urbanization, or reserved for livestock grazing (Sanderson et al. 2008; Gates et al. 2010). Despite their broad niche size (Plumb and McMullen 2018), many bison managed for conservation purposes are occupying areas considered to be the periphery of their former range such as intermountain mixed-forest (Meagher 1973) and arid steppe ecosystems (Ranglack and du Toit 2015). . . . Ignoring habitat suitability of this once widely distributed species may be restricting them to environments which inhibit their fitness, putting them in danger of becoming a 'refugee species' and continuing their extinction risk (Kerley et al. 2012). Bison are particularly susceptible due to the anthropogenic influences of their range contraction (Sanderson et al. 2008) and the fact that the remaining wild herds were only found in remote areas away from humans (Meagher 1973). If disturbances are causing bison to take refuge from humans by choosing secluded habitats, those areas may not be . . . optimal resources for their long-term survival.

Ritson 2019 at 53–54.

In addition, "management practices can artificially manipulate selection by either restricting or supplementing access to resources (Ramos et al. 2016)." Ritson 2019 at 55. In Yellowstone, managers restrict bison's migrations to seasonal ranges and access to vital resources during winter and spring.

"[H]erds which are more actively managed, such as those restricted by fencing, have ambiguous conservation value (Hayward et al. 2015) and may use resources differently (Lea et al. 2016)." Ritson 2019 at 56.

Intensive management of Yellowstone bison and other conservation herds is depriving the wildlife species of their ability to evolve — with far reaching, long-term consequences on bison's biological interactions, adaptive behaviors, and fitness in the wild.

Intensive management is transforming — in ways yet unstudied and unmeasured — the characteristics and traits forged by Yellowstone bison's wild ancestors.

"We detected seasonal variation in the size of free-range bison home ranges, but not in captive bison, which suggests that management limitations may affect the ability of bison to respond to landscape changes and has possible consequences on their fitness. . . . In the context of bison conservation, decreased access to foraging patches may discourage their natural feeding patterns and result in individuals less similar to their wild ancestors." Ritson 2019 at 79, 80.

> Restricting the natural space use tendencies of bison could have cascading effects on their long-term conservation. While the physiological needs of captive bison are likely being fulfilled by the pastures they occur in (Kohl et al. 2013, Schoenecker et al. 2015), it may not be adequate for the large-scale biological interactions bison have as a keystone species (Knapp et al. 1999; Freese et al. 2007; Fuhlendorf et al. 2010).
>
> . . .
>
> The unencumbered movement ability of free-range bison could enable their response to anthropogenic disturbance (Fortin and Andruskiw 2003) while captive individuals may be restrained from such responses. Continued restriction of natural responses to disturbance may lead to captive bison becoming desensitized to humans, a characteristic selected in commercially raised herds but maladaptive for bison conservation (Freese et al. 2007; Sanderson et al. 2008).
>
> . . .
>
> [S]patial isolation is a greater issue for bison conservation than suitability of habitat . . . indicating differences in spatial patterns which could have negative impacts on adaptive behaviors in bison. . . . These findings suggest the possibility that limitations on bison movement might result in behaviors unsuitable for long-term evolutionary fitness, as well as capacity for ecological interactions, working against the conservation goals of these herds.

Ritson 2019 at 80, 81, 82.

In addition to the foregoing factors, rapid climate change and climate variability is intensifying demands on managers for even more human intervention who may or may not have the resources available to cope, thus reinforcing the influence of management policies domesticating bison "conservation" herds.

As an example, one need look no further than the protected area of Wind Cave National Park where a drought in western South Dakota (2002–2007) reduced "the reproductive capacity of bison and elk, which was attributed to reduced forage quality and quantity," prompting park staff to make "unprecedented inquiries about water rights and delivery in the bison enclosure." Beeton et al. 2019 at 56. The Wind Cave herd is descended in part from Yellowstone bison lineages. Wood 2000, *see* Figure 1.

"Managers were concerned about the need to develop additional stock dams for bison and to better distribute bison within enclosures (Table 4)." Beeton et al. 2019 at 62.

> Managing bison, especially under frequent and recurring drought, is challenging for several reasons. Bison in the NPS system are confined to fenced enclosures with limited water

> availability. These enclosures restrict long-range dispersal for adapting to climate variability, and therefore place pressure on forage and water availability for bison and other wildlife in the PA [Protected Area]. For instance, at Wind Cave National Park (WICA) bison are housed within an approximately 28,000 acre enclosure in the park boundaries, with a recommended herd size of 350–500 animals (Department of the Interior, 2014b). Water availability at WICA is limited to only a few reliable sources of surface water streams (e.g., Beaver Creek, Highland Creek), as well as six developed springs distributed throughout the park (Wildlife Biologist, Personal Comm.). The surface water streams sink underground inside the park and charge the lakes in the cave system. WICA recently acquired an additional 5500 acres of rangeland in the southeast corner of the park. The bison herd at Badlands National Park (BADL) roams within an approximately 64,000 acre enclosure that falls predominately within the boundaries of the Badlands Wilderness Area (Fig. 1; Amberg et al., 2012; Department of the Interior, 2014b). Water availability within the bison range is limited as there are no perennial streams in the fenced enclosure (Department of the Interior, 2014b). There is only one significant spring that flows into a large tank for bison and several smaller seeps and springs, which are located in the northwest portion of the Badlands Wilderness Area (Park Ecologist, Personal Comm.). There are several water-holding structures that are scattered in other parts of the bison range, though many run dry during drought. The recommended herd size is 600–700 bison (Department of the Interior, 2014b). Currently, an environmental assessment is ongoing at BADL to consider expanding the bison range by more than 20,000 acres.

Beeton et al. 2019 at 52.

Adjacent jurisdictions — even good neighbor agreements — reinforce enclosing or confining bison to protected areas too small to accommodate factors such as rapid climate change and the ability of bison to naturally disperse and find water and forage on their own. Beeton et al. 2019 at 62 (stipulating "prairie dog colonies . . . be controlled from streaming out of park boundaries" which in turn, limits forage available for bison, disrupting the symbiotic ecological relationships of these native species).

> [T]hese results helped to determine the appropriate modeling framework to address the complex and uncertain factors that impact bison management. Local seasonal and inter-annual climate and drought; fire and prescribed fire management; and prairie dogs, invasive plants, and their management combined to impact the spatial distribution and availability of forage for bison. Increased water use from rural population development and drought combined to impact surface water availability for bison. Cross-scale institutional arrangements were a climate risk multiplier. For instance, arrangements between NPS, tribal organizations, and NGOs can, at times, affect bison round-up timing and amount, which affects timely response and the ability to manage bison under recommended grazer densities, and therefore can increase drought vulnerability.

Beeton et al. 2019 at 62.

Nearly all "conservation" herds share a commercial purpose in common: because of limited or restricted ranges imposed on the migratory species, bison are auctioned or sold. Ecoffey 2009 at 21 ("Most of the refuges sell excess bison through a public auction each year.").

“Conservation” herds include privately held bison that are managed as stock, e.g., Nature Conservancy bison are confined in fenced pastures, tagged, and subject to roundups, selective culling, vaccination, livestock per capita fees, and other domestication processes. Smith 2015; Boyd 2003 at 168–169, 169–170; The Nature Conservancy 2018 (Medano-Zapata Ranch bison).

The 1,500 captive bison on the Medano-Zapata Ranch in the San Luis Valley of south-central Colorado was established in 1986 for meat production and is privately managed by the Nature Conservancy on a fenced range of 153 square kilometers (37,807 acres). “Genetic analysis indicates cattle gene introgression in this population (Schoenecker et al. 2015).” Ritson 2019 at 5, 6.

> The Nature Conservancy Preserves usually have a round-up each fall and weigh and ear-tag all calves. All surplus bison are sold by sealed bid. There is no public hunting. All calves are kept the first year, but older animals are culled during that time. Animals with poor vigor are removed as well as the excess males. Animals are also tested for any diseases such as brucellosis and tuberculosis and culled if there are any positive animals. The typical fence for the Nature Conservancy is usually between 5-6 ft tall barbed wire. Bison numbers vary according to forage availability and assessment (Hamilton, 1993).

Ecoffey 2009 at 24–25 (Nature Conservancy bison conservation herds include the Samuel H. Ordway Memorial Prairie Preserve in South Dakota, Niobrara Valley Preserve in Nebraska, Cross Ranch Preserve in North Dakota, Konza Prairie Research Natural Area in Kansas, and the Tallgrass Prairie Preserve in Oklahoma).

The Tallgrass Prairie Preserve holds 2,500 bison on 16,000 hectares (39,536 acres), while the Wichita Mountains Wildlife Refuge manages 650 bison and 220 longhorn cattle on approximately 23,885 hectares (59,020 acres) in Oklahoma. McMillan et al. 2021 at 2, 3.

Many parks conduct management “roundups” of conservation herds for vaccinating, weighing, and attaching identification tags or inserting microchips with the “surplus” or “excess” bison auctioned or given to tribal bison programs. Ecoffey 2009 at 23.

“Park personnel have conducted regular bison roundups, during which they have tagged captured animals with unique identifying marks and used computer technology to process and store roundup data, and, in some cases, they have used helicopters to conduct post-roundup censuses.” Licht 2017 at 85 (Badlands, Wind Cave, and Theodore Roosevelt National Parks “regularly remove surplus bison, typically by roundups and disposal of live animals.”).

“Currently, six herds are maintained by the U.S. Fish and Wildlife Service (FWS) at National Wildlife Refuges (NWRs) and are intensively managed through annual culling to keep herd size at targeted levels.” Toldness 2014 at ii.

“Most of the parks and refuges are devoid of one important element to maintain overall ecological diversity, large predators.” Ecoffey 2009 at 23.

Furthermore, virtually all commercial herds “have cattle ancestry and even a number of the conservation herds have cattle ancestry introduced around 120 years ago by these ranchers.” Hedrick 2010 at 3328.

To understand how pervasive domestication of conservation herds is consider the bison surveys conducted by Boyd (2003), Hartway (2020), and Bailey (2013).

Boyd's status review, which established the original baseline on the conservation status of the wildlife species, identified fifty plains bison conservation herds in North America.

The number of plains bison currently in conservation herds is approximately 20,000 a number that has not substantially changed since the 1930s. Hedrick 2009 at 412.

Bison conservation herds are geographically isolated across the subspecies' indigenous range in North America. Boyd 2003 at 49, *see* Figure 5.4.

Captive herds account for thirty-seven of fifty plains bison conservation herds subject to various forms of management interventions including supplemental feeding, round-ups, perimeter and cross fencing, pasture rotation, and most have no predators. Boyd 2003 at 56–57, *see* Figure 5.9.

Thirty-two percent of conservation herds "have 50 or fewer bison . . . Thirteen herds have populations greater than 400" with only twenty-two percent "currently increasing in size." Boyd 2003 at 38, *see* Figure 5.1 and Figure 5.2.

> Human activities have profoundly influenced the Earth's natural resources. Foremost among man's effects has been the fragmentation of historically large and contiguous habitats, and the associated transformation of large and extensive populations into a number of smaller, isolated populations. Long-term management of small populations presents special problems associated with random population processes that can lead to skewed sex ratios, genetic drift, founder effects, loss of genetic variation, and expression of deleterious alleles. Populations with fewer than 500 breeding individuals are thought to be especially susceptible to harmful consequences of inbreeding depression and other effects that can be directly traced to the genetic composition of the populations (Frankham 1995; Keller and Waller 2002).
>
> Biologists are concerned about the genetic health of bison (*Bison bison*) herds because all North American herds were founded by few individuals and they have generally been maintained at small population sizes (Boyd 2003). National Park Service (NPS) bison herds were established from groups of about 20 to 50 bison (Halbert 2003:16) and NPS herds have largely been managed to maintain a size of fewer than 1000 animals. The small size and isolation of bison herds has led to concerns about their long-term genetic health.

Gross & Wang 2005 at 3.

"One consequence of intensive management is that populations are often managed in small, isolated populations, due to factors such as limited availability of habitat or resources. This, in turn, makes them more susceptible to evolutionary processes, such as genetic drift, that erode genetic variation over time (Wright 1931, Allendorf and Luikart 2007)." Toldness 2014 at 1.

Five of fifty conservation herds are managed for a maximum of 1,000 bison or more; two are owned by the

Nature Conservancy, two are public herds, and one in Canada is outside bison's indigenous range. Boyd 2003 at 144–147 (Appendix 1).

> Conservation herds are generally small and maintained at low population sizes, as space is limited (Boyd 2003). This results in the need to remove or cull individuals from the population every year in order to keep the population size below carrying capacity. Also, little or no gene flow occurs between conservation herds, as bison are hosts to a wide variety of diseases (Williams and Barker 2001) and regulations have restricted the transfer of individuals in order to inhibit the spread of disease.  Furthermore, managed herds were established with very small numbers of individuals, and those founders likely already exhibited reduced genetic variation as a result of the bottleneck of the 1800's. Thus, populations of bison are highly vulnerable to the loss of genetic variation and there exists a need to evaluate alternative culling strategies in order to maximize the retention of genetic variation over the long term as well as reduce the amount of inbreeding. Currently implemented culling strategies vary by herd; some manage for demographic stability (maintaining balanced sex and age ratios) and some incorporate genetic data into the culling selection process.

Toldness 2014 at 5–6.

"Eight herds residing in Arizona, California, northern British Columbia, and Alaska are distinctly outside plains bison range (Figure 5.4)." Boyd 2003 at 45.

> Free-ranging herds are those not contained within a fence, although there may be topographic or socio-political barriers that prevent the herd from roaming freely over the landscape. Captive herds reside within a perimeter fence. Thirteen of [fifty] plains bison conservation herds are free-ranging . . . Two free-ranging herds reside on islands. . . . one free-ranging herd is supplementally fed. Eleven herds experience, or potentially experience, predation . . . three herds . . . are not subject to regular handling . . . there are few plains bison populations within original range that exist under natural conditions, and none that are considered viable by the current benchmark.

Boyd 2003 at 54, 56.

Thirty-seven of fifty conservation herds are subject to roundups. Boyd 2003 at 156–161 (Appendix 1).

Eleven of fifty conservation herds are not confined by perimeter or boundary fences; four of the eleven herds are in bison's indigenous range. Boyd 2003 at 156–161, 148–151 (Appendix 1).

Thirty-eight percent of "conservation herds reside on ranges smaller than 10 $km^2$," and sixty percent on ranges smaller than 100 $km^2$. "[T]here is no range expansion potential" for fifty-two percent of the herds. Boyd 2003 at 49, *see* Figure 5.7.

At least twenty-one of fifty conservation herds are supplementally fed or provided water. Boyd 2003 at 156–161 (Appendix 1).

Providing feed, minerals, or water undercuts natural selection of bison because "spatial and temporal variation in resource abundance and quality are important factors influencing reproduction and survival." *See* Aune, Jørgensen, & Gates 2018 Supplemental Material Criteria 3.2 (Table 1).

In thirty-three of fifty conservation herds, bison are selectively killed mainly based on age, but also appearance, condition or health, conformation, fertility or reproductive success, size, temperament, and weight. Boyd 2003 at 156–161 (Appendix 1).

"Age structure of a population can also impact genetic variation through its influence on the mean generation time. Since alleles are expected to be lost with each generation due to random sampling (i.e., genetic drift), a shorter mean generation time would result in a greater loss of genetic variation in a population over time." Toldness 2014 at 3.

"Bull replacement" is a management policy in twenty of fifty conservation herds. At least twenty-eight conservation herds are regularly augmented with bison from other herds. Boyd 2003 at 148–151, 152–155 (Appendix 1).

"Mate selection is achieved through competition among males, and female choice," otherwise a bison conservation herd is not wild if there is "artificial selection of mates" of either sex through "importation, bull rotation, or other artificial means." *See* Aune, Jørgensen, & Gates 2018 Supplemental Material Criteria 3.1 (Table 1).


PHOTO: BFC Archives

Thirty-four percent of "conservation herds are maintained at male to female ratios lower than 1:2," thirty percent between 1:2–1:9, and eighteen percent at higher than 1:9. "The highest ratio is 1:16." At least fourteen herds have male to female ratios of 1:5 or more. Boyd 2003 at 45, 148–151 (Appendix 1).

Adult mature male to female ratios exceeding 1:5 (20:100) in bison conservation herd's do not meet the International Union for the Conservation of Nature's criteria for a wild population. *See* Aune, Jørgensen, & Gates 2018 Supplemental Material Criteria 2.3 (Table 1) (the ratio is contested by other sources who find male to female ratios of 1:3 to 1:15 as skewed or highly skewed, *see* Bailey's survey below).

In Yellowstone, "[m]ales were overrepresented more so in the central herd with 149 males per 100 females (5-year average of 153:100) compared to 114 males per 100 females in the northern herd (5-year average 97:100)." Geremia 2020 at 4. Skewing and distorting sex ratios is a consequence of management actions, predominantly trapping Yellowstone bison for slaughter but also hunting.

Managers may skew the male to female ratio by selectively culling bulls of all ages, leaving

> just enough males to facilitate reproduction in the herd. This also minimizes handling and containment problems associated with aggressive bulls, and forage use by unneeded bulls (Bragg *et al*. 2002). To achieve cost-effective management of a herd, some managers may increase the percentage of females to maximize calf production and, therefore, the number of surplus animals for sale. Such a practice is common for production management, as employed by many commercial herd managers, rather than management for species conservation (Bragg *et al*. 2002).

Boyd 2003 at 49.

> For intensively managed populations that are often small and isolated, retaining genetic variation over the long term is a difficult challenge given that genetic drift is strong and the loss of genetic variation cannot be mitigated by gene flow. . . . Small populations are susceptible to wide fluctuations in sex ratios through demographic events such as an increase in male mortality or all offspring born in a particular year being the same sex (Lande et al. 2003). Populations with skewed sex ratios have been shown to exhibit a greater reduction in genetic variation over time (Gross and Wang 2005), increased inbreeding (Harris et al. 2002, Peek et al. 2002), and more variable population survival (Komers and Curman 2000). In principle, skewing the sex ratio of populations may also affect mate choice and sexual selection, potentially altering the long-term evolutionary trajectory of populations (Clutton-Brock et al. 1997; Jirotkul 1999; Jiggins et al. 2000).
>
> . . .
>
> Managing a population to encourage a balanced sex ratio would limit the loss of genetic variation through drift by maintaining variation in both sexes (Gross and Wang 2005, Allendorf and Luikart 2007) and avoid a reduction in viability due to demographic stochasticity (Shaffer 1981; Brook et al. 1999). Age structure of a population can also impact genetic variation through its influence on the mean generation time. Since alleles are expected to be lost with each generation due to random sampling (i.e., genetic drift), a shorter mean generation time would result in a greater loss of genetic variation in a population over time. Long generation time is one reason why some long-lived species that have gone through severe bottlenecks have retained high levels of genetic variation (Dinerstein and McCracken 1990, Swart et al. 1994, Hailer et al. 2006).

Toldness 2014 at 2–3.

Additionally, “many conservation herds are managed with incentives to produce and sell” bison. Bailey 2013 at 84.

Twenty-nine of fifty conservation herds hold live sales of, or sell bison. Fort Robison State Park and Wildcat Hills State Recreation Area slaughter bison to provide meat for restaurants, while Custer State Park has a commercial contract with a meat company. Boyd 2003 at 156–161 (Appendix 1).

Signs of bison inbreeding were reported in three conservation herds. Boyd 2003 at 152–155 (Appendix 1).

Badlands National Park reported signs of inbreeding in its' bison herd, while Konza Prairie Biological Station recorded "rabbit-hocked legs" of bison in the past. Managers in twenty-seven of fifty conservation herds reported inbreeding as an unknown. Boyd 2003 at 152–155 (Appendix 1).

Another harmful consequence of managing bison in limited or fenced ranges is the threat and potential threat for new diseases to arise, and enabling livestock carried diseases to be transferred more readily to bison confined to small, limited, or fenced ranges.

For example, the first case of pseudocowpox virus was reported in a seven-year old female American bison at Konza Prairie Biological Station. The source is unknown, but the occurrence of the virus in a new species "can cause severe infections and pose a significant threat to the entire population." Shivanna et al. 2020 at 1–2.

Boyd's status review demonstrates most bison "conservation" herds are "confined by fences or socio-political forces" in habitats of varying but limited sizes including outside of indigenous range, "subject to varying levels of management intervention," and a preponderance of human selection processes. Boyd 2003 at 1.

Hartway's survey of seven U.S. Fish & Wildlife Service, five National Park Service, and two state bison herds "revealed two herds were being managed below the estimated ecological carrying capacity," while ten "herds were being managed for target herd sizes equal to the estimated ecological carrying capacity, and, in seven cases . . . estimated ecological carrying capacity was reported as either "unknown" or not stated. Herd managers listed a variety of factors influencing the management carrying capacities for each herd, including ecological integrity, wildlife and hunting advocates, livestock and grazing associations, and habitat quality." Hartway et al. 2020 at 8.

In addition, fourteen herds:

> [W]ere being managed via capture and removal operations. Eight of these herds were managed via annual removals; in six of these herds, managers removed yearlings and occasionally 2 or 3-year-olds determined to be the most closely related to the rest of the herd, to minimize mean kinship or relatedness within the herd. The largest herd was managed via annual capture operations focused on removing a random selection of yearlings to 2.5-year-olds, while the smallest herd, managed as a display herd, removed yearlings, bison over 10 years old, or bison that were sick or injured annually. Three herds were managed with removals every other year, primarily taking yearlings and pre-reproductive juveniles (<2 years old) along with some older adults in two herds (>5 years old in one herd; >10 years old in another herd). A fourth herd was managed via removals every other year, primarily taking yearlings and some 2-year-olds if no animals from that age class had been removed as yearlings.

Hartway et al. 2020 at 8.

In comparing results from Halbert and Derr's 2008 study, Hartway found "measureable loss" of genetic diversity in bison herds in the Grand Teton National Park/National Elk Refuge and Theodore Roosevelt National Park North and South Units. Hartway et al. 2020 at 18 (due to population isolation and genetic drift ongoing loss is expected without intervention).

> Ecological, social, and political limitations currently restrict the geographic distribution and abundance of bison herds on DOI lands (DOI 2014). As a consequence of these limitations, many DOI herds remain geographically isolated from one another with little natural movement between herds, and the majority of herds are actively managed to maintain population size of fewer than 500 animals on range-restricted landscapes. The isolation and relatively small sizes of many of these herds has led to concerns about their long-term population and genetic viability (Dratch and Gogan 2010; Hedrick 2009). In particular, it has long been recognized that small, isolated populations have a greater risk of extirpation due to random catastrophic events (Lande 1993; MacArthur and Wilson 1967) such as disease outbreaks (Smith et al. 2006), extreme weather events (Ameca y Juarez et al. 2012; Tyler 2010) or wildfire (Potvin et al. 2017). Small isolated populations also lose genetic diversity more quickly through the process of genetic drift (Hartl and Clark 2007), with detrimental effects on both the short- and long-term viability of the population.

Hartway et al. 2020 at 19.

Bailey's review found the influence of State and federal managers use of domestication practices in bison "conservation" herds, including Yellowstone bison, is extensive, widespread, and ongoing.

According to Bailey's ecological and evolutionary baseline a wild population requires a minimum of 500 square miles (320,000 acres) of range and 2,000 bison for each population or subpopulation where substructure is evident. Bailey 2013 at 190–191.

Under Bailey's baseline no "conservation" population remaining in the wild has reached or is maintained in a population size where bison genetic diversity is not lost.

For the Yellowstone population, the Central herd has been below 2,000 bison since government trapping for slaughter operations decimated the genetically distinct subpopulation during the winters of 2006–2008. The Northern herd did not reach 2,000 bison until 2010. Geremia 2020 at 7–8.

Only the range of Yellowstone bison exceeds 320,000 acres but is limited and reduced by State and federal management actions in Montana, Idaho, and Wyoming. Bailey 2013 at 180, 195–197.

PHOTO: BFC Archives

In addition to limiting the range of migratory bison, managers are subjecting Yellowstone bison to management actions that "replace or weaken natural selection" leading toward domestication, including selective culling, vaccinating, trapping and feeding, harassment from home ranges including calving grounds, and experimentation with contraceptives. U.S. Dept. of the Interior & U.S. Dept. of Agriculture 2000 FEIS Vol. 1 at 233 ("Vaccinate all captured vaccination-eligible bison"); Yellowstone National Park 2011 (approving the transfer of up to 108 bison for experimentation with GonaCon, a chemical sterilant).

"Even our most wild herd of plains bison on native range in the USA is being subject to many interventions that jeopardize its wild genome." Bailey 2013 at 196.

Bailey identified forty-four "conservation" herds of 16,500 bison on their native range in the United States and reviewed twenty-eight herds with supplemented data from Boyd (2003), Dratch & Gogan (2010), site investigation, and interview. Bailey 2013 at 179, 197.

Common threats Bailey found for bison include small, isolated population sizes; limited or confined ranges, and the lack of potential to expand range; and perhaps more concerning of all, a preponderance of human selection (domestication) processes and loss of natural selection processes:

> Thirty-four herds have 400 or fewer bison; of these herds, nineteen have fewer than 100 bison.
> Only four herds south of Canada have more than 1000 bison.
> Only the Yellowstone herd "is large enough to limit loss of genetic diversity to moderate levels in the long term."
>
> (Large bison herds allow evolved social and dominance relations and contributes to natural selection of wild characteristics in good times and bad).
>
> Eleven herds live on ranges of less than 1 square mile (640 acres).
> More than 60% of forty-four conservation herds have ranges of or less than 10 square miles (6,400 acres).
> Four herds have ranges of at least 100 square miles (64,000 acres) with caveats: Badlands includes much barren ground; Custer State Park is forested; Jackson is artificially fed; Yellowstone is mainly high elevation habitat.
>
> (Small ranges limit herd size, undermine ecological contributions and relationships, limit mobility, do not maintain natural selection, represent a major limiting factor for wildness, and are a major factor of domestication).
>
> Ranges of fourteen herds are subdivided by cross fencing to permit pasture rotation.
> Eight herds with more than 100 bison are managed with rotation grazing systems, much like domestic livestock.
>
> (Pasture rotation constrains bison from selecting foraging habitat and creates unnatural foraging effects upon vegetation).
>
> At least twenty-five herds are subject to annual, or more frequent, roundups and handling chutes.
> At least eight more herds have less frequent roundups and handling in "squeeze" chutes.
>
> (Roundups facilitate processes leading to domestication of bison).
>
> Selective culling is routine in thirty-five herds; five more herds will likely be subject to selective culling once herd sizes are reached.

Few managers emphasize random culling or retention.
Bison are killed based on sex, age, size, appearance, and behavior.

(Selective culling is a major factor weakening or replacing natural selection).
(Inadvertent selection for characteristics based on genetically-linked traits is likely common).
(Bison are killed before the values of the fittest individuals are fully realized in natural selection).
(The distinct population segment of Yellowstone bison is subject to nonrandom and selective culling and roundups with an emphasis on killing bison carrying antibodies to *Brucella abortus*, although bison may not be infected and may be resistant to the cattle-introduced disease).

Only three herds are managed primarily by hunting.

(Hunting rules are rarely if ever based upon consideration of evolutionary effects).

Significant natural mortality was noted in six of twenty-eight herds.
Very few bison die of natural mortality in eighteen of twenty-eight herds.
Natural mortality is likely even less common in the remaining sixteen herds of small size.

Thirteen herds are routinely fed.
At least eight additional herds are fed during deep snows or drought.

(Natural selection for dominant, energy efficient bison is weakened in twenty-one herds).
(Unnatural concentration of bison and routine feeding increases rates of disease transmission and densities of disease organisms).

Seventeen herds are regularly vaccinated for diseases (from one to eight herds).
Vermicides to control parasites are used in many of the seventeen herds.

(Veterinary practices weaken natural selection for disease resistant bison and modify coevolution of disease organisms; outcomes for flora and fauna are unstudied and unknown).

Sixteen herds are managed with skewed or highly skewed sex ratios (adult bull to female ratios of 1:3 to 1:15).

(Selection leading to skewed sex ratios weakens or eliminates the natural selective value of bull competition, and female selection of mates is reduced or lost).

Only Yellowstone bison face significant natural predation by bears and wolves.

(Unlikely natural selection values of predation will be restored).
(Without predators, the value of and natural selection for acute senses in bison is diminished).

> Twenty-eight herds are located in States (or parts of them) that do not recognize bison as wildlife but as livestock.

Bailey 2013 at 179, 182–186, 136, 83.

The encroachment of livestock and veterinary agency authority over Yellowstone bison and other conservation herds in the States has entrenched the policies of managing bison as livestock. As a consequence, livestock and veterinary management of and authority over Yellowstone bison will remain an institutional threat to the wild species for the foreseeable future.

> [T]he notion of domesticity is strengthened by the changing jurisdiction of state agencies. In the past 5 years, the Montana Department of Livestock and the Idaho Department of Agriculture have taken over the responsibility of managing Yellowstone's migrant bison from their state's respective Game and Fish Departments (Keiter, 1997).

Lulka 1998 at 121.

The jurisdictional takeover of Yellowstone bison by livestock and agricultural departments is the final stroke of domestication management.

The U.S. Fish & Wildlife Service must examine and investigate the ongoing effects of managing Yellowstone bison for domestication in the agency's threats assessment and status review.

***Bison are at risk of genomic extinction as a consequence of domestication and artificial selection, an artifact of ranchers breeding cattle and bison in confinement to exploit bison's attributes for commercial purposes.***

PHOTO: BFC Archives

> Perhaps no other extant animal in North America possesses the cultural, spiritual, ecological, economic, political, and natural history attributes that are emblematic of the North American bison (*Bison bison*; Artiodactyla, Bovidae, Bovini; Isenberg, 1997; Sanderson et al., 2008). Certainly, no other animal boasts the story of surviving the brink of extinction twice. This story does not stop at the North American plains subspecies (*Bison bison bison*), but it also applies to the North American woods bison subspecies (*Bison bison athabascae*) along with the European bison species (*Bison bonasus*; wisent). First, *Bison* survived the megafaunal extinction at the end of the Pleistocene approximately 11,700 calendar years Before Present (cal yr BP) and, in North America, the genus outlived mammoths (*Mammuthus*), mastodons (*Mammut*), horses (*Equus*), ground sloths (*Megalonyx* et al.), and other megafauna while coexisting with early Americans (Paleoindians; Koch and Barnosky, 2006). Second, *Bison* survived the threat of Americans of European descent, who purposefully hunted the bison nearly to extinction, during the late 1800s Common Era (Hornaday, 1889).

Martin et al. 2017 at 14.

> Species extinctions occur in two basic ways: (1) the last individuals of a species die, bringing the genetic lineage of that species to an end; (2) the genetic makeup of a species changes substantially over time, whether through natural evolutionary processes, anthropogenic selection, or hybridization, resulting in genomic extinction (Rhymer and Simberloff, 1996; Allendorf et al., 2001).
>
> . . .
>
> Bison barely escaped the first type of extinction in the late 1800s. Now, more than a century later, the plains bison is confronting the second form of extinction due to two major problems: (1) domestication and anthropogenic selection and (2) cattle gene introgression.

Freese et al. 2007 at 176–177.

Recent genome-wide testing of all seven founding population lineages remaining after the near extinction of bison in the 19th century found genetically intact populations may be extinct throughout their indigenous range in North America.

> Following robust and detailed approaches, we found that every bison herd examined, including Yellowstone, Wind Cave, and Elk Island (plains and wood bison) National Parks that have been previously believed to be free from cattle introgression, all have detectable levels of hybrid ancestry with cattle (Supplementary Table 6, Extended Data Figs. 4 and 5).

Stroupe et al. 2022 at 7.

While the study sample size was small (25), all six samples from Yellowstone bison (5 modern from 2000–2011 and 1 historic from 1925) detected introgression of cattle genes. Stroupe et al. 2022 at 3, 4.

The detection of cattle genes in the Yellowstone bison population is likely an artifact and result of transferring bison to the Northern Range sourced from private owners who came into the purchase of cross-bred bison and cattle or cross-bred the two species in captivity and sold them to the U.S. government.

Cattle gene introgression was also found "immediately downstream" of the major histocompatibility complex, a region "associated with susceptibility to several infectious diseases." Stroupe et al. 2022 at 6.

> During the late nineteenth century North American bison underwent a significant population bottleneck resulting in a reduction in population size of over 99% and a species-level near-extinction event. Factors responsible for this destruction included indiscriminate killing, loss of access to suitable habitat, and diseases. At the nadir of this population crash, very few wild plains bison survived and were restricted to Yellowstone National Park, USA and a small number of wild wood bison remained in Wood Buffalo National Park, Canada. However, most surviving bison in the late 1800's were maintained by cattle ranchers in private herds where hybridization between bison with various breeds of domestic cattle was often encouraged. Over the last 20 years, the legacy of this introgression has been identified using

> mitochondrial DNA and limited nuclear microsatellite analyses. However, no genome-wide assessment has been performed, and some herds were believed to be free of introgression based on current genetic testing strategies. Herein, we report detailed analyses using whole genome sequencing from nineteen modern and six historical bison, chosen to represent the major lineages of bison, to identify and quantitate signatures of nuclear introgression in their recent (within 200 years) history. Both low and high coverage genomes provided evidence for recent introgression, including animals from Yellowstone, Wind Cave, and Elk Island National Parks which were previously thought to be free from hybridization with domestic cattle. We employed multiple approaches, including one developed for this work, to identify putative cattle haplotypes in each bison genome. These regions vary greatly in size and frequency by sample and herd, though we detected domestic cattle introgression in all bison genomes tested. Since our sampling strategy spanned across the diversity of modern bison populations, these finding are best explained by multiple historical hybridization events between these two species with significant genetic recombination over the last 200 years. Our results demonstrate that whole genome sequencing approaches are required to accurately quantitate cattle introgression in bison.

Stroupe et al. 2022 at 1.

The risk of genomic extinction is directly connected to human exploitation of fitness traits and characteristics bison forged in the wild for private, commercial benefit.

Hybridization has caused the extinction of plant and animal species before. Freese et al. 2007 at 178 (citing Rhymer and Simberloff, 1996; Allendorf et al., 2001).

> The concept of crossing bison with domestic cattle dates back to Spanish colonizers of the sixteenth century (Dary 1989). Cross-breeding was attempted in Virginia, the Carolinas, and Pennsylvania during the 1700s (Ogilvie 1979). In 1888, C. J. "Buffalo" Jones coined the term *catalo* to refer to hybrids between cattle and bison. Private ranchers involved with salvaging bison had aspirations of combining the hardiness and winter foraging ability of bison with the meat production traits of cattle through hybridization (Ogilvie 1979; Dary 1989). The Canadian government pursued experimental production of crossbred animals from 1916–1964 (Ogilvie 1979; Polziehn *et al*. 1995).

Boyd & Gates 2006 at 18.

> Fertility problems thwarted many of the original cross-breeding attempts because crosses result in high mortality for offspring and mother (Ward 2000). Experimentation has revealed that crosses of bison females with domestic cattle males produce less mortality than the more deadly reverse cross, which was more common because it is very difficult to compel domestic cattle bulls to mate with bison females (Ward 2000). All F1 generation hybrids experience reduced fertility and viability relative to either parent: F1 males are completely sterile, but the fertility of F1 females makes introgressive hybridization possible (Ward 2000).

Boyd 2003 at 67.

> Historical cross-breeding attempts have created a legacy of genetic issues related to the introgression of cattle DNA into bison herds. *Introgression* refers to gene flow between populations caused by hybridization followed by backbreeding of the hybrid offspring to their respective parental populations (Rhymer and Simberloff 1996). The introgressed DNA displaces sections of the original genome, thereby affecting the genetic integrity of a species. Many contemporary bison herds are founded on, and supplemented with, animals from herds with a history of hybridization. Seven of fifty conservation herds currently show evidence of cattle DNA introgression (Ward *et al*. 1999; Ward 2000). There is a high percentage of untested herds (68 percent), creating a large information gap in understanding hybridization prevalence among plains bison conservation herds (Boyd 2003). Plains bison herds with no evidence of hybrids include all five U.S. National Park herds, two of five U.S. National Wildlife Refuge herds, the state-managed Henry Mountains herd in Utah, and the Elk Island National Park herd in Canada. These herds account for approximately 7,984 bison, or 42 percent of the total estimated plains bison in conservation populations (Boyd 2003).

Boyd & Gates 2006 at 18.

The genome-wide study sampled bison from Caprock Canyons State Park (Texas), Elk Island National Park (Alberta, Canada), Mackenzie Bison Sanctuary (Northwest Territories, Canada), Santa Catalina Island (California), Vermejo Park Ranch (New Mexico), Wind Cave National Park (South Dakota), and Yellowstone National Park (Wyoming/Montana). Stroupe et al. 2022 at 4 (Table 1).

Of seven founding bison population lineages, four of the five founding herd owners Dupree, Goodnight, Jones, and McKay & Alloway "were actively involved in hybridization experimentation (Fig. 1)." Walking Coyote sold his bison to Pablo–Allard who subsequently purchased hybrid bison from Jones and introduced the hybrids into their herd. Stroupe et al. 2022 at 7.

Cattle ranchers were not alone in attempting to cross breed bison and cattle for private gain and commercial profit.

Cross-breeding bison and cattle was carried out at an experimental station near Wainwright, Alberta from 1916 to 1935. Hedrick 2009 at 413.

The Canadian government crossbred bison and cattle into the 1960s. Boyd 2003 at 67 (citing Ogilvie 1979; Polziehn et al. 1995).

All of the commercial bison herds in existence today were founded with cross-bred bison and cattle, and movement of bison to augment small, isolated herds (metapopulation management) contributed to the spread of cattle DNA in bison "conservation" herds. Hedrick 2009 at 412–416.

Wood (2000) documented the transaction of bison lineages from private to public hands over the period 1866 to 1987, *see* Figure 1 and Figure 2.

The legacy of cross-breeding bison and cattle, hybridization, "is evident today in the widespread domestic cattle gene introgression in both the mitochondrial (Polziehn et al., 1995; Ward et al., 1999) and nuclear (Halbert et al., 2005; Halbert and Derr, in press) genomes of bison herds across North America." Freese et al.

2007 at 178.

> To date, evidence of mitochondrial or nuclear domestic cattle introgression has been identified in all except 6 of 14 US and Canadian public bison populations (Ward et al. 1999; Halbert et al. 2005) and all except 1 of the more than 50 private bison herds examined to date (Derr JN, unpublished data).

Halbert & Derr 2007 at 1.

Prior to the availability of genome-wide testing, cattle genes have been found in American bison previously thought to have no cattle ancestry including Wind Cave National Park, Grand Teton National Park, and Sully's Hill National Game Preserve. Dratch 2008 at 5 (testing for cattle introgression using mitochondrial DNA and nuclear microsatellite genetic samples).

Until recently, only Yellowstone bison and herds founded only with Yellowstone bison were thought to have no cattle ancestry:

- Polziehn et al. 1995 at 1641 (finding cattle mitochondrial DNA must have been present in the bison used to set up the Custer State Park herd).
- Ward et al. 1999 at 54 (finding cattle mitochondrial DNA in Antelope Island State Park, Custer State Park, Finney Game Refuge, Maxwell Game Refuge, National Bison Range, and the Williams Ranch herds).
- Halbert & Derr 2007 at 4–11 (finding cattle mitochondrial DNA in the National Bison Range herd, and confirmed cattle nuclear DNA in Wichita Mountains National Wildlife Refuge, Badlands National Park, Fort Niobrara National Wildlife Refuge, Neal Smith National Wildlife Refuge, Theodore Roosevelt National Park (south), and National Bison Range herds).
- Schnabel 2011 at 11 (finding cattle gene introgression in Custer State Park, Jackson/Grand Teton National Park, Sully's Hill, Wind Cave National Park, Wood Buffalo National Park, and Elk Island National Park herds).

Until recently, within the jurisdiction of the U.S. Dept. of the Interior, Yellowstone was thought to be the only ecosystem remaining with an intact bison population. Dratch & Gogan 2010 at 8–9 ("no suggestion of cattle introgression using all of the available molecular methods.").

"Herds with no molecular evidence of cattle ancestry constitute a genetic resource that must be protected from inadvertent introgression." Dratch & Gogan 2010 at 9.

Reliably sensitive new technologies have now been developed to confidently detect cattle DNA in individual bison. Stroupe et al. 2022.

Widespread genome wide testing has yet to be undertaken to determine the full extent of introgression of cattle genes in North American bison populations.

The concern is not only with genomic extinction for bison but the harmful biological effects of cattle genes on bison's fitness.

"The ability to identify bison herds without domestic cattle introgression is important for conserving the original bison genome and also for providing founder animals with unimpaired fitness." Ranglack et al. 2015 at 4.

Numerically or demographically, commercial bison number 500,000 with 20,000 counted in "conservation" herds in North America. Boyd & Gates 2006 at 16; Boyd 2003 at 70.

Using mitochondrial DNA and nuclear microsatellite analyses, at best, "less than 1.5% of the 500,000 plains bison in existence today can be classified as likely free of domestic cattle gene introgression." Freese et al. 2007 at 178.

The biological and evolutionary implications of cattle genes in bison herds has yet to be fully investigated. "[I]t is possible that cattle ancestry in bison may have important undesirable phenotypic effects." Hedrick 2009 at 415.

Based on the limited research performed to date, effects are detrimental and of serious concern for herds that may still retain an intact bison genome — without which the genetic adaptation of intact populations of the migratory species roaming the wild would be irreversibly lost.

Cattle introgression in bison mitochondria has the potential to alter and effect metabolic rates and function. Hartway et al. 2020 at 39.

One study suggests cattle genes in bison may impair mitochondrial health and function and the overall fitness of bison. Douglas et al. 2011 at 172.

"An association between mitochondrial cattle DNA and reduced body size in bison has been detected (Douglas et al. 2011). Furthermore, anthropomorphic selection of larger, more docile bison in commercial herds may also negatively alter bison genetics (Kolipinski et al. 2014)." Ritson 2019 at 2.

A study of a hybrid bison-cattle herd on Catalina Island found lower weight and height and smaller body size. Derr et al. 2012 at 1130.

> The ability to identify bison herds without domestic cattle introgression is important for conserving the original bison genome and also for providing founder animals with unimpaired fitness. There is, for example, an association between mitochondrial DNA type (bison or cattle) and body size, which is likely deleterious in this species with its highly competitive mating system. In both nutritionally rich and poor environments, bison with domestic cattle mitochondrial DNA are on average smaller than bison with bison mitochondrial DNA, demonstrating at least one of the possibly numerous phenotypic expressions of genetic introgression that could be deleterious. It is, however, possible that introgression could provide increased fitness in the form of adaptive introgression, though this has not been demonstrated in bison.

Ranglack et al. 2015 at 4 (endnotes omitted).

> [M]itochondrial DNA (mtDNA), [is] a maternally inherited, selectively neutral trait that occurs

> outside the nucleus and undergoes mutation at a more-or-less constant and, on a geological timescale, rapid rate. Although relatively plentiful in the geological record, mtDNA reveals only the history of a single locus and is susceptible to genetic drift even though, correspondingly, it can effectively reveal bottlenecks and population changes. Partial or complete nuclear genomes reflect the far broader ancestral pool that contributed to an individual's DNA and can provide a richer and more detailed record of genetic changes over time and other insights into demographic history such as changes in effective population size, genetic diversity, and inbreeding (Nyström et al. 2012, Palkopoulou et al. 2015).

Meltzer 2015 at 46.

"At this point, inbreeding depression has only been documented in the Goodnight herd (discussed below) and suggested for the population in Badlands NP [National Park] (Berger and Cunningham 1994). However, this does not mean that it has not been present in other herds, only that it has not been demonstrated." Hedrick 2009 at 415.

Domesticated bison "provide a potential threat of introducing nonadaptive ancestry if they are ever crossed into conservation populations." Hedrick 2009 at 412.

"Intentional translocations or unintentional immigration of cattle-gene introgressed bison" is one source by which intact bison herds are compromised. "The Wind Cave herd is separated from the cattle-gene introgressed herd of Custer State Park by a single fence, and Custer bison have recently crossed this divide into Wind Cave (S.C.F., C.H.F. and K.K., unpublished data)." Freese et al. 2007 at 178.

> At least one private bison herd with cattle gene introgression (J.N.D. and C.H.F. unpublished data) and other herds that have not been tested for cattle gene introgression occur in the region around Yellowstone and Grand Teton National Parks, raising the possibility of cross-breeding with these valuable conservation herds. In spring 2006, a young male bison that escaped from a private herd was shot inside Yellowstone National Park's north boundary (R. Wallen, personal communication). As the popularity of private bison breeding increases without restrictions on bison that can inhabit lands near these conservation herds, the potential for interbreeding between conservation herds and cattle-gene introgressed herds that are also undergoing selection for domestication will increase.

Freese et al. 2007 at 178.

Interpopulation movements are rare between bison herds in the Yellowstone and Jackson Hole regions.

> In winter 1995/96, 3 bulls from the Hayden Valley and wintered in the vicinity of Polecat Creek . . . were captured and radio collared. For several years after they returned each year to Hayden Valley during the rut then back to the Jackson Lake area to spend the winter. During the harsh winter of 1996-1997 a mixed group of 3 cows and 3 juveniles followed the road from YNP through the south gate and spent winter in the same area as the 3 bulls. Then they moved south and joined the Jackson herd; this mixed group did not return to YNP.

Gates et al. 2005 at 93 n. 34.

Impaired fitness, the maladaptive effects of cattle genes in bison such as impaired mitochondrial health and function, impaired metabolic rate and function, reduced body size and weight, and the potential genomic extinction of intact Yellowstone bison are factors the U.S. Fish & Wildlife Service must examine and investigate in the agency's threats assessment and status review.

***Domestication of bison as livestock, a commercial activity, is not compatible with natural selection, evolutionary adaptation, and restoring bison as a wildlife species.***

The character and traits distinguishing bison as a wildlife species is jeopardized by ongoing domestication processes that are depriving the migratory species of the vitality bequeathed to them by their wild ancestors.

Selection for non-wild traits and characteristics is not compatible with natural selection of wild bison and adaptation as a migratory wildlife species.

"[B]ison are the only conservation species (except for some fishes, such as salmon) that has been extensively selected for livestock-related traits, such as docility and meat production, which would be nonadaptive in a wild population." Hedrick 2009 at 412.

Ranched or domesticated bison are selectively bred for attributes that keep the ranch in business.

"Bison possess several traits that make them preferable to cattle as a range animal, including greater ability to digest low quality forage (Peden *et al*. 1974; Hawley *et al*. 1981; Plumb and Dodd 1993), ability to defend against predators (Carbyn *et al*. 1993; Gese 1999), and low incidence of calving difficulties (Haigh *et al*. 2001)." Boyd 2003 at 70.

Domesticating wild species has led to their extinction in the past.

> Domestication is an evolutionary process involving the genotypic adaptation of animals to the captive environment (Price and King 1968; Price 1984). Purposeful selection for traits favourable for human needs over several generations results in detectable differences in morphology, physiology, and behavior between domestic species and their wild progenitors (Darwin 1859; Clutton-Brock 1981; Price 1984). . . . Intensive management practices and competition between domesticated animals and their wild ancestors often pushed wild varieties and potential predators to the periphery of their ranges or to extinction (Price 1984; Baerselman and Vera 1995; Hartnett *et al*. 1997).

Boyd 2003 at 71.

Domestication of bison is pervasive in commercially ranched operations.

"The commercial bison population in North America is at least 500,000 and growing. . . approximately 95% of North American bison are under commercial production and experiencing some degree of domestication (Lott 1998)." Boyd 2003 at 70–71.

In a commercial enterprise, bison are selected for attributes that produce the most profit and gain for the owners.

> The primary goal of many commercial bison ranchers is to increase profits by maximizing calf production, feed-to-meat conversion efficiency, and meat quality (Schneider 1998). This requires non-random selection for traits that serve this purpose, including conformation, docility, reduced agility, growth performance, and carcass composition. Selection for these traits reduces genetic variation and changes the character of the animal over time (Schneider 1998).
>
> . . .
>
> The goals of commercial bison production are generally not compatible with the conservation of the wild species. Further, commercial bison operations could pose a threat to conservation populations through a form of genetic pollution, if genetically selected commercial animals are mixed into conservation herds.

Boyd 2003 at 72.

Husbandry, the selective breeding and raising of livestock, is prevalent throughout the commercial bison industry.

> Ranchers continue to enter the bison industry to capitalize on economic opportunities afforded by bison. The increase in commercial bison production may reflect recognition of advantages afforded by the adaptations and ecological efficiency of bison as an indigenous range animal. . . The demand for bison meat cannot currently compete with the much larger scale of the beef production industry. Therefore, many bison producers apply cattle husbandry practices and standards to bison; standards that may be practical for the bison business, but will not maintain the bison genome.

Boyd & Gates 2006 at 18.

"Wildlife ranching" is the intentional genetic manipulation of wildlife species for commercial purposes. Russo et al. 2019 at 237. The term also properly describes the transformation of bison as a wildlife species into domesticated livestock for a commercial industry.

While publicly touted as conservation, the loss of genetically intact bison, spread of cattle-bison hybrids, the breakdown of normal behaviors and herd social structure, and other maladaptive effects on bison in a ranch management system undercuts whatever conservation value was once present.

"The history of the aurochs offers a lesson for bison: domestication can lead to altered genetically-based behavior, morphology, physiology, and function, and to the loss of the wild type and the genetic diversity it contains." Boyd 2003 at 72.

With few populations functioning as wild (Aune, Jørgensen & Gates 2018 at 1), and only one remnant population of migratory bison remaining in the United States (Harris et al. 2009 at 69), domestication, whether intentional or not and regardless of purpose, is not compatible with natural selection, evolutionary adaptation, and restoration of bison as a wild species.

***Regulatory quarantine has not led to restoring bison in the wild. Managers have not investigated if genetic diversity is lost, and the rate and extent of loss, in the source population of Yellowstone bison undergoing regulatory quarantine.***

According to one park ranger, "to call captivity humane is an oxymoron . . . Injuries suffered by animals in pens included broken legs and necks and becoming disemboweled from getting caught on gate latches (Sahagun 1997)." Cromley 2002 at 136.


PHOTO: Jim Peaco

Restoring bison in the wild — elsewhere, outside Yellowstone — has not been accomplished by State and federal regulatory quarantine.

Furthermore, managers have not investigated if genetic diversity is lost, and the rate and extent of loss, in the source population of Yellowstone bison undergoing regulatory quarantine.

Instead, managers are operating on the assumption bison genetics are being conserved elsewhere while neglecting to systematically examine and publish data investigating the consequences of lost genetic variation and diversity in Yellowstone bison.

Managers have not examined long-term consequences of subjecting Yellowstone bison to quarantine and transferring bison out of the population for 50 years.

In other depauperate species, translocated populations "often harbour reduced genetic diversity compared to source populations and initiating translocated populations can decrease the genetic diversity of source populations, placing them at an increased risk of extinction." Furlan et al. 2020 at 831.

"[A]t least 2 blind bison calves have been born to a small herd that was restricted in numbers and breeding opportunities according to a research protocol designed to study quarantine effectiveness. The small Texas state bison herd had poor calf production and survival, with abnormal sperm and clear inbreeding evidence obtained in genetic analyses." Bailey 2016 at 2.

Managers are overlooking the consequences of taking founders from the remnant source population of Yellowstone bison, a factor that could harm the wild population but remains unstudied despite the 50-year program put in place by Yellowstone National Park. Yellowstone National Park 2018 entire (finding no significant environmental impact from trapping and reducing wild bison to captivity and quarantine including transferring bison for commercial purposes).

Beginning in 2005, Yellowstone National Park permitted the trapping of over 200 bison for a quarantine feasibility study run by the U.S. Department of Agriculture Animal and Plant Health Inspection Service and Montana Fish, Wildlife & Parks. Yellowstone National Park 2006 (permitting the taking of up to 100 bison calves per year).

Similar to past efforts to reduce wild bison to captivity, quarantine breaks social bonds and herd structure resulting in goring, calf abandonment, and other injuries from being trapped. *See* U.S. Department of Agriculture Animal and Plant Health Inspection Service 2011 Freedom of Information Act records ("gutted," "impaled herself," "calf found drowned in creek," "Crushed in [corral]," "calf dead from starvation," "Found dead," "broken neck in chute," "calf found dead," "Cut left horn off," "slit in gut wall, intestines" with several bison euthanized from injuries).

The initial criteria for relocating quarantined Yellowstone bison and any offspring, stipulated that they must be managed as native wildlife held in trust for the public and Indigenous tribes — not for private commercial benefit — forever.

> Cannot be used for commercial purpose (including any offspring) — i.e., sold as livestock vs. ecotourism, outfitting, etc. Include description of assurances/means to prevent commercialization of these bison and their offspring.

Montana Fish, Wildlife & Parks May 1, 2008 at 6.

> • Quarantine bison (and any offspring) must be managed as native wildlife (pre- and post 5-year closed herd). Bison will be public/Tribal wildlife (not private) forever.

Montana Fish, Wildlife & Parks Feb. 2009 at 29 (Translocation Criteria as Described in Request for Proposals Announcement).

> • Quarantine bison, including any offspring, cannot be used for commercial purposes — i.e., sold as livestock (vs. ecotourism, outfitting, etc.).

Montana Fish, Wildlife & Parks Aug. 10, 2009 at 3.

> The proposals from other private entities were eliminated from additional consideration because they did not meet the translocation criteria [and] were requesting the bison for solely commercial interests.

Montana Fish, Wildlife & Parks Feb. 2010 at 17.

Despite repeated public assurances made to the contrary, Montana Fish, Wildlife & Parks struck a deal with Turner Enterprises Inc. to take three-fourths of bison offspring for private commercial use after a five-year quarantine period. Montana Fish, Wildlife & Parks, Montana Dept. of Livestock, and Turner Enterprises, Inc. Feb. 2010 entire.

Montana's decision to alienate public trust bison for private commercial use was contested in court. The court found Mont. Code Ann. § 81-2-120 allows the Montana Dept. of Livestock to sell bison "to help defray costs that the department incurs in building, maintaining, and operating necessary facilities related to the capture, testing, quarantine, or vaccination of the wild buffalo or wild bison," granting Turner Enterprises Inc. three-fourths of the bison offspring. *Western Watersheds Project v. State of Montana*, No. DV–10–317A at 19–20 (Apr. 22, 2013).

The Memorandum of Understanding signed by the State of Montana and Turner Enterprises Inc. was executed in 2015. Bison not alienated as private commercial stock under the deal struck with Turner Enterprises were transferred to Fort Peck. Montana's decision to transfer the remaining bison to the Assiniboine and Sioux Tribes was contested and resolved in favor of the tribes by Montana's Supreme Court. *Citizens for Balanced Use v. Montana*, No. DA 12–0306, 2013 MT 166 (June 19, 2013).

PHOTO: Darrell Geist

The bison's habitat on Fort Peck is confined to a 320-acre holding pen and three electrified fenced ranges initially totaling 10,778 acres. Fort Peck Assiniboine and Sioux Tribes 2014 at 2, 4, 5, 6.

As of 2022, Fort Peck has 97 $km^2$ or 23,969 acres and Fort Belknap 93 $km^2$ or 22,980 acres allocated for bison. Shamon et al. 2022 at 8.

"[A] shock resulting from a bison coming into contact with the electric fence is very uncomfortable and bison quickly learn to respect this fence." Fort Peck Assiniboine and Sioux Tribes 2014 at 5.

> The Fort Peck Tribes have observed uncharacteristic behaviors among the first QFS [Quarantine Feasibility Study bison] . . . and were again required to break up the family structure . . . when 33 bison were removed and sent to the Fort Belknap Tribes. The bison have a tendency to follow the biggest bull in the herd, despite the fact that they would typically follow one of the lead females.

Fort Peck Assiniboine and Sioux Tribes 2014 at 9.

The bison are managed as a "conservation" herd per the terms of an agricultural leasing, permitting and grazing program, and a Memorandum of Understanding with Montana Fish, Wildlife & Parks addressing bison escapes, disease issues, responsibilities for any damage to persons or property for which liability insurance is retained. Fort Peck Assiniboine and Sioux Tribes 2014 at 4, 2, 7.

Increased toxic levels of selenium and molybdenum and low levels of copper were detected in liver tissues collected from tribal herds including bison transferred from the Yellowstone population. Rhodes et al. 2018.

Plants bison forage on "absorb unusually high levels of selenium and molybdenum." Rhodes et al. 2019. Malabsorption of nutrients including deficiencies in copper, manganese, and zinc were detected in transferred bison. "With the limited grazing opportunities, it has been discovered that many of these bison have serious health problems related to malnutrition which can cause lower birth rates." Rhodes et al. 2020.

Internal parasite infections were also investigated because "heavy burdens of internal parasites were commonly present in bison in conventional herds that we have studied to date." Rhodes et al. 2019. The authors concluded malabsorption of nutrients was "caused by increased absorption of selenium and molybdenum but not infections from parasites in the Bison digestive tract." Rhodes et al. 2020.

It required over twenty years of advocacy by members of the Fort Peck Assiniboine and Sioux Tribes and a successful outcome in a Montana Supreme Court case that overturned a lower court ruling to return bison to their indigenous range on tribal lands. *Citizens for Balanced Use v. Montana*, No. DA 12–0306, 2013 MT 166 (June 19, 2013).

After suffering the great loss of bison for over 140 years, the spiritual, cultural, and ecological significance of returning bison most directly related to the ancestral herds that populated indigenous territories is to be celebrated and commended. Haggerty et al. 2018 entire.

However, the prospect that these bison will remain in fenced, limited ranges is likely to continue for the foreseeable future. Fort Peck Assiniboine and Sioux Tribes 2014 at 6–7.

Prior Acts by Congress, including the Dawes Act and homesteading Acts, fragmented reservation land held in common into private parcels. Hubbard 2016 at 92–93 (imposed on over 100 reservations, land once commonly held was parceled out to enrolled individuals in a tribe with the remainder deemed "surplus" and sold to settlers). Even a large reservation like Fort Peck with 2,093,318 acres could only initially allocate — after the Bureau of Indian Affairs approved — 3 electrified ranges totaling 10,778 acres for Yellowstone bison surviving the quarantine process.

The Sioux and Assiniboine have 378,000 acres scattered across Fort Peck. Fort Peck Assiniboine & Sioux Tribes 2020; Fort Peck Assiniboine and Sioux Tribes 2014 at 6–7, 12. *See also* Shamon et al. 2022 at 7, 8 (Tribes on the Blackfeet, Fort Belknap, Fort Peck, and Rosebud reservations have set aside between 36 and 112 $km^2$ (8,895 and 27,675 acres) for bison restoration, and seek more pastures for growing their bison herds. However, the "majority of unplowed lands within these reservations are used for cattle operations." All four tribal bison herds have boundary and or interior fencing and culling is based on stocking rates or estimation of rangeland health based on Animal Unit Months used in cattle ranching).

In summary, Yellowstone bison taken from the wild for State and federal regulatory quarantine were reduced to private property in a commercial operation, and where they were transferred to their indigenous range on tribal lands, reduced to captivity and remain confined for the foreseeable future.

***Yellowstone National Park's 50-year bison quarantine program includes transfer for commercial purposes and has not led to restoring self-sustaining bison populations in the wild.***

The U.S. Congress never intended for wild bison in Yellowstone to be declared "surplus" and did not authorize the Secretary of the Interior to take wild bison as "surplus" for quarantine.

> The "tame" herd of buffalo in Yellowstone National Park was established under authority contained in the act of July 1, 1902 (32 Stat. 574), with an appropriation of $15,000 for the purpose. Twenty-one animals were purchased in the fall of that year, and these have multiplied until now the herd contains 578. *It is estimated that the "wild" herd, a remnant of the vast hordes that once roamed this region, numbers from 125 to 150, but it has no place in the present discussion*.

U.S. Congress 1923 at 46 (distinguishing the "wild" herd from "surplus" captive bison transferred to the Lamar Buffalo Ranch) (emphasis added).

While the practice of Yellowstone National Park transferring "surplus" bison elsewhere began in the 1930s, including to the Apsáalooke (Crow) and Oglala Sioux (Franke 2005 at 77–80), it has not led to the restoration of self-sustaining populations in the wild.

Yellowstone National Park's 50-year quarantine program includes transferring bison from the wild for commercial use in contravention of the purposes of the Organic Act and National Park Service policies.

> The quarantine program would entail testing bison captured to reduce abundance and segregating some bison testing negative for brucellosis exposure from other bison. These test-negative bison would be tested repeatedly over time using established protocols to evaluate if they remain free of brucellosis (USDA, APHIS 2003; Clarke et al. 2014). Animals that remain test-negative for brucellosis through these protocols would be sent alive to other public, tribal, or private lands for conservation, cultural, or commercial purposes. Animals not selected for quarantine would be released or sent to terminal pastures, meat processing facilities, or research facilities.

Yellowstone National Park 2016 at 22 (Programmatic Actions Common to All Action Alternatives) (footnote omitted).

Since 2005, a total of 578 wild Yellowstone bison have been trapped and taken for quarantine: 364 bison since completion of the feasibility study involving 214 bison. Each bison is fitted with a unique radio-frequency identification and bangle tag. Of 364 bison, 44 adults and 1 bison calf died in captivity. Browne et al. 2023 at 3 (restraint, dystocia, and trauma recorded as sources of mortality).

An expansion of Yellowstone National Park's quarantine program is expected to triple the number of bison juveniles and calves taken from the wild for "breeding and conservation" elsewhere. Browne et al. 2023 at 3, 1.

Yellowstone National Park's desired condition of reducing the bison population through quarantine, terminal pastures, and trapping for slaughter operations is having an unknown level of impairment on Yellowstone bison's natural immunity to introduced diseases including brucellosis from cattle, and is increasing the risk of more virulent and persistent strains arising in the wild population.

> Low diversity in immune system genes may enable parasites and pathogens to replicate more quickly and become more virulent (Kubinak et al. 2015). Having more genetic diversity within a single herd or population may counter the ability of diseases to adapt and replicate quickly (Kubinak et al. 2015).
>
> . . .
>
> [L]arger brucellosis transmission events could become more likely if more resistant animals are removed and naïve animals make up a larger portion of the population.

PHOTO: BFC Archives

> This should not be a substantial concern if bison are culled from the population in an unselective manner with regards to brucellosis exposure.

Yellowstone National Park 2016 at 51, 55.

However, bison are not "culled" in an "unselective manner" and government slaughter of bison is not random. For detailed evidence and analysis identifying large-scale, nonrandom, and disproportionate government-led slaughter as a threat to Yellowstone bison, *see* factor 8.C.

Additionally, Yellowstone National Park did not and has not undertaken an impairment review of its' 50-year quarantine program together with its' on-going bison trapping for slaughter program.

Yellowstone National Park's track record of permitting bison to be taken from the wild for quarantine led to the wildlife species being commercially exploited and subject to domestication, artificial selection, and livestock management.

Bison taken from the wild for quarantine are under the same harmful processes of domestication, artificial selection, and livestock management that jeopardize wild bison remaining in the Yellowstone ecosystem.

Yellowstone National Park's policy and program of quarantining bison is a detriment to bison remaining in Yellowstone, and, as a regulatory mechanism, has not led to restoring self-sustaining bison populations in the wild elsewhere.

Once bison are taken from the wild the U.S. Department of Agriculture asserts the agency's costly, restrictive, and burdensome quarantine requirements must be followed.

"APHIS [Animal and Plant Health Inspection Service] maintains quarantine facilities for Yellowstone bison must be established in the DSA [Designated Surveillance Area] and approved by federal and state animal health officials per the 2003 Brucellosis Eradication: Uniform Methods and Rules." Yellowstone National Park 2018 at 9; Browne et al. 2023 at 2 (male and female bison are currently confined in quarantine pens for 930 and 1,356 days respectively).

Quarantining bison and Yellowstone National Park's ongoing bison trapping for slaughter program harms Indigenous tribes with cultural and traditional ties to bison roaming wild in Yellowstone. Little Thunder & Geist 2014 ("The slaughter of the buffalo is not about a disease, really. It is about a commodity and profiting from that commodity.").

Quarantining bison together with Yellowstone National Park's trapping for slaughter program also harms Indigenous tribes with treaty rights to hunt bison on open and unclaimed public lands including National Forests contiguous to the park.

Quarantining bison impairs herd social structure and modifies behavior in unnatural ways. In quarantine, bison are subject to conditioning, artificial selection, and processes of domestication. Quarantined bison are managed like livestock on electrified and fenced range units of limited acreage. Compare and contrast the free and wild migrations of bison as a wildlife species with the U.S. Department of Agriculture's costly, restrictive, and burdensome quarantine requirements imposed on Indigenous tribes.

Contrary to misleading claims made by Yellowstone National Park and others, in Montana, bison in the wild that are reduced to captivity for quarantine are not wild according to the Montana Supreme Court.


PHOTO: BFC Archives

> A "wild buffalo or bison" is defined as a bison "that has not been reduced to captivity and is not owned by a person." Sections 81-1-101(6) and 87-2-101(1), MCA. The brucellosis quarantine bison involved in this case have been reduced to captivity for a number of years and therefore arguably are not "wild buffalo or bison" as defined in Montana law . . .

*Citizens for Balanced Use v. Montana*, No. DA 12–0306, 2013 MT 166 at ¶ 15.

> **Concern Statement:** Commenters suggested Yellowstone bison are wildlife, but quarantine will result in commercializing and domesticating bison.
>
> Response: Quarantine will not lead to commercialization. Judicial evaluations have concluded that Yellowstone bison completing quarantine are wild animals under Montana law (*Citizens for Balanced Use et al. v. Director Maurier, Montana Department of Fish, Wildlife & Parks et al.*; Montana Seventeenth Judicial District, Blaine County; Cause No. DV–2012-1 [2012, 2014], overturned No. DA 12-0306 [Montana Supreme Court 2012]).

Yellowstone National Park 2018 at 18 (emphasis in the original).

In its' decisions about Yellowstone bison the public expects frank and honest communications from Yellowstone National Park. In announcing its' 50-year program taking Yellowstone bison from the wild for quarantine, the National Park Service misled the public.

Quarantine is an inadequate regulatory mechanism because it is a detriment to the wild population in Yellowstone and has failed to establish self-sustaining populations in the wild elsewhere.

***Proximity of domestic cattle, sheep, and ranched bison is a risk to bison roaming wild in the Yellowstone ecosystem.***

The loss of bison range to domestic livestock also gives rise to the risk of livestock transferring diseases to bison roaming wild.

Likewise, the infection of bison with domestic livestock diseases such as *Brucella abortus* has given rise to intensive management of bison that threatens their wild traits, characteristics, and adaptive behaviors in the Yellowstone ecosystem.

Arc GIS mapping data show numerous ranched bison operations in multiple counties surrounding Yellowstone National Park and the Custer Gallatin National Forest in Montana, Idaho, and Wyoming. Martin & Wehus-Tow 2021.

A 2017 census counted 183,780 bison on 1,775 private ranches in the United States. Griffith 2020 at 3. A 2016 census counted 119,314 bison on private ranches in Canada. National Bison Association 2021.

> Many important diseases of livestock are shared among multiple species, including foot-and-mouth disease, Rift Valley fever, and Johne's disease (Daszak et al., 2000; Chivian, 2001; Taylor et al., 2001; Woolhouse et al., 2001; Belloy et al., 2004; Cunningham, 2005; Böhm et al., 2009; Tomley and Shirley, 2009). Human population growth and associated landscape changes, as well as competition for grazing lands, have made wildlife-livestock disease transmission more likely by reducing the spatial separation between livestock operations and wildlife habitat (Daszak et al., 2001; Western, 2001).

Schumaker 2010 at 1.

"[G]enetically homogenous populations tend to suffer from harsher disease outbreaks than populations that are more genetically diverse (King & Lively, 2012). As of today, the bison's susceptibility to diseases has to be studied further, because of their vast history that includes a large population reduction that caused genetic bottlenecking." Griffith 2020 at 1–2.

Confining and reducing bison to limited ranges is also a factor in making conservation herds more susceptible to livestock introduced diseases such as *Mycoplasma bovis*, a lethal respiratory disease. Smith 2015 entire (reporting on the spread of the deadly disease in The Nature Conservancy's Tallgrass Prairie Preserve bison, a conservation herd).

"In less than 15 years, it [*Mycoplasma bovis*] has moved with surprising speed in bison herds across Canada and the United States, where it has killed up to a quarter of adults in a matter of months or even weeks. In one location, more than 45 percent of adult cows died, many leaving defenseless calves." Smith 2015 at 54.

> Until this century *M. bovis* was not considered to be an infectious disease threat to North American bison. . . . Healthy cattle exposed to *M. bovis* may become chronic carriers but rarely develop disease in the absence of co-infecting pathogens or other stressors. Over the next several years, mycoplasmosis in bison spread widely throughout North America and was reported in ranched and free-ranging bison of all ages, with case fatality rates as high as 45% (Bras et al., 2017; Dyer et al., 2008, 2013; Janardhan et al., 2010; Register et al., 2013b).

Register et al. 2018 at 55.

"The finding that healthy, seronegative bison can act as inapparent carriers of the bacterium will likely complicate efforts to monitor its spread and to control related disease." Register et al. 2018 at 62 (a finding that confounds transferring bison for metapopulation management).

A study in Western Canada found an association between a disease that can decimate a bison herd, malignant catarrhal fever, with large herd size of ranched bison, size of sheep farm, and proximity (< 1 kilometer) to sheep farming operations. Epp et al. 2018 at 7.

A bison herd in a southern Idaho feedlot was decimated by an outbreak of malignant catarrhal fever traced to exposure to sheep. Li et al. 2006 at 119 (51.2% mortality rate recorded among 825 bison).

Respiratory disease (*Mycoplasma bovis*), *Mannheimia* sp. (pneumonia and haemorrhagic septicaemia), reproductive disorders, malignant catarrhal fever, diarrhea, gastrointestinal parasites and disease, and mineral abnormalities, are among the diseases and disorders being reported in commercial bison operations. Epp et al. 2018 at 1, 6.

There is also "a significant risk of clinical disease and production impacts associated with gastro-intestinal nematode parasites in western Canadian bison," including commercial and conservation herds. Avramenko et al. 2018 at 11.

> [A] major reason managers regularly handle bison is to apply topical dewormer (USDA, 2016). Research indicates that clinically significant levels of GI [gastrointestinal] nematodes that develop under conditions of restricted movement and high stocking densities can be effectively controlled with commercial anthelmintics (e.g., doramectin; Eljaki et al., 2016). Conversely, the use of anthelmintics to control GI nematodes may influence diet choice, grazing behavior, movement, limit natural selection by altering host immune profiles, and unintentionally promote domestication (Lehman et al., 2006; Gates and Aune, 2010; Stott, 2017).

Wiese et al. 2021 at 224.

PHOTO: BFC Archives

"Production loss, clinical disease, and mortality due to parasitism in the commercial cattle and bison industry have led to routine deworming becoming a common practice for bison managers in North America and Europe (Wade et al., 1979; Hennings and Hebbring, 1983; Eljaki et al., 2016; Woodbury et al., 2014; Kryzsiak et al., 2015)." Wiese et al. 2021 at 217.

A significant pathogen in cattle, Bovine viral diarrhea viruses "associated with reproductive failure, respiratory disease and immune dysregulation" was detected in a private captive bison herd in Nebraska. While cattle are the reservoir for Bovine viral diarrhea viruses, the ability of bison to be chronically infected is another source of disease concern. Hause et al. 2021 at 1, 2.

Confining or reducing bison to a domesticated state is a factor in the spread of infectious diseases. Yellowstone bison may be vulnerable to diseases found in ranched cattle, sheep, and bison.

PHOTO: Western Watersheds Project

**8.C. Disease management threatens or endangers Yellowstone bison in the wild.**

• Disease management is a threat to Yellowstone bison in the wild.

• State and federal livestock management and veterinary policy is a threat to Yellowstone bison in the wild.

• Yellowstone National Park's disease management actions threaten or endanger Yellowstone bison in the wild.

• Disease management is a threat to Yellowstone bison's genetically distinct subpopulations.

• State and federal disease management actions threaten genetic variation, disease resistance, and evolutionary adaptation of Yellowstone bison in the wild.

• The State of Montana's and Yellowstone National Park's bison management plan is not based on the best available science.

• The State of Montana's statutory scheme (Mont. Code Ann. § 81-2-120) is a threat to Yellowstone bison in the wild.

• The Montana Dept. of Livestock is not enforcing and Montana cattle ranchers are not complying with Designated Surveillance Area rules.

• In the Designated Surveillance Area, Montana manages wild elk populations to prevent commingling with cattle.

• Designated Surveillance Area management of cattle, bison biology, scavengers, and environmental conditions reduce and prevent disease transmission to cattle in Yellowstone bison's range.

• Eliminating Yellowstone bison from their home range precipitates a cascade of harmful effects on native species and biological diversity. Evidence of management actions harmful effects on Yellowstone bison and bison ecology is not being systematically examined for publication.

PHOTO: BFC Archives

• Displacing bison as a native food source undermines the recovery of grizzly bears.

• Displacing bison, a keystone species and ecological engineer, depletes biological diversity in the ecosystem.

***Disease management is a threat to Yellowstone bison in the wild.***

> Although both elk and bison are native species, elk continue to be treated more like "good animals" throughout Greater Yellowstone. The recent Draft Bison and Elk Management Plan for the National Elk Refuge and Grand Teton National Park included a section that explained "The Role of Elk" in the Jackson area. Elk were described as "diligently protected," "important to residents and interest groups," "important to backcountry users as well as to people that never leave the road," and "at the mercy of sometimes severe winters" (U.S. Department of the Interior 2005). The document made no mention of elk's depredation of ranchers' haystacks, the cost of the feedgrounds and vaccination using biobullets, or the role elk presumably had in transmitting brucellosis to Wyoming livestock in recent years.
>
> The next section of the plan, "The Role of Bison," described the problems caused by the Jackson bison herd, which has been at the mercy of more critical thinking than the elk. "All of the adults were destroyed" in 1963 because of brucellosis. Not only do these animals currently pose a "risk of disease transmission to elk and livestock," but they also "disrupt feeding operations" for the elk, "displace and injure elk," "eat supplemental feed provided for elk," cause "damage to habitats," "damage to private property," "conflicts with landowners," and pose a "risk to human safety."

Franke 2006 at 73.

In the migratory species' indigenous range, no viable population of plains bison that is free of regulated diseases exists under natural conditions. Freese et al. 2007 at 178.

Managing for disease control is domestication, a factor threatening or endangering migratory bison in the Yellowstone ecosystem.

> With disease control, we are interfering with evolved and evolving mechanisms of resistance and accommodation between bison and their pathogens. We do not fully understand the implications of wildlife disease control; and we will not learn what they are unless we retain at least a few wild populations without disease control, as a basis for comparison.

Bailey 2013 at 145.

The best available evidence indicates bison transferred and held in captivity on the Buffalo Ranch in Lamar Valley contracted brucellosis from cattle introduced to bison's range in Yellowstone National Park.

> All lines of inquiry indicated that the organism [*B. abortus*] was introduced to North America with cattle, and that the introduction into the Yellowstone bison probably was directly from cattle shortly before 1917.

Meagher & Meyer 1994 at 645, 650 ("The most likely source was cows maintained for Park employees."); O'Brien et al. 2017 at 339 ("first introduced" to wildlife in the Greater Yellowstone bioregion "by cattle in the 19th century.").

Between 1903 and 1909, four wild bison calves were captured and "mothered by domestic bovine cows" and pastured with cattle that were brought into Yellowstone National Park to feed park workers and tourists. Meagher & Meyer 1994 at 649–650 (citing Holte 1910).

PHOTO: I-Stock

Elk fed in artificial feeding stations on the National Elk Refuge in Wyoming contracted the disease from introduced cattle on ranches established in elk winter range. In turn, elk are the probable source of infection for bison in Grand Teton National Park. Meagher & Meyer 1994 at 645, 650.

Cattle introduced by European Americans passed brucellosis to wild elk and bison populations at least 5 times in the Yellowstone ecosystem. Kamath et al. 2016 at 1.

The best available science indicates that for over a century bison in the wild have not transmitted *Brucella abortus* to cattle introduced into the bison's range in the Yellowstone ecosystem. This century old fact has held true with or without a bison management plan and its' prior reincarnations covering various management regimes across several decades.

Under various plans (husbandry, natural regulation, strict containment, population reduction, etc.) spanning decades, bison in the wild have never transmitted brucellosis to cattle introduced into Yellowstone bison's range.

There is no demonstrable disease risk from Yellowstone bison on habitat where there is no susceptible cattle host. Nicoletti 2008 at 2.

"Paul Nicoletti, formerly of the University of Florida and now an epidemiologist with the department [U.S. Department of Agriculture], described the risk of transmission from buffalo to cattle as nearly risk free, citing the thousands of times before this that cattle and buffalo mingled together over the previous fifty years with no proof of transmission outside of one study in unnatural conditions." Sprung 2012 at 174–175 (footnote omitted).

"Hank Rate, a local rancher who lives next to Yellowstone, notes that brucellosis prevention in buffalo is now an industry in and of itself, regardless of the probability of actual transmission." Sprung 2012 at 175 (footnote omitted).

Yet, where cattle are not present on public or private lands, State and federal managers confine and reduce bison range, abundance, and distribution in Montana, Idaho, and Wyoming under the rubric of brucellosis disease management.

"[M]anagement actions (for example, vaccination, culling) directed towards bison in Yellowstone NP may not affect brucellosis prevalence elsewhere" in the Greater Yellowstone bioregion because the cattle-introduced disease is persisting in wild elk populations. Kamath et al. 2016 at 7 (finding evidence of 17 elk to cattle transmissions between 2002 and 2012).

Findings from a phylogenetic network analysis suggest elk were the source of recent transmissions in Montana, Idaho, and Wyoming, and ruling out wild bison as a source of two more recent transmissions found in Montana cattle as "humans have precluded Yellowstone bison from entering any further than a few kilometers into the Paradise Valley of Montana for >100 yr (White et al. 2011)." O'Brien et al. 2017 at 342, 341.

"In contrast, the predicted number of bison to livestock transitions was close to zero and no transmissions of brucellosis from wild bison to cattle have been detected." Kamath et al. 2016 at 6.

Managers in Montana forcibly remove Yellowstone bison where cattle do not range. These government-led "hazing" operations harass bison in their home range resulting in mother-calf separation, injury, nutritional deprivation, and stress. Buffalo Field Campaign video May 16, 2013 and May 11, 2015.

From 2009 to 2021, State and federal managers carried out 340 hazing operations against bison on their range and habitat in Gardiner basin, and 267 hazing operations against bison on their range and habitat in Hebgen basin. Geremia 2022 at 9 (Table A4). Most government-led harassment operations occur during the winter and spring when bison's nutritional condition is depleted.

While the data is incomplete, from 2011 to 2021, the State of Montana made 695 "management requests" for the government to remove bison from their range and habitat. Geremia 2022 at 9 (Table A4).

Intrusive management actions beyond Yellowstone National Park also bring government officials into conflict with local residents who object to agents trespassing on private land to harass bison. Buffalo Field Campaign video Aug. 23, 2007 and June 23, 2014.

For decades, the National Park Service has cooperated with the U.S. Dept. of Agriculture in directing brucellosis control actions against bison in Yellowstone including "vaccination of calves and removal of reactors during reductions (held primarily to cut herd numbers). This cooperation resulted in reduction of animal numbers below the park's management objective at Lamar in 1964–65." Meagher 1973 at 71.

"Dave Pierson, Buffalo Herder and Animal Keeper over a period of 30 years, believed that observed abortions occurred as a result of the handling of pregnant females in chutes, and their confinement in pens during the reductions held at the Buffalo Ranch (1968 pers. comm.)." Meagher 1973 at 71.

Despite extensive and intrusive State and federal disease management activities directed at bison, brucellosis does not pose a threat to Yellowstone bison in the wild.

PHOTO: BFC Jim Peaco

A recent study "found no relationship between pregnancy rates and serological status for brucellosis across a range of ages." Gogan et al. 2013 at 1276.

> *Brucella abortus* characteristically establishes in the bovine female's lymphatic system and uterus and proliferates during the latter stages of pregnancy to cause abortion or premature birth of weak calves (Rhyan et al. 2001, Carvalho Neta et al. 2010).
>
> . . .
>
> Additionally, since some 20% of Yellowstone bison convert from seronegative to seropositive for brucellosis between 1 and 3 years old (Treanor et al. 2011), associated with their first pregnancy (Cheville et al. 1998), any failure to conceive the following year may erroneously be attributed to positive serological status for brucellosis when other factors affecting pregnancy, such as body condition, are ignored. Additionally, classification of brucellosis status on the basis of seroprevalence may contribute to errors in estimates of active infection. Roffe et al. (1999) found a poor relationship between bison serological status for brucellosis and tissue culture results.
>
> . . .
>
> Our results suggest caution in identifying brucellosis infection as influencing pregnancy rates in central Yellowstone bison because we found no evidence to support this conclusion.

Gogan et al. 2013 at 1277.

The U.S. Fish & Wildlife Service must examine and investigate how managing Yellowstone bison for disease control threatens genetic diversity, and dispersal to range and ecological settings for the wild species to adapt to changing environmental conditions in the agency's threats assessment and status review.

***State and federal livestock management and veterinary policy is a threat to Yellowstone bison in the wild.***

In the late 1960s and early 1970s, Yellowstone National Park signed several "boundary control agreements" with the States of Montana, Idaho, and Wyoming which "began the "official" policy of excluding bison outside park boundaries, even when they roamed on publicly-owned wildlands such as the national forests." Yellowstone National Park 1997 at 83.

The "boundary control agreements" were pushed by State and federal livestock and veterinary agencies to confine the natural migrations of Yellowstone bison in their indigenous range.

Adopting veterinary policy and the use of livestock management practices in the State of Montana's and Yellowstone National Park's bison management plan is a threat to Yellowstone bison in the wild.

State and federal veterinary policy is a threat to bison because strict application of the rules driving the bison management plan destroys the migrants, depletes bison range and habitat, and nutritionally restricts the native species' access to resources.

Veterinary policy is expressed in current management schemes such as preventing spatial and temporal overlap of Yellowstone bison and cattle by excluding bison from their indigenous range through government trapping, shooting, and harassment from habitat.

Furthermore, State and federal managers have drawn a boundary line beyond which migratory bison are killed or removed altogether. In contrast, there is no boundary line beyond which wild elk are eliminated in government management actions.

In addition, wild elk are not subject to government trapping for slaughter like wild Yellowstone bison on National Park, National Forest, and private lands.

> The history indicates the risk of brucellosis transmission to cattle is not a credible reason for the incongruent treatment of wild bison compared to elk, which pose a much greater risk but are generally allowed to move freely without intrusive management. Elk are viewed as a beneficial asset, while bison are viewed as a new, unwanted burden by many state managers and ranchers; apparently because bison compete with cattle for grass and are seen as an uncontrollable threat to the ranching lifestyle (CWG 2011).

White et al. 2018 at 4 (unpublished manuscript).

The use of veterinary and livestock management on wild bison but not wild elk in the same ecosystem is invoked by managers to prevent disease transfer to cattle and meet the veterinary standards for brucellosis of the U.S. Dept. of Agriculture Animal and Plant Health Inspection Service.

Despite any evidence justifying the disparate treatment of wild bison and wild elk, veterinary policy continues to be used exclusively on wild bison to the detriment of Yellowstone bison roaming the ecosystem.

Managing for disease control is a "veterinary cordon fence" (Harris et al. 2009 at 72) blocking the natural migrations of bison responding to fluctuations in environmental conditions such as the onset of winter, deep snow, ice pack, and spring green up.

In turn, limiting or restricting dispersal of bison and access to resources during winter and spring disrupts the evolution of bison's "herding and migration patterns" and adaptation to climatic variability. Bamforth 1987 at 4, *see also* Bamforth's discussion of variation in environmental conditions and influence on bison dispersal and movement patterns at 5–7.

Authorizing the trapping of bison in Yellowstone for a study evaluating sterilization using an immunocontraceptive vaccine (GonaCon) is one example of veterinary policy encroaching on managing bison as a wild species. Yellowstone National Park 2011 (permitting the taking of 108 bison for the U.S. Dept. of Agriculture Animal and Plant Health Inspection Service's GonaCon study).

In a similar study of Santa Catalina Island bison, porcine zona pellucida (PZP) completely halted calving for 4 to 5 years — far longer than investigators anticipated. Duncan et al. 2017 at 1281.

Managing bison for disease control and domestication is a decades old threat that continues to operate as a threat to the wild species from State and federal managers adoption and use of livestock management and veterinary policies.

A bison herd transferred from Yellowstone National Park to the Crow Tribe Reservation was completely eradicated in the 1960s due in part to ranchers wanting a "a slaughter owing to confirmed bison-cattle contact in the winter range off the flanks of the Bighorn Mountains. Worthy of note, the Crow bison stewards never observed the effects of brucellosis, e.g., early births, in their herd." Zontek 2003 at 127.

An attempt to trap bison for slaughter in Yellowstone National Park was initiated by "veterinarians and allied interests" in 1962 and abandoned in 1964 due in part to concern over changes in "the wild behavior of bison," reducing the herds to "dangerously low numbers," and eliminating "the genes of dominant females who teach historical habitat use patterns (Meagher 1972, Meagher 1974)" that could "threaten the wild bison herd." Cromley 2002 at 65.

"A border control policy and other attempts to deter the migrations, including cattle guards and fences, failed to end the migrations in the 1970s and early 1980s." Cromley 2002 at 66.

Acting at the behest of the State veterinarian, Fish, Wildlife & Parks agents shot 88 bison migrating into Montana in 1984–1985 which "set the stage for policies to manage border crossings in the future." Cromley 2002 at 67.

Montana escalated its' killing on the border with 579 of 900 bison from the Northern herd shot during the winter of 1988–1989. Cromley 2002 at 69.

Montana then coerced Yellowstone National Park in assisting in killing bison migrating beyond the park "reflecting pressure from livestock groups and state officials on Park officials to accept responsibility for protecting livestock by controlling bison." Cromley 2002 at 70.

Livestock groups, veterinarian associations, and 17 western State veterinarians also pressured the U.S. Dept. of Agriculture Animal and Plant Health Inspection Service (APHIS) "to downgrade the status of states that allowed wild bison exposed to brucellosis to roam (Alley 1995)" and "threatened to revoke Montana's status without a scientific or legal basis." Cromley 2002 at 70.

Livestock and veterinary control of policy culminated in 1995 with the Montana Legislature transferring

PHOTO: Jackson Doyel

authority for wild bison to the Montana Dept. of Livestock (Mont. Code Ann. § 81-2-120), a statute which then Governor Marc Racicot used to sue Yellowstone National Park "because the Park failed to prevent bison migrations into Montana and because APHIS threatened to downgrade Montana's brucellosis-free status based only on the presence of diseased wild bison in the state." Cromley 2002 at 72.

> At the University of Florida, Paul Niccoletti, a leading authority on brucellosis, described the possibility of cross contamination between buffalo and cattle as having "no firm foundation in science." Niccoletti noted that no study in real world natural conditions had ever proven the possibility of buffalo to cattle brucellosis contamination. As such, he described the alarmist, doomsday attitudes of the Montana Department of Livestock and APHIS as "scare tactics." Another report seemed to confirm this assessment. C&C Meats, the company contracted by the state of Montana to slaughter animals shipped out of Yellowstone that tested seropositive for brucellosis, found that only two of the two hundred animals killed by them actually tested positive for brucellosis. Despite this report, the state veterinarian, Clarence Siroky, disputed the findings and insisted that the shooting of buffalo continue. To frame the issue in another light, John Varley, the chief scientist at Yellowstone, described the brucellosis issue as "a struggle between the park and agribusiness and we're losing badly." To wildlife advocates and to the National Park Service, the buffalo only left the park based on natural needs and should be favored, since the lands they were attempting to go to in search of food were mostly public lands, such as national forests. In addition, no cattle would be allowed onto the range until June anyway, ensuring the animals would not co-mingle. To the ranchers though, the buffalo represented a sinister threat that needed to be dealt with. In addition, the animals represented a land use struggle, in which land could be taken away from individuals, to promote "public" causes.

Sprung 2010 at 159–160 (footnotes omitted).

A severe winter with ice crusting over snow during 1996–1997 led bison to mass migrate into a livestock industry designed regulatory scheme resulting in 1,084 bison being shot by government agents or killed in traps. Cromley 2002 at 135. Bison biologist Mary Meagher predicted the "best-case scenario is a population crash . . . The worst case is a system collapse." Pritchard 1997 at 4.

Evan after the U.S. Dept. of Agriculture Animal and Plant Health Inspection Service announced Montana could "cease shooting buffalo and not lose its brucellosis free status . . . Department of Livestock officials continued to shoot buffalo." Sprung 2010 at 163.

By mid-March, the "government-sanctioned slaughter combined with the winterkill, had already wiped out more than 2,000 bison—nearly two-thirds of the Yellowstone herd." Peacock 1997 at 42 (Audubon). The widespread snow crusting event led to the natural death of approximately 1,300 bison. Sprung 2010 at 163.

The shooting of bison migrating to find forage was carried out "because of pressure from the Interior Department to be a "good neighbor" to the State of Montana." Peacock 1997 at 43 (Audubon).

"The agency responsible for most of the Bison killing was the Montana Department of Livestock. Once control of wild Bison was turned over to agricultural agencies, their fate was sealed. . . . The Yellowstone slaughter went far beyond any notion of "wildlife management" in both scale and brutality." Peacock 1997 at 10, 11.

The following year a draft Environmental Impact Statement was released with alternatives that favored "handling and manipulating bison rather than cattle" through a series of intensive management actions reflecting livestock and veterinary policies. Cromley 2002 at 78–79.

In 2000, the State of Montana and Yellowstone National Park released Records of Decisions codifying a plan that rigidly set in place the use of livestock and veterinary management of bison for the foreseeable future. Montana Dept. of Livestock and Montana Fish, Wildlife & Parks 2000; U.S. Dept. of the Interior and U.S. Dept. of Agriculture 2000.

The government's plan continues to operate today.

Each of the alternatives managers considered in 2000 involved killing bison migrants and restricting bison's natural range:

Alternative 1: No action — continuation of the current revised interim management plan.
Alternative 2: Minimal management.
Alternative 3: Management with emphasis on public hunting.
Alternative 4: Revised interim management plan with limited public hunting and quarantine.
Alternative 5: Aggressive brucellosis control within YNP through capture/test/slaughter.
Alternative 6: Aggressive brucellosis control within YNP through vaccination.
Alternative 7: Preferred alternative — manage for specific bison population range.
New preferred alternative — manage for higher bison population range.

Angliss 2003 at 35–41; *see also* U.S. Dept. of the Interior & U.S. Dept. of Agriculture 2000 Record of Decision at 21 (rejecting the environmentally preferred alternative 2 and the public's overwhelming support for "natural management" and "use of all public lands in the analysis area" for wild and free-roaming bison).

"Each alternative management plan included the removal of bison migrants from the population by managers in order to achieve at least one of the following: reduce the seroprevalence, reduce the probability of bison coming into contact with cattle, or reduce the size of the population." Angliss 2003 at 51; *see also* U.S. Dept. of the Interior & U.S. Dept. of Agriculture 2000 Record of Decision at 21 (rejecting the public's "extremely strong support for the management and/or restriction of cattle rather than bison given a choice between the two.").

Many of the "aggressive" and intensive practices managers imposed on Yellowstone bison, "were adapted from ranch and range management techniques developed for cattle." Cromley 2002 at 64.

The U.S. Animal Health Association's bison management proposal was analyzed in 2000. The veterinary association's policies, many of which were adopted in part or entirely by the State of Montana and Yellowstone National Park include:

- "Aim to totally eradicate brucellosis from the Yellowstone bison;"
- "reduce the number of bison testing positive through vaccination;"
- establish two permanent traps at Stephens Creek and Seven-Mile Bridge inside the Park;
- add seven temporary traps in the Park for parkwide bison capture, test, and slaughter program;
- "begin parkwide capture, test, and slaughter";
- "maintain population at 1,800" and "Never more than 2,200" bison;

- “capture and test every bison within the park, slaughter those testing positive,”;
- immediately build quarantine for bison;
- not allow bison outside the Park except in Eagle Creek and Bear Creek (if approved);
- “do not allow bison north of Reese Creek”;
- “do not allow bison in West Yellowstone area”;
- “Encourage vaccination of female [cattle] calves that may come in contact with bison”;
- “Require testing of cattle in areas near West Yellowstone”;
- “Immediately vaccinate [bison] calf and yearlings with RB51”.

U.S. Dept. of the Interior & U.S. Dept. of Agriculture 2000 FEIS Vol. 1 at 237–241 (Table 13) (finding “bison would not remain wild and free ranging as they would be extensively handled”).

Standing members of the U.S. Animal Health Association include fifty State animal health officials, nine federal agencies, and thirty-seven national organizations, among them. U.S. Animal Health Association 2022.

The State of Montana’s and Yellowstone National Park’s intensive disease control actions threaten bison with domestication because the primary mechanisms for evolutionary adaptation and natural selection have been overridden by a preponderance of human selection processes that will continue to be exerted on the migratory species for the foreseeable future.

Intensive human selection for disease control has whip-sawed the size of Yellowstone bison subpopulations with the Northern herd fluctuating from 590 to 4,507 (2000–2022), while the Central herd was decimated and severely reduced from 3,553 to 1,432 (2005–2022) with a low of 847 counted in 2017. Geremia 2022 at 5–6.

Intensive population control under current State and federal management is resulting in nonrandom and disproportionate government slaughter of Central and Northern bison herds.

Census from Yellowstone National Park biologist summer counts record large declines in subpopulations or herds and large variations in response to State and federal disease control actions:

| YEAR | TOTAL | CENTRAL HERD | NORTHERN HERD |
|---|---|---|---|
| 2000 | 2432–2708 | 1924–2118 | 508–590 |
| 2001 | 2859–3256 | 2564–2595 | 661–719 |
| 2002 | 3648–4045 | 2902–3240 | 548–812 |
| 2003 | 3766–3811 | 2770–2923 | 878–996 |
| 2004 | 3995–4215 | 2811–3339 | 876–1337 |
| 2005 | 4747–5015 | 3394–3553 | 1266–1484 |
| 2006 | 3713–3889 | 2430–2512 | 1279–1377 |
| 2007 | 3959–4694 | 2390–2734 | 1569–2070 |
| 2008 | 2881–2969 | 1150–1540 | 1341–1793 |
| 2009 | 2977–3301 | 1464–1544 | 1433–1837 |
| 2010 | 3563–3898 | 1652–1730 | 1855–2246 |
| 2011 | 3485–3720 | 976–1406 | 2155–2675 |
| 2012 | 3885–4230 | 1395–1640 | 2490–2669 |
| 2013 | 4492–4924 | 1327–1504 | 3165–3420 |

| | | | |
|---|---|---|---|
| 2014 | 4386–4865 | 1340–1444 | 2942–3517 |
| 2015 | 4616–4910 | 1282–1323 | 3325–3628 |
| 2016 | 4736–5459 | 1451–1638 | 3152–4042 |
| 2017 | 4816 | 847 | 3619–3969 |
| 2018 | 4372–4527 | 758–1162 | 3210–3643 |
| 2019 | 4664–4829 | 1162–1124 | 3540–3667 |
| 2020 | 4658–4680 | 1243–1251 | 3407–3437 |
| 2021 | 4922–5394 | 1299–1564 | 3623–3830 |
| 2022 | 5704–5939 | 1284–1432 | 4420–4507 |

Geremia 2022 at 5–6 (Data showing the lowest and highest number of bison counted).

The only common factor accounting for the dramatic shift in subpopulation size is artificial selection of Yellowstone bison under State and federal management. Under the government's plan, the adaptive trait of migration, which natural selection favors, is systematically selected against in each distinct herd in the Yellowstone bison population.

PHOTO: BFC Archives

"Natural selection has led grazing animals to develop both the ability to select the highest quality forage available to them at any one place and to seek out those places within a larger region where high quality forage can be found. Migrations tend to be closely associated with the locations of permanent water and recent precipitation because these factors are the major determinants of forage quantity and quality." Bamforth 1987 at 4–5.

Reducing migrants through over-killing and restricting range contributes to habitat loss, population declines, shortens the distances migrants can travel, can destroy mass migration, and drive the migratory species to extinction. Harris et al. 2009 at 68.

> An increasing threat to animal migrations is that of international veterinary policy. We identify 2 main issues, the first being veterinary cordon fences. Since the late 1950s, these have been erected in Southern Africa to separate livestock from wildlife populations. These fences block migration routes and have devastating effects on ungulate populations (Owens & Owens 1983, Williamson et al. 1988, Martin 2005, Mbaiwa & Mbaiwa 2006). Their purpose is to limit disease transfer from wild to domestic ungulates in order to meet the high standards of disease management put forward by beef-importing nations (Taylor & Martin 1987, Martin 2005, Mbaiwa & Mbaiwa 2006). Ironically, the transfer of exotic diseases from domestic to wild populations is an increasing threat, and migratory ungulates might be especially sensitive due to their gregarious behavior, as likely exemplified by Mongolian gazelle (Lhagvasuren & Milner-Gulland 1997, Nyamsuren et al. 2006). Despite any clear evidence that these fences effectively control disease outbreaks, there are rising concerns that this method will be copied elsewhere, and hence threaten other migrations (e.g. Mongolia; Nyamsuren et al. 2006). The second issue is culling to control disease transfer to

> domestic stock. This policy has reduced migratory populations in the past (Newmark 2008), and threatens existing migratory populations now (e.g. Mongolian gazelle; Nyamsuren et al. 2006). We recognize the needs to control the spread of potentially dangerous zoonotic diseases; however, we seek novel solutions that retain ecological processes, such as mass migrations.

Harris et al. 2009 at 72.

Despite the new National Forest planning rule requirement "to restore or maintain landscape connectivity to facilitate movement, migration, and dispersal" (Schultz et al. 2013 at 5), the Custer Gallatin has:

- permitted several barriers to thwart connectivity to bison's National Forest range and habitat;
- permitted the Montana Dept. of Livestock to set up and trap Central herd bison on their calving grounds for disease control;
- permitted cattle grazing allotments in bison's range and habitat; and
- agreed, in the name of disease control, to a Zone 3 boundary beyond which Yellowstone bison are excluded from substantial portions of their National Forest range and habitat, and killed for breaching the boundary.

In addition to State and federal managers enforcing a "boundary line beyond which bison will not be tolerated," erecting fences and other barriers in bison habitat to thwart migration, subjecting migrating bison to extensive trapping for slaughter operations for disease control threatens the phenomena of mass migration, truncates travel distances, and disrupts connectivity to habitat. Interagency Bison Management Plan Members 2022 at 2 (adopting exclusionary boundaries beyond which bison are killed).

For detailed evidence and analysis of the government permitting fencing and other barriers to thwart bison's migrations and regulatory mechanisms threatening or endangering Yellowstone bison's migrations, *see* factor 8.D.

> Eradicating migrations and relegating migrants to zoos or fenced parks represents one of the worst examples of destructive human impact. Their senseless destruction by a shortsighted few causes long-term losses in the natural spectacles for many. Humanity can and should advance society while maintaining such migrations.
>
> . . .
>
> Conserving mass migrants means preserving animals' freedom of movement in response to the temporal aspects of forage across seasonal extremes. This requires understanding basic parameters of the migration (e.g. location, numbers, routes, distances traveled), ecological drivers, habitat needs and threats. When migrants are excluded from forage and water resources, their numbers plummet and migrations disappear.

Harris et al. 2009 at 56, 72.

The "veterinary cordon fence" and boundary line for Yellowstone bison which is renewed annually, must be examined and investigated by the U.S. Fish & Wildlife Service as an enclosure and threat for bison adapting to variations in climate and fluctuating environmental conditions in the agency's threats assessment and status review.

***Yellowstone National Park's disease management actions threaten or endanger Yellowstone bison in the wild.***

Under disease management, the government is the leading source of population loss for Yellowstone bison.

The largest source of mortality and an ongoing threat for Yellowstone bison is Yellowstone National Park's disease management actions. White et al. 2011 at 1327 (Table 2), 1329 (Table 4); Autellet et al. 2015 at 90–91 (capturing bison for slaughter is "overwhelmingly" one of the "principal causes" of mortality).

Since 1991, the government has shot or trapped 7,104 bison for slaughter on the Northern range and 1,588 bison on the Western range in Yellowstone. Geremia 2022 at 7–8 (Table A3).

Despite ample authority provided by the U.S. Congress, the Organic Act and National Park Service regulations are ineffective in mitigating the threat of Yellowstone National Park's disease management actions as an artificial population sink for Yellowstone bison.

Disease management actions threatening bison roaming their range in the wild also harms the ecosystem bison engineer to benefit native species diversity.

Ostensibly, management actions directed at bison by Yellowstone National Park and the State of Montana are to prevent *Brucella abortus* from being transmitted to cattle. This foundational premise is belied by the "lack of any scientifically documented evidence of transmission from bison to cattle in the wild." Lancaster 2005 at 429 (citing National Research Council 1998); *see also* National Academy of Science's 2017 report indicating wild elk — not wild bison — are the source of brucellosis transmission risk to cattle grazing in the range of wildlife populations.

While managers claim their plan and actions have successfully prevented such an occurrence, bison in the wild have not transmitted any disease to cattle under various management practices — transfer into captivity, herding and roundups, ranching and hay-baiting, husbandry, preservation in a natural state, natural regulation, intensive culling, intrusive management, government hazing operations, trapping for slaughter, confinement in fenced paddocks — for over a century. Meagher 1973 at 29–32, 12; Geremia et al. Feb. 2011 at 1; White et al. 2011 at 1326–1328 (Tables 1–3).

The evidence demonstrates State and federal disease management actions have "differentially affected breeding herds," altered sex and age structures, disproportionately killed female and calf cohorts, and increased seroprevalence in bison according to Yellowstone National Park scientists:

- White et al. 2011 at 1322, 1326 (proportion of adult females testing positive increased; calves were vaccinated).
- White et al. 2011 at 1328 (large-scale disproportionate killing of females significantly reduced the Central herd; disproportionate killing of calf-mother pairs; perturbed male to female ratios with fewer males in the Northern herd and more males in the Central herd).

- White et al. 2011 at 1330 (skewing sex ratios to more males than females reduces bull over-winter survival rates and increases aggression and mortality during the rut).
- White et al. 2011 at 1331 (differential killing significantly reduced the Central herd's numbers and growth; nonrandom, large-scale killing "could have consequences that persist for multiple generations" in long-lived, age-structured bison subpopulations).
- Auttelet et al. 2015 at 146–147 (Table 10.1) (showing a decline in Central bison herd adults from 2,560 in 2002 to 880 in 2011 under current management).

The consequences of disease management actions for Yellowstone bison include loss of genetic variation, artificial intervention with mate choice and sexual selection, and reduced viability.

> Populations with skewed sex ratios have been shown to exhibit a greater reduction in genetic variation over time (Gross and Wang 2005), increased inbreeding (Harris et al. 2002, Peek et al. 2002), and more variable population survival (Komers and Curman 2000). In principle, skewing the sex ratio of populations may also affect mate choice and sexual selection, potentially altering the long-term evolutionary trajectory of populations (Clutton-Brock et al. 1997; Jirotkul 1999; Jiggins et al. 2000). . . . Managing a population to encourage a balanced sex ratio would limit the loss of genetic variation through drift by maintaining variation in both sexes (Gross and Wang 2005, Allendorf and Luikart 2007) and avoid a reduction in viability due to demographic stochasticity (Shaffer 1981; Brook et al. 1999). Age structure of a population can also impact genetic variation through its influence on the mean generation time. Since alleles are expected to be lost with each generation due to random sampling (i.e., genetic drift), a shorter mean generation time would result in a greater loss of genetic variation in a population over time.

Toldness 2014 at 2–3.

Unforeseen outcomes of managers trapping, testing (if done at all), and slaughtering bison was modeled years ago.

Among the harmful effects of subjecting Yellowstone bison to disease population control, model results showed "most seropositive animals in the population will be individuals infected within the previous year or two, and they therefore belong to the class of highly infectious animals most likely to shed *B. abortus* at birth or abortion. While the proportion of seropositive animals in the population will decline, the proportion of highly infectious animals in the population can actually rise." Gross et al. 2002 at 31–32.

Slaughtering large numbers of Yellowstone bison — 10 to 25% of the total population — would be ineffective in leading to the eradication of brucellosis but would "lead to major reductions" in population size. Gross et al. 2002 at 31.

Harms from disease management actions targeting Yellowstone bison occur over long time periods and "may not be detectable for decades (e.g., genetic diversity) and, as a result, unintended consequences may occur." White et al. 2011 at 1331.

> Due to risk management and other concerns, more than 3,600 bison were removed from the population during 2001 to 2010, with more than 1,000 bison and 1,700 bison being removed

> from the population during winters 2006 and 2008, respectively. These culls unintentionally removed more calf and female bison from the central breeding herd which, if continued over time, could result in alterations of the sex and age structure of the population and consequent changes in demographic processes that could persist for decades (White et al. 2011). Also, productivity in the northern breeding herd increased, resulting in record abundance in 2011, with higher proportions of females and calves in the herd.

Geremia et al. Sept. 2011 at 2.

The “unintentional” and “unintended” consequences of managing Yellowstone bison for disease control keeps the public in the dark because evidence is not being systematically examined for publication.

Instead of admitting apparent consequences of current management regimes, harmful effects to Yellowstone bison are concealed behind “would,” “could,” “might,” and “may,” words that are too often used in place of actual analysis of evidence.

Despite the increased risk of loss in herd variation, genetic diversity, and family lineages, managers carried out large-scale slaughters of Yellowstone bison during the winters of:

- 1997 >1,000 bison with 21% of the total population destroyed,
- 2006 >1,000 bison with 32% of the total population destroyed, and
- 2008 >1,700 bison with 37% of the total population destroyed.

Geremia et al. Feb. 2011 at 7; Geremia 2022 at 8 (Table A3).

> *In 2008, IBMP managers decided to implement moderated culls in an attempt to avoid large annual fluctuations in the bison population, which occurred during the early IBMP period and could threaten long-term preservation of Yellowstone bison, cause societal conflict, and reduce hunting opportunities outside the park.*

Geremia et al. 2014 at 1 (emphasis in the original).

“Removing less than 25% of the population reduces the chances of altering population age and sex composition and reducing genetic diversity.” Geremia 2020 at 3 (describing an objective to take fewer than 25% of the total population and less than 1,000 bison “when possible” in disease management actions).

Despite manager’s public assurances recurrent, large-scale government slaughters occurred again with >1,200 bison killed in 2016-2017 (23% of the total population) and >1,100 bison killed in 2017-2018 (24% of the total population). Geremia et al. Sept. 2018 at 1, 17.

In disregarding warnings by park scientists and biologists, managers continue to undertake disease management actions that are significantly transforming the subpopulation structure and constitution of Yellowstone bison’s population.

Recommendations by park scientists “to remove bison in proportion to their occurrence in the population,” do not represent actual year-to-year killing of bison in government management actions. "As a result, the 2018 population continued to move away from objectives for sex ratio and juvenile proportion." Geremia et al. Sept. 2018 at 8.

Government disease management actions and hunters killed 1,887 females compared to 1,264 males from the Yellowstone bison population during the winters of 2013–2018. Geremia et al. Sept. 2018 at 8 (Table 1).

During the winter of 2019–2020, government disease management actions "were biased to adult females" who comprised 68% of the adults trapped for slaughter in Yellowstone National Park. Geremia 2020 at 3 (For each adult male, nearly 2 adult females were trapped for slaughter from 2015–2020).

Managers now report "limited observations" of older-aged bison. Autellet et al. 2015 at 86.

Bison have evolved social and dominance relations around older-aged adults. The consequences of losing this vital age-structured demographic in Yellowstone's bison herds through disease management remains unknown because evidence is not being systematically gathered for publication.

"Long distance migrations by ungulate species often surpass the boundaries of preservation areas where conflicts with various publics lead to management actions that can threaten populations." Geremia et al. 2011 at 1 (ignoring disease management actions occur regardless of "conflicts" if any exist, which are generalized and lacking local context).

In disproportionately killing females, State and federal managers are not just artificially changing sex ratios among bison subpopulations but reducing the number of older-aged matriarchs who pass on knowledge of migration pathways to family groups, and increasing the number of bulls who must expend more energy in the rut to have a chance of passing on their genetics.

> Frequent large-scale, non-random culls could have unintended effects on the long-term conservation of bison, similar to demographic side effects detected in other ungulate populations around the world (Ginsberg and Milner-Gulland, 1994; Schaefer et al., 2001; Coulson et al., 2001; Raedeke et al., 2002; Nussey et al., 2006). For example, bison sent to slaughter from the west ($n = 556$) and north ($n = 2650$) boundaries during 2003–2008 were female-biased (1.8 females per male in 2003, 3.0 in 2004, 2.3 in 2005, 5.3 in 2006, and 1.2 in 2008) and likely contributed to changes in the gender ratio of bison greater than 1 year-old in the central herd from 1.7 ± 0.2 (standard deviation) females per male in 2003 to 0.9 ± 0.2 female per male in 2009 (Fig. 3).

White et al. 2011 at 1330.

State and federal disease management actions are also changing bison subpopulation sex ratios.

"Males were overrepresented more so in the central herd with 149 males per 100 females (5-year average of 153:100) compared to 114 males per 100 females in the northern herd (5-year average 97:100)." Geremia 2020 at 4.

In the Central herd there are 1.53 males for each female and males comprise 61% of the subpopulation.

Geremia et al. Sept. 2018 at 5.

> Skewing bison sex ratios in favor of males could increase mate competition among males and result in higher levels of aggression and mortality during the breeding season. Also, over-winter survival is usually lower in males than females in large sexually dimorphic species such as bison due to the expenditure of resources during the rut (Clutton-Brock et al., 1982). For male Yellowstone bison, internal resources depleted during the autumn rut cannot be replenished until new forage is produced in the spring. Thus, management actions that skew the sex ratio in favor of males may further reduce male over-winter survival by increasing the intensity of competitive interactions during the breeding season.

White et al. 2011 at 1330.

Large-scale government slaughters also "contributed to a substantial reduction in juvenile cohorts when captured bison were not tested for brucellosis exposure before being removed from the population." White et al. 2011 at 1330.

In addition, large-scale government slaughter of females "apparently reduced the productivity of the central herd, which decreased from between 0.71 and 0.75 ± 0.01 juvenile (calves and yearlings) per female greater than 2 years-old during 2004–2007 to 0.49 ± 0.10 in 2008 and 0.63 ± 0.01 in 2009." White et al. 2011 at 1331.

Excessive and disproportionate killing of bison from the Central herd "lowered the actual (including culls) growth rate of the herd . . ." White et al. 2011 at 1331.

> The expected long-term effect of continued, sporadic, largescale culls is a slower-growing bison population with large fluctuations in abundance. Removing juvenile cohorts creates gaps in the population age structure, while removing young adult females that contribute the most to population productivity could reduce the resiliency of Yellowstone bison to quickly recover from reductions. Also, the large-scale culling of Yellowstone bison could have consequences that persist for multiple generations after culling has ceased. In long-lived, age-structured populations such as bison, a rapid increase in population density after release from culling can lead to a sequence of changes in age-specific fecundity and survival that affect fluctuations in population size for many years (Eberhardt, 2002). For example, different vital rates responded to increased density at different rates in red deer, causing long-term changes to the demographic structure of the population that persisted for decades (Coulson et al., 2004). Thus, sporadic, nonrandom, large-scale culls of bison have the potential to maintain population instability (i.e., large fluctuations) by altering age structure and increasing the variability of associated vital rates. Long-term bison conservation would likely benefit from management practices that maintain more population stability and productivity.

White et al. 2011 at 1331.

Disease management actions driving the loss of bison genetic diversity and harmful changes in population structure remains an unknown because State and federal managers are not systematically examining evidence for publication.

The failure to study actual effects of frequent, recurrent, large-scale, non-random government slaughter of Yellowstone bison is a serious defect in State and federal management because disease management actions are disproportionately harming the genetically distinct subpopulation in the Central herd, and changing the demographics, age structure and constitution of Yellowstone's bison population.

In the absence of a critical examination of manager's assumptions and actions, proceeding to manage for a single population without regard for subpopulations is a danger to Yellowstone bison.

The faulty premise of managing for a single population without regard for bison subpopulation or herd distinction was not based on the best evidence available to State and federal managers decades ago.

> The management alternatives I modeled were developed by the management agencies after consultation with stakeholders.
>
> . . .
>
> However, modeling the management alternatives required estimates of this and similar rates, and although "the best available" data were used, in some cases the "best available" data left much to be desired.

Angliss 2003 at 65, 66.

Funded in part by Yellowstone National Park, objectives for Angliss' study included determining "the relative outcomes of the bison management plans," identifying "any implications of having two discrete bison populations within" the Yellowstone bison population, and predicting "likely outcomes of different management alternatives" for the State of Montana's and Yellowstone National Park's plan for managing bison for disease. Angliss 2003 at i, 2.

> Recent information from tagged bison (Gogan pers comm 2002) indicates that little or no migration of animals occurs between Central and Northern Range herds. Thus, management actions in one area may have a disproportional affect on one bison group. To investigate the impacts of removing this movement, I eliminated the migration between areas in the model for the new preferred alternative, and looked at the change in the average minimum number of bison in the population in any one year. When migration was included in the new preferred alternative, the average population in the Central and Northern Range wintering areas was 2356 and 968, respectively (averaged over 18 years for 10 model runs). When the low net migration rate from Central to Northern was eliminated, the average estimated population size was 2588 and 883, respectively, which indicates a slight increase for the Central group and a slight decrease for the Northern Range group relative to the results when the model included migration between areas. Clearly, whether there are two separate herds of bison in YNP should be investigated further, as the impacts of management actions on separate, smaller bison groups, will likely be different than the impacts of management on a population of 3500.

Angliss 2003 at 60.

The plan developed and adopted by the State of Montana and Yellowstone National Park in 2000 "generally assumes that any culling . . . will be genetically random and therefore have no real impact on the genetic constitution of the [Yellowstone] bison population. These assumptions, however, are largely untested." Halbert 2003 at 131.

Halbert's investigation of subpopulation structure and non-random government slaughter demonstrated results indicating "some level of population subdivision" in the Yellowstone bison population. Halbert 2003 at 146, 147 (finding "sufficient evidence to exclude the possibility of a single, admixed bison population").

Despite Halbert's and Angliss's studies, and even more recent science demonstrating strong evidence of genetically distinct subpopulations, managers have not adopted any change to mitigate the harmful effects of disease management actions on each individual herd and the Yellowstone bison population as a whole.

> The caveat, however, is that caution must be practiced in the management of populations with substructure to ensure the maintenance of both subpopulation and total population variation. The [Yellowstone] bison population has not previously been managed with this consideration in mind. For example, 1,084 bison were removed from YNP in the winter of 1996 – 97, representing a 31.5% decrease in total population size. Even more troubling, however, is the inequality in the reductions across the Northern and Central herds. While the Northern herd suffered a loss of approximately 83.9% (726/825), the Central herd was reduced by only around 13.9% (358/2,571; Peter Gogan pers. comm.). If in fact the Yellowstone bison population is represented by 2 or 3 different subpopulations, disproportionate removals of bison from various subpopulations might have detrimental long-term genetic consequences.

Halbert 2003 at 148–149.

In addition to significant and disproportionate loss of Yellowstone bison subpopulations, government trapping for slaughter is also taking a "disconcerting" number of family lineages (generational parent-offspring).

"Although a disconcerting number of parent-offspring pairs and family groups were found in this study, providing evidence of nonrandom culling within the YNP bison population, the magnitude and long-term genetic and demographic effects of this type of nonrandom culling are unknown." Halbert 2003 at 151–152.

PHOTO: BFC Archives

"Even random culling of bison will weaken natural selection. Random removal of animals treats the most fit and least fit bison equally, whereas natural selection would favor survival and reproduction of bison most suited for wild conditions." Bailey 2013 at 142.

In a study of strategies to avoid accumulation of inbreeding and retain genetic variation in bison conservation herds, the random "culling strategy yielded the greatest reduction in allelic richness and heterozygosity at target loci (decrease of 44% and 35%, respectively) and allelic richness at non-target loci (decrease of 45%; Fig. 1). Gene diversity was reduced by 36% and inbreeding increased to 0.360 under the Random strategy (Table S1, Fig. 1)." Giglio et al. 2018 at 770.

"The Random strategy resulted in the lowest retention of allelic richness and heterozygosity at the target (decrease of 56% and 32%, respectively) and non-target loci (decrease of 58% and 35%, respectively; Fig. 2)." Giglio et al. 2018 at 771.

> [O]ne noteworthy question stands out among the rest: is the *Bison bison* species a conservation success story? An answer of "no" might be supported by the facts that bison are found only in fragmented populations maintained through human influence, that many of the federally protected populations contain remnants of domestic cattle introgression, and that disease and potentially damaging culling practices are prevalent in one of the few populations with high levels of genetic variation and no evidence of domestic cattle introgression (YNP).

Halbert 2003 at 156.

Managers are continuing to ignore or reject the best available science on the distinct and unique structure of the Yellowstone bison population.

The U.S. Fish & Wildlife Service must examine and investigate how State and federal disease management actions threaten bison subpopulation structure, genetically distinct subpopulations, and retention of family lineages and genetic variation in Yellowstone bison in the agency's threats assessment and status review.

***Disease management is a threat to Yellowstone bison's genetically distinct subpopulations.***

In 2012, scientists discovered strong evidence of two "genetically distinct and clearly defined subpopulations" in the Yellowstone bison population "based on both genotypic diversity and allelic distributions."

> [A] comparison of the cluster assignments to the 2 principle winter cull sites revealed critical differences in migration patterns across years.
>
> Genetic isolation among subpopulations affects many demographic and evolutionary processes. . . The recognition of population substructure is fundamental to the identification of management units and an important consideration for wildlife conservation.

Halbert et al. 2012 at 360 (the study investigated "genetic substructure" within the Yellowstone bison population "which is among the most critical to bison conservation.").

Halbert's evidence of genetically distinct subpopulations is based on a STRUCTURE analysis using 46 nuclear microsatellites from 661 Yellowstone bison sampled from 1997–2003. Halbert et al. 2012 at 362.

"Analyses of both tooth wear patterns (Christianson et al. 2005) and parturition timing and synchrony (Gogan et al. 2005) have demonstrated significant differences between northern and central range bison, which are expected only when bison remain isolated for much of their lives." Halbert et al. 2012 at 367.

> Bison that live in the central and northern regions of Yellowstone have significantly different distributions of alleles and genotypes, and are genetically distinguishable based on 20 alleles only found in one of the two regions (14 central; 6 northern; Halbert et al. 2012).

Auttelet et al. 2015 at 123.

Scientific evidence finding significant herd distinctions in the Yellowstone bison population include:

- Different tooth wear patterns (Christianson et al. 2005 at 674).
- Different parturition timing and synchrony (Gogan et al. 2005 at 1716).
- Longitudinal differences in migration patterns (Halbert 2012 et al. at 368).
- Differential migration at the herd scale (Geremia et al. 2011 at 6).
- Spatial separation between herds (Olexa & Gogan 2007 at 1536).
- Differences in diet (Birini & Badgley 2017 at 6–7).
- Differences in plant communities, diet, and environmental conditions (Fuller et al. 2007 at 1925).
- Fidelity to breeding territories and female philopatry to natal ranges (Gardipee 2007 at 10, 31–32).
- Detection of strong substructure in mitochondrial DNA (Gardipee et al. 2008).

Furthermore, the ecological settings for the Central and Northern herds are distinct, reflecting the geographic, genetic, and life history variation found in the Yellowstone bison population.

> Ecological conditions differ between the Northern and Central ranges in Yellowstone National Park (Chapter 3), making it necessary to consider population and distribution trends of Northern and Central bison subpopulations separately. Two previous analyses have considered YNP bison as if they were one population (Cheville et al. 1998, Klein et al. 2002). Lumping population subunits ignores important gradients in environmental conditions between YNP bison ranges that differentially influence reproduction and survival, and spatial ecology of bison, elk and their predators.

Gates et al. 2005 at 113.

> Ecological conditions are markedly different on the Northern and Central bison ranges requiring separate consideration of population and trophic ecology. On the Northern Range, reduced snow cover in the grassland habitat of the Gardiner basin provides refuge habitat for bison during harsh winters. In contrast, there is no range-wide gradient in snow conditions on the Central Range. Rather, geothermally-influenced areas provide refuge for a significant part of the Central subpopulation in harsh winters.

Gates et al. 2005 at 127.

> At the present time, there remain two relatively separate subpopulations, one on the Northern Range and the other on the Central Range. Some exchange has occurred since the

> 1920s via the Mirror Plateau. In recent years, there have been major migrations from the Central Range to Gardiner basin via the road allowance between Madison Junction and Swan Lake Flats. The Gibbon Canyon may not be navigable by bison in the absence of snow grooming.

Gates et al. 2005 at 128.

Halbert's (2012) finding corroborates earlier findings by Olexa & Gogan (2007) who identified 2 subpopulations: the Northern and Central bison herds, and Meagher's (1973) earlier finding of 3 subpopulations.

> We identified 2 groups, the northern and central herds, during winter. Minimal exchange of individuals occurred between these groups. The spatial distribution of cross-classified relocations showed that exchange during this period continued to occur almost entirely in the upper Pelican Creek and Mirror Plateau areas of YNP.
>
> . . .
>
> We found consistent agreement among fusion strategies in classifying radiomarked bison into 2 subpopulations with no cross-classification during the rut. Exchange was greatest during the winter management period, and was intermediate during the extended rut. These patterns indicate that bison exhibit high fidelity to a specific range during the rut and lower fidelity in winter. In addition to the spatial separation exhibited by Yellowstone bison, limited exchange of individuals may result in genetic or demographic disjunction. When we assume the rut occurs between 15 July and 15 September, distinct northern and central herds with no exchange are most pronounced. Thus, these 2 groups may function as separate populations. Exchange rates were low during the extended rut. We documented the exchange of only 4 of 87 bison during the extended rut in 1998. Three of the 4 returned to their original group before the end of that year's extended rut. We were unable to determine the subsequent movements of the fourth bison. We did not detect similar movements by the 65 bison radiotracked during the extended rut in 1999. The extent of genetic exchange between subpopulations cannot be determined without knowing when and where individual bison breed. If bison breed in multiple disjunct groups during a single breeding season, then a single population would exist. However, even if individuals breed in multiple groups, a metapopulation would exist as long as breeding occurs in only one group per breeding season (Wells and Richmond 1995). Such a pattern has implications for conservation genetics.
>
> An analysis of the genetics of Yellowstone bison slaughtered as they left the park in the vicinity of Gardiner, Montana, or West Yellowstone, Montana, between the winters of 1996–1997 and 2001–2002 (P. J. P. Gogan, unpublished data) revealed a genotypic differentiation >75% between bison at the 2 locations (Halbert 2003). Such differences imply long-term separation during the rut.
>
> . . .
>
> The influence of Yellowstone bison population size on the dynamics of spatial population

> structure is not well understood. We documented 2 subpopulations during a period when Yellowstone bison numbered approximately 2,500. Meagher (1973) identified 3 subpopulations during a period when bison numbered <600. Winter movements of bison from the Norris Geyser Basin area to the Swan Lake Flats area were observed prior to our study during the winter of 1996–1997, when the central herd numbered approximately 2,900 and the northern herd approximately 875 (Taper et al. 2000), and during the winters 2002–2003 and 2003–2004 when total numbers were approximately 4,000 (R. Wallen, National Park Service, personal communication). However, there has been no assessment of spatial population structure at these higher numbers.

Olexa & Gogan 2007 at 1536 (finding the Central and Northern herds may function as separate populations).

"It is not clear at this point how the subpopulations may be changing over time or how the current bison management plan (US Department of Interior and US Department of Agriculture 2000) might influence the genetic integrity of the subpopulations." Halbert et al. 2012 at 368.

> It is highly likely, therefore, that the 2 subpopulations have been disproportionately culled in some years. For example, approximately 735 bison were culled near Gardiner at the park's northern boundary during the 1996–1997 winter. Applying our estimate that around 68% of the bison culled near Gardiner that year originated from the Northern subpopulation (Figure 3A), we calculate that approximately 500 of the bison culled during the 1996–1997 winter were from the Northern subpopulation. Given the prewinter estimate for the Northern subpopulation of 877 bison (US Department of Interior and US Department of Agriculture 2000; Gates et al. 2005), the 500 culled bison represent approximately 57% of the entire subpopulation.

Halbert et al. 2012 at 368.

Over a decade later, State and federal managers have not recognized the best available science and have failed to heed the warnings that government management actions are permanently harming the genetic diversity and constitution of Yellowstone's bison population.

The scientific evidence of distinct and unique herds in the Yellowstone bison population is not new information; managers have been aware of the mounting body of evidence of subpopulation structure and distinction long enough to make an adaptive management change and have failed to do so. Yellowstone National Park Aug. 7, 2008 ("New science indicates there may be 2-3 genetic subdivisions within the overall bison population."); Yellowstone National Park Nov. 5, 2008 ("New science characterizes Yellowstone bison as a single population with two genetically distinguishable breeding groups or subpopulations, and that 1,000-2,000 bison in each of the central and northern breeding herds are adequate to retain 90-95% of genetic diversity to enable bison to adapt to a changing environment through natural selection, drift, and mutation.").

The record demonstrates managers have repeatedly failed to reconsider management practices using the best available science.

In not examining and investigating the long-term detrimental consequences of disease control, managers are jeopardizing the genetic diversity of distinct and unique bison herds in the Yellowstone population.

> [T]he identification of genetic subpopulations in this study raises serious concerns for the management and long-term conservation of Yellowstone bison.
>
> . . .
>
> In conclusion, we have presented strong evidence for the existence of 2 genetically distinct subpopulations of bison . . . Our study has also revealed longitudinal differences in migration patterns among Yellowstone bison, as it appears that bison moving to the park boundary in the vicinity of West Yellowstone are consistently from the Central subpopulation, whereas those moving to the park boundary in the vicinity of Gardiner may originate from either the Central or Northern subpopulation. These observations warrant serious reconsideration of current management practices. The continued practice of culling bison without regard to possible subpopulation structure has the potentially negative long-term consequences of reducing genetic diversity and permanently changing the genetic constitution within subpopulations and across the Yellowstone metapopulation. Population subdivision is a critically important force for maintaining genetic diversity and yet has been assessed in only a handful of species to date. The identification of cryptic population subdivision of the magnitude identified in this study exemplifies the importance of genetic studies in the management of wildlife species.

Halbert et al. 2012 at 368.

White & Wallen's rebuttal contained no new data to refute Halbert's findings of distinct subpopulation structure in the Yellowstone bison population. Instead, Yellowstone National Park scientists say any distinction is a result "likely created or exacerbated by human actions." White & Wallen 2012 at 753.

Managers continue to deny acknowledging the best available science and evidence of subpopulation structure because doing so would require significant and fundamental changes in management and reevaluation of the State and federal manager's flawed plan.

In 2016, scientists assessed mitochondrial haplotypes and "did not detect geographic population subdivision. . . However, we identified two independent and historically important lineages in Yellowstone bison" representing the descendants of the indigenous bison remaining in the Central herd, and reintroduced bison in the Northern herd. Forgacs et al. 2016 at 1. "The reason for the difference in the findings could be due to differences in the structure and function of the genomic regions analyzed, the differences in mutation rates, and the sensitivities of the statistical tests used." Forgacs 2016 at 5.

The objective of Forgacs's research was to determine if the distinct population segment of Yellowstone bison carried an hypothesized, detrimental mitochondrial DNA and to investigate haplotype diversity. Forgacs et al. 2016 at 2.

While Forgacs found mutations in the Northern bison herd and not in the Central bison herd, the scientists did not find evidence the mutations were harmful due to "the lack of any kind of reported lesion or disease" affecting "a large proportion of Yellowstone bison." What they did find was significant: ten unique haplotypes from 25 Yellowstone bison sampled representing "nearly half—10 of 22 modern plains bison haplotypes—of all the known haplotypes in plains bison . . ." Forgacs et al. 2016 at 6.

“Before new management standards and policies are defined for the Yellowstone bison population, additional studies involving population structure and genetic diversity based on both mtDNA and nuclear genetic diversity assessments need to be conducted.” Forgacs et al. 2016 at 7.

No such studies have appeared in publication, and no new standards or policies for preserving Yellowstone bison’s population structure and genetic diversity have been developed using the best available science.

The U.S. Fish & Wildlife Service must examine and investigate how disease management threatens Yellowstone bison’s genetically distinct subpopulation structure and the population’s genetic variation in the agency’s threats assessment and status review.

***State and federal disease management actions threaten genetic variation, disease resistance, and evolutionary adaptation of Yellowstone bison in the wild.***

Managers know Yellowstone National Park’s trapping for slaughter program is taking recovered and disease resistant bison from the population. Because data is not being systematically examined for publication the rate and extent of loss of disease resistant and recovered Yellowstone bison is unknown.

> Removing brucellosis-infected bison is expected to reduce the level of population infection, but test and slaughter practices may instead be removing mainly recovered bison. Recovered animals could provide protection to the overall population through the effect of population immunity (resistance), thereby reducing the spread of disease. Identifying recovered bison is difficult because serologic tests (i.e., blood tests) detect the presence of antibodies, indicating exposure, but cannot distinguish active from inactive infection.

Yellowstone National Park 2014 at 236–237.

“Studies indicated many older bison testing positive for brucellosis exposure were no longer infectious and may have some resistance to the disease if reexposed.” Auttelet et al. 2015 at 144.

Such admissions demonstrate manager’s disease management practices undercut Yellowstone bison’s natural resistance and adaptation to *Brucella abortus* introduced by cattle.

In addition to managers not systematically examining data on the rate and extent of loss in disease resistance among bison taken in disease management actions, there has also been no recent study or scientific investigation of bison’s natural resistance to disease organisms such as brucellosis.

One study implies disease management altered the genetic composition and natural resistance to *Brucella abortus* in several bison populations:

> It is possible that test-and-slaughter management in both the Wind Cave NP and Henry Mountains bison populations, and the seronegative founder event establishing the Castle Rock population, effectively altered the genetic composition of these herds with respect to genes involved in natural resistance to brucellosis.

Seabury et al. 2005 at 108, 104 (finding evidence of “natural resistance of bison to brucellosis infection”).

> Meyer (1992) noted greater resistance of wild bison to *Brucella abortus*, causative agent of brucellosis, compared to resistance in domestic cattle. Seabury et al. (2005) detected evidence of a genetic basis for this resistance in Yellowstone bison. Either the resistance of bison to *Brucella* is a case of "preadaptation" or some resistance and accommodation evolved during about 10 generations of bison since first exposure of the Yellowstone herd.

Bailey 2013 at 149 n. 12.

Artificially selecting against a non-native disease has implications for the ability of Yellowstone bison to naturally resist disease. *See* PhD wildlife biologist James A. Bailey's comments for a Brucellosis Remote Vaccination Program for Bison in Yellowstone National Park (July 4, 2010).

"There is already evidence of Yellowstone bison having resistance to *Brucella* infection." Bailey 2010 at 2 (citing Derr et al. 2002, Yellowstone National Park's Draft Environmental Impact Statement 2010 at 155, and Seabury et al. 2005).

> Vaccination will interfere with natural selection for resistance . . . Bison already exhibiting resistance to *Brucella* will be less favored by selection and overall resistance to *Brucella* in the bison herd could decline.

Bailey 2010 at 3.

Intensive disease management and the extensive use of artificial selection pressures on Yellowstone bison is in conflict with National Park Service management policies allowing for natural selection and evolutionary processes using the best available science.

> The Service recognizes that natural processes and species are evolving, and the Service will allow this evolution to continue—minimally influenced by human actions.
>
> . . .
>
> [The Service's policies and directives require] natural resources, processes, systems, and values . . . [be preserved in a] natural condition . . . [which] would occur in the absence of human dominance over the landscape.
>
> . . .
>
> [General management concepts require the National Park Service] to maintain all the components and processes of naturally evolving park ecosystems, including the natural abundance, diversity, and genetic and ecological integrity of the plant and animal species native to those ecosystems.

National Park Service 2006 at 36.

Despite the policy directives and mandates, Yellowstone National Park's use of veterinary management is a dominating selection pressure interfering with Yellowstone bison's natural adaptation and resistance to diseases.

Furthermore, vaccinating bison against a non-native disease may give rise to more virulent and persistent diseases bison must cope with to survive in the wild under natural selection processes.

Vaccination poses an unacceptable risk to the nation's last wild population of migratory bison continuously roaming their indigenous range because vaccinating trapped bison is based on "uncertainty" and "incomplete and unavailable" science:

> • "many of the current diagnostic tools have been extrapolated from livestock for use in wildlife without rigorous evaluation . . ." (at 72);
> • "We are not aware of any available test that conclusively or reliably detects active infection of *Brucella abortus* in live bison." (at 73);
> • "Davis and Elzer (1999, 2002) concluded that SRB51 had little efficacy in adult and calf bison despite repeated vaccinations." (at 74).

Yellowstone National Park 2010 at 72–78 (discussing reasonably foreseeable significant adverse impacts from vaccinating bison).

Vaccination is not for the benefit of the Yellowstone bison population; it is for the perceived benefit to cattle and intended to appease State and federal livestock and veterinary agencies. *See* Interagency Bison Management Plan Partner Agencies 2008 at 6 ("Continue bison vaccination under prevailing authority."), ("vaccinate and release eligible bison (i.e., calves, yearlings, non-pregnant females) captured near the boundary") (reiterating vaccinating bison is not as part of adaptive management).


PHOTO: Jim Peaco

Vaccinating trapped bison intended for release from captivity continues despite the risks to bison. According to Yellowstone National Park, vaccinating bison can change the disease pathogen:

> [U]sing less effective vaccines or delivering the vaccine to a relatively small proportion of the eligible animals can lead to adaptive changes in the disease pathogen that select for variants able to evade the immunological response induced by the vaccine. These vaccine-adapted variants can then spread in the population, reduce the efficiency of the vaccination program, and result in longer-term evolutionary changes in the host-pathogen association.

Yellowstone National Park 2010 at 73.

Additionally, Yellowstone National Park managers know the dangers of vaccination and the potential of disease management actions to increase transmission of more virulent and persistent forms of the pathogen with all the resulting risk to bison:

> These aspects of SRB51 and the life history of *B. abortus* may provide a selective advantage for bacteria whereby SRB51 vaccination becomes ineffective leading to an increase in transmission potential, stronger persistence within the bison host, and greater pathogenicity (i.e., virulence or degree of intensity of the disease produced by a pathogen). This potential adaptation of *B. abortus* to SRB51 could be exacerbated if delivery via remote vaccination is hampered due to logistics or bison behavior and only a relatively small proportion of the eligible females are vaccinated.

Yellowstone National Park 2010 at 73.

Despite knowing the risks of vaccinating bison with SRB51 could lead to increased levels of transmission and more virulent forms and stronger persistence of *Brucella abortus* in bison, managers continue to reflexively vaccinate trapped bison intended for release from captivity.

Knowing the risks and the lack of any measurable benefits to the bison population in the wild, managers continue to disregard their own warnings of the dangers of vaccinating bison. The precautionary principle dictates decision makers must exercise caution and take preventive action if scientific knowledge is lacking or uncertain. But the science is not lacking, and the cautionary warnings must be heeded before vaccination proves disastrous for bison.

Far less intrusive cattle management policies are available to the U.S. Dept. of Agriculture Animal and Plant Health Inspection Service and the States to manage specific and identifiable risks in the Designated Surveillance Areas of Montana, Idaho, and Wyoming.

Instead of working with bison who have adapted to *Brucella abortus* for over 100 years, State and federal disease management actions threaten to undercut Yellowstone bison's ability to naturally evolve resistance to a disease introduced by cattle. The U.S. Fish & Wildlife Service must examine and investigate this government-driven threat in the agency's threats assessment and status review.

***The State of Montana's and Yellowstone National Park's bison management plan is not based on the best available science.***

There is ample evidence the State of Montana's and Yellowstone National Park's bison management plan assumptions are flawed, and disease management actions are changing sex ratios, distorting age structure, disproportionately harming subpopulation or breeding groups, changing population genetics, and contributing to other detrimental effects as yet undiscovered.

While the record evidence demonstrates State and federal disease management is a threat to migratory bison, managers have not adopted changes to ameliorate the detrimental and harmful consequences to the wild species resulting from disease management actions.

Furthermore, on-going systematic government actions directed at killing and confining the migratory species has profoundly disrupted the adaptive and ecological roles bison fulfill in the Yellowstone ecosystem.

"[E]cological processes play out over many decades so management actions cannot be fully comprehended at shorter time scales." Gates et al. 2005 at vi.

In theory, the State of Montana's and Yellowstone National Park's bison management plan is an adaptive one based on science. In practice, it is not.

A 2008 memorandum acknowledged the government's "haze-back" dates of bison on their calving grounds on National Forest range and habitat could be adjusted based on the best science available. But the record is devoid of any adaptive management change incorporating the results of a *Brucella abortus* study (Aune et al. 2010 and several other studies) that would provide relief to females and their newborn calves from government harassment, also known as, "hazing" operations. Yellowstone National Park Aug. 28, 2008 ("The plan indicates that haze back dates toward temporal and spatial separation may be modified by the Montana State Veterinarian, or joint agreement of the agencies if the persistence and viability research indicates the dates can be adjusted.").

Notwithstanding changed circumstances, such as establishment of Designated Surveillance Areas for cattle, an evaluation of adaptive management adjustments made in 2011 were not significant enough to warrant supplementing a decade old environmental impact statement. Federal and State Interagency Bison Management Plan Agencies 2011 (the proposed adjustments were within the range of the alternatives analyzed in 2000).

Adaptive management adjustments made in 2016 also failed to adopt new science on Yellowstone bison genetics, such as strong evidence of genetically distinct populations found by Halbert et al. 2012. Bischke 2016 ("Define genetic diversity and integrity, and establish long-term objectives for conserving genetic integrity, including assessing hunting and risk management removal strategies that are compatible with conservation of genetic diversity.").

Simply repeating a management metric and response on Yellowstone bison genetics without any substantive review of the best available science is not adaptive management.

According to the U.S. Government Accountability Office, State and federal manager's decisions for Yellowstone bison:

- Lack "accountability and transparency, more often resembling trial and error or crisis management, rather than adaptive management."
- In a three tiered-step plan, managers lack "linkages" to get to the next steps, and have "lost opportunities to collect data" to resolve "important uncertainties" in the absence of a scientific and systematic monitoring plan.
- "Park Service, APHIS, and Montana Department of Livestock officials also told us that they are not testing any hypotheses or the assumptions on which the plan is based."
- Furthermore, managers "have no process to collectively review new scientific information …" These flaws have impaired manager's decisions who do not share defined and measureable objectives.
- "Meanwhile, the federal government continues to spend millions of dollars on uncoordinated management and research efforts, with no means to ensure that these efforts are focused on a common outcome that could help resolve the controversies."

U.S. GAO 2008 at 24, 28, 33.

The flaws in "adaptive management" continue a decade after the Government Accountability Office issued its' report to the U.S. Congress because, to a "large degree," State and federal managers:

> • no longer build their meetings, interactions, and decisions around their AM [Annual Management] Plan;
> • no longer measure their performance against the metrics put forth in their AM Plan (including no longer building their Annual Report on measuring their performance against metrics set forth in the AM Plan);
> • no longer rigorously follow the Partner responsibility matrix declared under each Management Action described in the AM Plan (and also in the Partner Protocols); and
> • no longer use adaptive changes to their AM Plan to drive changes in their Winter Ops Plan.

Bischke 2017 at 1.

PHOTO: BFC Archives

National Park Service management policies require Yellowstone National Park to "use scientifically valid resource information obtained through consultation with technical experts, literature review, inventory, monitoring, or research to evaluate the identified need for population management." National Park Service 2006 at 44.

Time and again, State and federal managers have ignored briefings by scientists and biologists and failed to incorporate crucial information necessary for informed decision-making.

For example, the State of Montana and Yellowstone National Park continue to impose "haze-back" deadlines and repeatedly harass bison on spring calving grounds when no cattle are present and environmental conditions eliminate any risk by mid-June.

> Evidence from these studies indicates that after May 15 (bison haze-back date in the IBMP), natural environmental conditions and scavenging conspire to rapidly kill or remove brucella from the environment.

Aune et al. 2010 at 25.

> Brucellosis transmission risk from bison to cattle is extremely low after June 1 and negligible

> by June 15 because (1) parturition is essentially completed for the year, (2) parturition events rarely occur in areas that will later be occupied by cattle, (3) cattle are generally not released on summer ranges until after mid-June, (4) females meticulously consume birthing tissues, (5) ultraviolet light and heat degrade *Brucella* on tissues, vegetation, and soil, (6) scavengers remove fetuses and remaining birth tissues, and (7) management maintains separation between bison and cattle (Aune et al. 2007, Jones et al. 2009).
>
> Allowing bison to remain on essential winter ranges outside Yellowstone National Park until late-May or early June, when they typically begin migrating back into the park to high-elevation summer ranges, is unlikely to significantly increase the risk of brucellosis transmission from bison to cattle.

Yellowstone National Park 2009.

> Allowing bison to occupy public lands outside the Park through their calving season will help conserve bison migratory behavior and reduce stress on pregnant females and their newborn calves, while still minimizing the risk of brucellosis transmission to cattle.

Jones et al. 2010 at 333.

Whatever quantifiable risk exists is localized, "predominantly low," "zero under all scenarios," and can be addressed by managing cattle at a significantly reduced cost to the American people while recovering bison in the wild. Kilpatrick et al. 2009 at 1, 8.

Kilpatrick's study was the first to quantitatively calculate the relative risk across 40,385 hectares (99,793 acres) grazing 266 head of cattle in four herds during winter, grazing 1,441 head of cattle in eighteen herds during spring under the current management plan, and three "no plan" management scenarios. Kilpatrick et al. 2009 at 3, *see also* Table 1 at 4, and Figure 2 at 7.

State and federal managers spend approximately $2,500,000 annually to implement its' plan whereas yearly testing for cattle is a thousand-fold lower. Kilpatrick et al. 2009 at 1, 8.

Published in 2012, a belated risk assessment of brucellosis transmission among bison, elk, and cattle in the Northern range of the Greater Yellowstone bioregion found the exposure risk from bison to cattle was miniscule 0.0–0.3% compared to elk to cattle 99.7–100% of the total risk. Yellowstone Center for Resources 2012 at 40; *see also* Schumacker 2010 at ix ("Transmission risks to elk from elk in other populations or from bison were very small. Minimal opportunity exists for *B. abortus* transmission from bison to elk under current natural conditions in the northern GYA.").

Yet elk freely roam Montana while government hazing or harassment of bison continues to be repeated inducing stress and depriving bison of nutrition during the calving season.

State and federal managers also refuse to consider and accommodate, through an adaptive management change, the biological impetus driving bison's natural migrations from spring to summer ranges.

At present, all bison rutting territories are found in the interior of Yellowstone National Park.

The best available science indicates bison have a strong or high fidelity to rutting territories and female philopatry to natal ranges. Olexa & Gogan 2007 at 1536; Gardipee 2008 at 31–32.

Scientists have noted bison migrations to summer ranges follow the green up of grasses along an elevational gradient. Frank et al. 1998 at 516; Frank & McNaughton 1992 at 2053–2054.

Yet managers have not made an adaptive change accommodating the biological impetus for migration to summer range and continue to harass bison from spring calving grounds.

It is unconscionable for managers to willfully ignore adopting the best available science and inflict harm, stress, and injury upon bison on their spring calving grounds in government-led management actions.

The creation of an artificial bison population sink in Yellowstone National Park and the resulting loss of range is in contradiction with the fundamental purposes of the park "to conserve the scenery and the natural and historic objects and the wild life therein." Ross 2013 at 68 (citing the 1916 Organic Act).

The U.S. Congress has mandated Yellowstone National Park conserve and leave bison "unimpaired for the enjoyment of future generations." Ross 2013 at 68 (citing the 1916 Organic Act).

"The Secretary has an absolute duty, which is not to be compromised, to fulfill the mandate of the 1916 Act to take whatever actions and seek whatever relief as will safeguard the units of the national park system." National Park Service 2006 at 10 (citing the Senate committee's report in passing the Redwood Amendment to the General Authorities Act).

PHOTO: BFC Archives

Yellowstone National Park has compromised its' duty to not impair wild bison in deference to the unreasonable and arbitrary regulatory scheme imposed by the State of Montana.

Yellowstone National Park's trapping of the bison population for slaughter and resulting loss of range contradicts its' public trust duty to caretake bison "for the benefit and inspiration of the people of the United States" and in "common benefit of all the people of the United States." Ross 2013 at 68 (citing the General Authorities Act of 1970), at 69 (citing the 1978 Redwood Amendment of the General Authorities Act).

In departing from and neglecting the best available science, the State of Montana and Yellowstone National Park are increasing the risk of extinction for bison — at great cost to bison and other native species in the ecosystem that depend upon them for survival and reproduction.

Clearly, "[t]he current power structure has led to cattle being protected at the expense of bison." Lancaster 2005 at 427.

***The State of Montana's statutory scheme (Mont. Code Ann. § 81-2-120) is a threat to Yellowstone bison in the wild.***

In Montana, the migratory species is listed in the wild as a "species of concern" and "considered to be 'at risk' due to declining population trends, threats to their habitat, and/or restricted distribution" and "at risk because of very limited and/or potentially declining population numbers, range, and/or habitat, making it vulnerable to global extinction or extirpation in the state." Adams & Dood 2011 at 32 (citations omitted).

Furthermore, Montana's Comprehensive Fish and Wildlife Conservation Strategy lists bison as Tier 1, a native species in "greatest conservation need. Montana Fish, Wildlife & Parks has a clear obligation to use its resources to implement conservation actions that provide direct benefit to these species, communities, and focus areas" (FWP, 2005, pp. 32)." Adams & Dood 2011 at 32.

Yet, as written, Mont. Code Ann. § 81-2-120 defines bison migrating into Montana as a threat to be eliminated.

As practiced, the statute threatens bison's ability to persist in the wild because the law is defined and enforced to kill or take all bison migrating into Montana:

> [T]he department [of livestock] may, under a plan approved by the governor, use any feasible method in taking one or more of the following actions:
> (a) The live wild buffalo or wild bison may be captured, tested, quarantined, and vaccinated…
> (i) sold to help defray the costs that the department incurs in building, maintaining, and operating necessary facilities related to the capture, testing, quarantine, or vaccination of the wild buffalo or wild bison. Proceeds . . . must be deposited . . . to the credit of the department.
> (b) . . . may be physically removed by the safest and most expeditious means from within the state boundaries, including but not limited to hazing and aversion tactics or capture, transportation, quarantine, or delivery to a department-approved slaughterhouse.
> (c) . . . destroyed by the use of firearms.
> (d) . . . taken through limited public hunts pursuant to 87-2-730 when authorized by the state veterinarian and the department.

Mont. Code Ann. § 81-2-120 (2021).

> [The Montana Department of Livestock] is granted broad and discretionary authority to regulate publicly-owned bison that enter Montana from a herd that is infected with a dangerous disease (YNP bison) or whenever those bison jeopardize Montana's compliance with state or federally administered livestock disease control programs including the authority to remove, destroy, take, capture, and hunt the bison (§ 81-2-120(1)-(4) MCA)).

Montana Fish, Wildlife & Parks and Montana Dept. of Livestock 2013 at 13.

The regulatory framework for eliminating Yellowstone bison from their range and habitat in Montana is defined in the State's and Yellowstone National Park's bison management plan in separately released decisions. The plan is a product of a negotiated settlement between Montana and Yellowstone National Park. The settlement is the result of a lawsuit Montana filed against Yellowstone National Park based on Mont. Code Ann. § 81-2-120. The statute became law in 1995 and displaced Montana Fish, Wildlife & Parks management of bison. The statute authorizes the Montana Dept. of Livestock to take bison wherever they roam in Montana. The statute is void of any provision for conserving bison in their range and habitat in the wild. The statute grants Montana's veterinarian and the Department of Livestock broad authority to use veterinary management (trap, slaughter, quarantine, vaccinate) and livestock agents to destroy or harass wild bison migrating into the State. The Interagency Bison Management Plan is the Governor-approved plan the statute calls for.

"There are no court orders covering the issuance of" the Record of Decisions agreed to by Montana and Yellowstone National Park. U.S. Dept. of the Interior & U.S. Dept. of Agriculture 2000 Record of Decision at 38 (IV. Findings A. Compliance with Court Orders); *see also* Montana Dept. of Livestock and Montana Fish, Wildlife & Parks 2000 at 1–3 (providing a rationale and context for the decision). The voluntary agreement is entered into by memorandum.

> [T]he plan was intentionally designed to "prevent the reestablishment of a free-ranging bison herd in places where bison have been absent for more than a century," which essentially defined the park, and small, nearby areas as "the acceptable limits for bison distribution" (State of Montana 2000:28–29, 33). In addition, the management of bison under the IBMP included many intrusive agrarian-type actions such as capture, test-and-slaughter, vaccination, and hazing animals back into YNP to constrain their abundance and distribution, while attempting to suppress brucellosis prevalence. Many of these actions are implemented by state agency personnel on public lands administered by the U.S. Forest Service. . . . This treatment differed from the management of other wildlife in the northern Yellowstone area, including elk that were also chronically infected with brucellosis yet allowed to move freely across the landscape without being subjected to similar intrusive actions.

White et al. 2018 at 2 (unpublished manuscript).

The government's plan "serves to perpetuate the myth that bison pose a much higher risk to cattle and people than elk, while undermining the widespread national, regional, and local support for managing bison more like other wildlife." White et al. 2018 at 7 (unpublished manuscript).

Since 1995, the U.S. Dept. of Agriculture Animal and Plant Health Inspection Service has maintained a cooperative funding agreement enabling the Montana Dept. of Livestock to enforce Mont. Code Ann. § 81-2-120 taking wild bison in disease management actions. Well over thirteen million dollars has already flowed from American taxpayers to Montana Dept. of Livestock coffers. The on-going appropriation is approximately $600,000 annually. Buffalo Field Campaign 2016.

Because the Montana livestock's assertion of authority over wild bison is reinforced and entrenched by the continuing appropriation of federal taxpayer money, there is no fiscal incentive to change livestock management of the wild species in Montana.

Thus, not only are wild bison in Montana subject to livestock authority, a federal livestock agency assists in entrenching veterinary control and livestock management through national appropriations funding the State's regulatory scheme (Mont. Code Ann. § 81-2-120).

Clearly, the Montana Dept. of Livestock "and allied veterinarians hold predominant power over bison management in the state of Montana." Cromley 2002 at 88.

***The Montana Dept. of Livestock is not enforcing and Montana cattle ranchers are not complying with Designated Surveillance Area rules.***

The State of Montana's and Yellowstone National Park's intensive management of migratory bison in the wild must be contrasted with Montana's lackadaisical approach to disease management of cattle in Yellowstone bison's range.

Montana's Designated Surveillance Area brucellosis action plan was designed in response to new rules by the U.S. Dept. of Agriculture Animal and Plant Health Inspection Service in classifying States as free of brucellosis. U.S. Dept. of Agriculture 2012 entire.

The new rules deal with "outbreaks in cattle on a case-by-case basis" thereby "eliminating the need to remove exposed herds and test across the entire state (USDA, APHIS 2014)." White et al. 2018 at 3 (unpublished manuscript).

Montana's Designated Surveillance Area is defined based on the "presence of brucellosis-positive wild elk, county boundaries and other features such as roads." Montana Dept. of Livestock 2008 at 1.

A legislative audit found the Montana Dept. of Livestock is not enforcing and cattle ranchers are not complying with Designated Surveillance Area rules. Montana Legislative Audit Division 2017 entire.

Despite the lack of enforcement and noncompliance with Designated Surveillance Area rules — and in spite of several infections in livestock from elk — Montana still retains its' brucellosis free status.

Legislative auditors found the Montana Dept. of Livestock's "current compliance and oversight process does not directly monitor" and verify whether brucellosis testing is occurring for movements of livestock out of the Designated Surveillance Area. Montana Legislative Audit Division 2017 at 18, 17 (less than one in five movements documented "health requirements" but did not disclose the required brucellosis test).

"A risk assessment conducted by a MDOL or a USDA APHIS employee on all herds [where brucellosis positive elk have been harvested] is required." Montana Dept. of Livestock 2008 at 1.

The Montana Dept. of Livestock is not following up on rancher noncompliance, is "not documenting herd management plan risk assessments," is not annually reviewing the 160 herd management plans in place (no documented risk assessments for 50 audited samples), and is not documenting its basis for providing variances or exemptions for ranchers from brucellosis testing requirements. Montana Legislative Audit Division 2017 at 17, 20, 19, 21.

PHOTO: Darrell Geist

Cattle ranchers are not complying with brucellosis testing requirements (107 cattle ranchers were noncompliant in 2015). Any ranch testing 5 percent or more of its eligible cattle for brucellosis is "in compliance" with the regulations. Montana Legislative Audit Division 2017 at 17, 16.

Vaccinating cattle "is the most efficient single control measure" to prevent the spread of bovine brucellosis. Abagna et al. 2022 at 9 (vaccinating cattle, culling seropositive cattle, and following protocols are the best prevention and reduction practices).

Importantly, Montana agreed in 2000 to encourage ranchers to voluntarily vaccinate cattle and "if voluntary compliance was not 100%, Montana would make it mandatory; federal government would reimburse direct cost of vaccination." U.S. Dept. of the Interior & U.S. Dept. of Agriculture 2000 FEIS Vol. 1 at 231 (Table 12 Summary Comparison of Alternative Actions: Vaccination of cattle with RB51).

The provision for mandating vaccination of cattle if voluntary compliance was not achieved is not being followed in Montana.

Legislative auditors could not determine what the $2 per head reimbursement for ranchers is intended to offset, and found the Montana Dept. of Livestock is making reimbursements for vaccination without proper documentation (73% of payments did not have an official record of vaccination) or the required administrator approval for payments exceeding $5,000. Montana Legislative Audit Division 2017 at 22, 25, 26.

Notably, Montana is maintaining its brucellosis Class Free status despite several incidents of brucellosis infections in livestock since 2010 — none of which came from bison in the wild (elk are considered to be the source of infections). Montana Legislative Audit Division 2017 at 5–6, 9.

> Spatial spread analyses by lineage identified the Wyoming feedgrounds as an ancestral source for the majority of GYE isolates sampled within the past three decades (Fig. 3, Supplementary Fig. 3). The most widespread lineages (L4, L5), in particular, originated from the NER [National Elk Refuge] and exhibited multiple long-distance linkages with other areas in the GYE. Interestingly, the most probable dates of the oldest lineage MRCA [Most Recent

> Common Ancestor] (L5, 95% HPD: 1930–1968) immediately follows the first diagnosis of brucellosis in NER elk in 1930 (ref. 47). The bison-dominated lineage, however, was predicted to originate within Yellowstone NP, and may represent the remnants of the first reported introduction of brucellosis into the GYE in the early 1900s (ref. 23).

Kamath et al. 2016 at 7.

> Over the past decade, in particular, there has been a substantial increase in documented transmission events from elk to livestock ($n$ = 17), standing in contrast to none recorded in the previous decade. We also demonstrated that the quantity of predicted elk to livestock transitions (that is, Markov jumps over *B. abortus* evolution in the GYE) was greater than between any other host pair (Fig. 2, Table 3). In contrast, the predicted number of bison to livestock transitions was close to zero and no transmissions of brucellosis from wild bison to cattle have been detected.
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> . . .
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> Furthermore, host-state reconstruction confirmed previous findings that elk were the most likely source of *B. abortus* outbreaks in livestock.

Kamath et al. 2016 at 6, 4 (endnotes omitted)

> Our results indicate that elk and cattle isolates are virtually identical genetically, differing by only one to two mutational steps. On the contrary, bison *B. abortus* differed from cattle and elk by 12–20 mutational steps (Fig. 1). These results suggest that the recent brucellosis outbreaks in cattle in Idaho and Wyoming originated from elk, not bison. *B. abortus* multilocus genotypes from elk remained similar across many years and geographic locations. For example, elk *B. abortus* isolates from Idaho between 1999 and 2002 were almost genetically identical. *B. abortus* isolated in Wyoming elk in 2003 were very similar to *Brucella* from Idaho elk and differed by only one to two mutational steps.
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> . . .
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> Our study also illustrates that infectious disease outbreaks are increasing worldwide as wild and domestic animals come in closer contact following fragmentation of wildlife habitats and expansion of human and livestock populations.

Beja-Pereira et al. 2009 at 1176.

"However, there was no loss of brucellosis-free status or trade sanctions from other states or nations due to these elk-to-cattle transmissions; though even a single transmission was deemed unacceptable for bison during the negotiation of the IBMP (State of Montana 2000)." White et al. 2018 at 3 (unpublished manuscript).

Montana's lackadaisical enforcement and interest in complying with disease management in cattle has not endangered the State's brucellosis status or led to sanctions by other States and countries.

The record evidence demonstrates the best available science has nothing to do with Montana's disparate treatment of wild bison and elk.

***In the Designated Surveillance Area, Montana manages wild elk populations to prevent commingling with cattle.***

> All detections of *B. abortus* infection in northern GYA cattle in the last decade have been attributed to elk (Donch and Gertonson 2008).

Schumaker 2010 at 105.

> Traditional methods of disease control, such as vaccination, culling, and test and slaughter, are unlikely to be effective, politically feasible, or logistically possible to implement on wide-ranging elk populations (Bienen and Tabor 2006, Kilpatrick et al. 2009). Thus, the primary strategy for managing brucellosis transmission risk between elk and livestock is to prevent commingling. This may be achieved by hiring herders to disperse or redistribute elk, by holding dispersal hunts during the transmission risk period, by fencing or removing haystacks and other attractants, or by improving available forage on public lands (Bienen and Tabor 2006).

Rayl et al. 2019 at 825.

With public input from a working group including ranchers and livestock representatives, the Montana Fish & Wildlife Commission makes management decisions for ≥26,800 elk (including ~17,500 adult female elk) in the Designated Surveillance Area to "minimize the risk of brucellosis transmission from elk to livestock." Rayl et al. 2019 at 827, 818; Montana Fish, Wildlife & Parks 2012.

Wild elk number 141,785 with populations distributed across more than 38,116,527 acres of land in Montana. Montana Fish, Wildlife & Parks 2021.

In contrast with how Montana manages wild bison, management actions "are focused on hazing, hunting, and other actions to disperse or redistribute elk" from March through May where the risk is greatest on private ranchlands. Rayl et al. 2019 at 827.

PHOTO: iStock

Management actions "are designed to adjust local elk distribution away from cattle at small geographic scales." Montana Fish, Wildlife & Parks October 2020 at 1.

> During winter, elk select for flat grasslands in windswept areas with more available forage (Gude et al. 2006, Proffitt et al. 2010), which brings them onto private ranchlands in valley bottoms. Across the DSA [Designated Surveillance Area], the largest wintering groups of elk tend to occur on flat grasslands in valley bottoms (where private land dominates) in areas with high elk population density (Proffitt et al. 2015). Over the last several decades elk have become more concentrated in larger groups on the Madison Valley bottom (Proffitt et al. 2012). Similarly, over the last 15 years, the proportion of the Northern Yellowstone herd wintering outside of Yellowstone National Park in the Paradise Valley has increased (White et al. 2010, 2012). The area of private land in irrigated alfalfa in these valleys has increased over the last decade (Haggerty et al. 2018), which reduces the propensity of elk to migrate off of these winter ranges in spring (Barker 2018).

Rayl et al. 2019 at 825.

Using a fine-resolution, large-scale risk predictions model the scientists found:

> Within the risk period during an average snowfall year, we estimated that 51% of the relative risk of abortion events inside the Montana DSA occurred on private lands (comprising 35% of land in the DSA), 37% on USFS lands (comprising 47% of land in the DSA), 8% on state lands (comprising 8% of land in the DSA), 4% on BLM lands (comprising 8% of land in the DSA), and <1% on USFWS lands (comprising 1% of land in the DSA; Fig. 3A). When we limited our analyses to include only areas with potential livestock presence, however, we found that 98% of the relative risk of abortion events occurred on private ranchlands (comprising 31% of land in the DSA), 1% on state livestock allotments (comprising 1% of land in the DSA), 1% on BLM livestock allotments (comprising 4% of land in the DSA), and <1% on USFS livestock allotments (comprising 5% of land in the DSA; Fig. 3B). We calculated the percentages of land in the DSA that were comprised of allotments (provided above in parentheses) only for allotments where livestock was present at some point during the risk period.
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> . . .
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> We estimated that 4% of transmission risk within the DSA occurred during February, 32% during March, 29% during April, 30% during May, and 5% during June (Fig. 4, Figs. S16–21).
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> . . .
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> Our results suggested that the risk of disease spillover within the Montana DSA was greatest on private ranch-lands, with only approximately 2% of total risk occurring on state or federal grazing allotments when livestock were present on these allotments (Fig. 3B). Within the DSA, areas that we predicted were at higher risk for elk abortions in livestock grazing areas were concentrated along the Madison Valley in the west (hunting districts 323, 330, 360, 362), and the Paradise Valley (hunting districts (313, 314, 317) in the east (Fig. 4, Figs S16–

> 21). This is in rough agreement with where livestock herds have been affected by brucellosis (Brennan et al. 2017).

Rayl et al. 2019 at 817, 823, 824.

Montana has not considered nor is the State contemplating managing wild bison like wild elk to prevent commingling with cattle.

Instead, Montana eliminates wild bison altogether from range and habitat on large geographical scales wild elk roam, while managing wild elk to prevent commingling with cattle at small geographic scales.

***Designated Surveillance Area management of cattle, bison biology, scavengers, and environmental conditions reduce and prevent disease transmission to cattle in Yellowstone bison's range.***

In Montana, cattle are being managed under a U.S. Dept. of Agriculture Animal and Plant Health Inspection Service approved and taxpayer supported plan that is providing cattle ranchers a net benefit of $9.50 to $14 per head, and an annual net benefit to cattle ranchers statewide of $5.5 to $11.5 million. Montana Dept. of Livestock 2011 at 3, 6.

The rules cover approximately 78,500 head of livestock comprising 5.2% of Montana's domestic cattle and bison. Bonser 2019 at 7.

Montana's Designated Surveillance Area rules are in place and remove the threat of whole herd cattle slaughter, loss of the State's brucellosis free status, and threat of sanctions against Montana cattle that contract brucellosis. U.S. Dept. of Agriculture 2012 at 5, 19; Montana Dept. of Livestock 2011 at 4.

The Designated Surveillance Area rules allow "a risk-based approach that protects producers in an entire State from unnecessary regulation for what is, in fact, a local problem." U.S. Dept. of Agriculture 2012 at 5.

Indeed, the new rules have resulted in net benefits of $66,000,000 to $138,000,000 for ranchers in Montana without any modification to the State of Montana's and Yellowstone National Park's bison management plan that takes these new rules and conditions into account.

For example, none of this new information is reflected at all in the draft alternatives, management tools and evaluation goals for the next iteration of the government's bison management plan. National Park Service 80 Fed. Reg. 13603 (Mar. 16, 2015).

The joint analysis with Montana was terminated in 2022 when Yellowstone National Park announced its' intent to restart the stalled public process. U.S. National Park Service 87 Fed. Reg. 4653 (Jan. 28, 2022).

However, Montana's Governor requested Yellowstone National Park withdraw its' notice and defer to the "State as to what management actions may be palatable, and which are unacceptable." Gov. Gianforte 2022 at 2.

What is unacceptable to Montana is embracing the "failed management" goal of managing for a 3,000 population target; what is palatable is for Yellowstone National Park to carry out "an in-park disease suppression regime" for Yellowstone bison. Gov. Gianforte 2022 at 4, 5.

> APHIS and Montana have increased pressure on the NPS to lower bison numbers and suppress brucellosis prevalence in bison through vaccination, fertility control, and hunting inside YNP (USDA, APHIS 2012, 2016; National Academy of Sciences 2015; Montana Environmental Quality Council 2016); even though these same actions are considered inappropriate to control elk herds spreading brucellosis elsewhere (MFWP 2015).

White et al. 2018 at 3 (unpublished manuscript).

Despite its' poor enforcement and weak compliance, Montana's Designated Surveillance Area is effectively accomplishing the purpose and need of the State's and federal government's bison management plan goal of protecting the cattle industry.

Yet, the assumption that it is necessary for the government to impose an intensive, harmful, and costly management plan on Yellowstone bison for "disease control" remains unexamined.

Whatever risk of disease transmission from bison to cattle exists, the scientific evidence indicates *Brucella abortus* behaves differently in the bison population from other species like elk while bison's biological behavior, the presence of scavengers, and environmental conditions conspire to reduce and prevent the risk of disease transmission to cattle in Yellowstone bison's range.

> To our knowledge, the probability of bacterial survival and risk for indirect transmission of brucellosis from bison to other susceptible hosts had not been evaluated prior to our study. Our combined model predicts that *Brucella* organisms are unlikely to survive after 11 June provided bison have been removed from grazing pastures by 15 May. . . . bacterial decay and scavenging interacted to rapidly eliminate infectious material from the natural environment.
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> . . .
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> Furthermore, our results demonstrate that preserving a complete component of natural scavengers in this environment will benefit disease management by rapidly removing *B. abortus* infected materials from the landscape.

Aune et al. 2012 at 260.

Does the actual incidence of brucellosis-induced and infected abortion in the wild present sufficient cause to maintain the State of Montana's and Yellowstone National Park's bison management plan?

The evidence demonstrates the incidence of a *Brucella*-induced abortion in female Yellowstone bison is a rare event.

The evidence also proves that if in the rare event there is a *Brucella*-induced abortion in female bison any risk is local, temporal, and eliminated by mid-June:

> Sixty-three samples (i.e., 14 fetuses, 21 tissues, and 28 swabs) from 47 different parturition events and one motor vehicle accident yielded only three positive cultures for *B. abortus*. Birthing females meticulously cleaned birth sites and typically left the site within two hours.

> The birth synchrony and cleaning behavior of bison females, combined with *Brucella* environmental persistence data from previous studies, indicates that the risk of brucellosis transmission from bison to cattle is minuscule after May.
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> . . .
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> The infrequency of observed abortions (*n* = 24), and the even rarer identification of *Brucella* from these abortions, supports claims that *Brucella*-induced abortions are rare events for Yellowstone bison (Meyer and Meagher, 1995; Dobson and Meagher, 1996). There have been seven documented, seropositive abortions in Yellowstone, including two from captive bison in 1917 (Mohler 1917), one in 1992 (Rhyan et al., 1994), and four during 1995-1999 (Rhyan et al., 2001). Only 2 of 25 samples collected from 15 termination events were culture positive for *B. abortus*. Ten stillborn calves have been submitted for culture testing and only one has been positive for *B. abortus*. Terminated pregnancies can occur for a multitude of reasons in bison (Williams et al., 1997), and *B. abortus* appears to play less of a role in inducing abortions than previously thought. Parturition events indicating a loss of pregnancy were typically observed prior to the onset of the bison calving season.
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> . . .
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> Based on field observations presented in this report, the potential for brucellosis transmission from bison to cattle is minimal by June 1 and essentially non-existent by June 15. Thus, the current haze back date of May 15 (i.e., the date after which bison are not tolerated outside the park) may be unnecessary from a disease transmission risk perspective.

Jones et al. 2009 at 3, 6, and 7.

"As for abortions in Yellowstone bison, the scientific consensus is that they are infrequent because the abortion rate drops in any ungulate herd that has become chronically infected with brucellosis (Cheville et al. 1998). Yet until the 1990s, the National Park Service's defense of its bison management policy routinely suggested that abortions were infrequent because the bacteria may have co-evolved with bison in North America (Yellowstone National Park 1972)." Franke 2006 at 73.

In part, the reason brucellosis-induced abortion in Yellowstone bison is a rare event is because "only 10 to 15 percent of adult female bison are infectious and could shed live bacteria . . ." White et al. 2018 at 3 (unpublished manuscript).

In addition to the few recorded brucellosis-induced abortions in Yellowstone bison, the National Academy of Sciences concludes the "[p]redation and scavenging by carnivores likely biologically decontaminates the environment of infectious *B. abortus* with an efficiency unachievable in any other way." Cheville et al. 1998 at 51.

"[I]n the wild that much high-quality protein [from a fetus] is unlikely to go uneaten by scavengers for more than a day or two. Brucellosis is not a catastrophic disease. Except for the occasional abortion, its symptoms are mild to nonexistent in infected cows, and it poses no meaningful threat to humans today." Lott 2002 at 111.

Szcodronski & Cross (2021) studied the removal of simulated abortion materials by scavengers across 264 sites from February to June in 2017 and 2018 in southwest Montana. The authors found the abundance and diversity of scavenger species such as coyotes, red foxes, golden and bald eagles, *Corvus* spp., and turkey vultures were important factors in reducing the transmission risk of *B. abortus*.

> Our research indicates that promoting, or at least not actively reducing, scavengers in these areas could serve as management practices that decrease the likelihood that cattle will encounter abortion materials on the landscape.
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> . . .
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> Regardless of habitat type or management strategies, the amount of time fetal units remained on the landscape before they were removed by scavengers in our study area was less than the estimated time *B. abortus* remains viable on the landscape (several days to weeks; Cook et al. 2004, Aune et al. 2012). Because the amount of time *B. abortus* remains on the landscape is directly tied to transmission risk (Aune et al. 2012, Cross et al. 2015), our research indicates scavengers, particularly coyotes, eagles, and foxes, are important species on the landscape for removing brucellosis transmission risk, especially on private rangelands.

Szcodronski & Cross 2021 at 10, 11.

Yet, the State of Montana and the U.S. Dept. of Agriculture continue to systematically target and kill scavengers and predators without regard for the role these native species fulfill in preventing disease transmission. Castle 2014; U.S. Dept. of Agriculture 2014.

Furthermore, ranchers' negative perceptions of predators, including the reintroduction of the gray wolf, reinforces the federal agency's targeting and killing of predators. Bonser 2019 at 92 ("all ranchers interviewed had negative perceptions of predators and the way in which they changed the elk ecosystem.").

In one year, the U.S. Dept. of Agriculture Wildlife Services killed nearly 7,000 coyotes in Montana. Many of the coyotes were "shot from helicopters or airplanes, but most of the others were trapped in leg or neck snares or poisoned using so-called M-44 cyanide capsules." Castle 2014.

Wolf, raven, and fox were also killed.

PHOTO: Cindy Goeddel

Systematically targeting and killing predators and scavengers continues unabated in Montana and surrounding States. U.S. Dept. of Agriculture Animal and Plant Health Inspection Service 2021.

The unscientific approach to disease management is further undermined by the unwillingness of the U.S. Dept. of Agriculture to share scientific data on the effectiveness of the agency's predator policy.

> Reps. Peter A. DeFazio (D-Ore.) and John Campbell (R-Irvine) requested the review, calling for a complete audit of the culture within Wildlife Services. The agency has been accused of abuses, including animal cruelty and occasional accidental killing of endangered species, family pets and other animals that weren't targeted.
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> Wildlife biologists also criticize the agency's work, which they say ignores science. Bradley J. Bergstrom, a conservation biologist at Valdosta State University in Georgia, and other biologists at the American Society of Mammalogists say they have been frustrated by the agency's unwillingness to share scientific data tracking the effectiveness of its approach.
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> . . .
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> Wildlife Services was created in 1931 as part of the [U.S. Department of Agriculture's] Animal and Plant Health Inspection Service.

Cart 2014.

State and federal managers continue to neglect examining, changing or updating policies to reflect the natural role scavengers fulfill in decontaminating the environment of *Brucella abortus*.

The failure of the State of Montana and the U.S. Dept. of Agriculture to change its' policies to accommodate the natural role of scavengers in reducing and preventing disease transmission to cattle is far removed from the best available science.

For over two decades Montana has restricted access to range and habitat and harmed the migrations of bison claiming the old brucellosis rules required such actions to prevent brucellosis transmission to cattle. Whatever risk is present can be effectively addressed by managing cattle. Doing so would provide assurance to cattle producers while permitting migratory bison to roam and adapt as a wild species.

Livestock managers have yet to incorporate the natural role of scavengers in managing for disease and reducing or preventing disease transmission to cattle. Instead, managers methodically destroy native scavengers, eliminating the most efficient and effective way to decontaminate brucellosis surviving the elements that also naturally kill the bacteria.

***Eliminating Yellowstone bison from their home range precipitates a cascade of harmful effects on native species and biological diversity. Evidence of management actions harmful effects on Yellowstone bison and bison ecology is not being systematically examined for publication.***

The systematic targeting of bison for disease management actions harms the migratory species' capacity and ability to fulfill the ecological benefits the keystone species and ecological engineer provides in sustaining native species in the Yellowstone ecosystem. At the same time, evidence of management action's harmful effects on bison ecology is not being systematically examined for publication.

For detailed evidence and analysis of bison's keystone and ecosystem engineering roles, *see* section 2.

The ecological roles bison fulfill in the Yellowstone ecosystem remains largely unknown due to managers fixation on killing bison for disease control.

A review of scientific research identified in the State of Montana's and Yellowstone National Park's bison management plan analysis finds over fifty disease-related study needs and not one study on the keystone contributions of bison in sustaining the ecosystem and native diversity. U.S. Dept. of the Interior & U.S. Dept. of Agriculture 2000 FEIS Vol. 1 Appendix D at 728–732. ( A high priority scientific study to ensure Yellowstone bison persist in the wild as a self-sustaining population with unique herd substructure remains unfulfilled).

Managers are also interfering with bison's function, role, and interrelationships in keeping grasslands available for other grassland species. Stockdale et al. 2019 at 15 (finding the extirpation of bison led to forest's encroaching into grasslands, while bison behavior "browsing, trampling, wallowing, and toppling" keeps the forest from encroaching into grasslands).

Wallows, a unique ecological feature of grasslands created by bison, provide a more diverse, drought and fire resistant vegetation structure during summer. In the spring, wallows catch the rain and runoff producing temporary pools for wetland species. Fallon 2009 at 2–3.

Bison carcasses not only provide a preferential food for grizzly bears emerging from hibernation, but increase soil respiration and nutrients, and are a driver of "soil microbial diversity and ecosystem functions." Risch et al. 2020 at 1940, 1941; Green et al. 1997 at 1047 (a bear is more likely to use a bison carcass than an elk carcass); Mattson 2017 at 17 (60 years of data affirming the "disproportionate importance" of meat from bison carcasses).

One of the few Yellowstone specific ecological studies found bison grazing grasslands green up faster, more intensely, and for a longer duration enhancing plant productivity by up to 40% and forage quality by 50–90%. Geremia et al. 2019 at 1, 2.

The role of bison as "ecosystem engineers" (Auttelet et al. 2015 at 108) and the full extent of their keystone ecological contributions has yet to be properly studied in the Yellowstone ecosystem.

In eliminating bison from their indigenous range, managers are also eliminating the ecological role of a keystone species and ecosystem engineer that is performing crucial roles in the functioning of a healthy grassland ecosystem and providing for a diversity of soil, insect, plant, bird, and animal life in Yellowstone.

***Displacing bison as a native food source undermines the recovery of grizzly bears.***

> Data from scientific investigations spanning nearly 60 years affirm not only the importance of meat to Yellowstone grizzly bears but more specifically the disproportionate importance of

meat from bison carcasses.

Mattson 2017 at 1.

PHOTO: Jackson Doyel

Preferentially managing National Forest range and habitat for cattle displaces bison resulting in the loss of a key grizzly bear food at the same time it brings grizzly bears into potential conflict with cattle resulting in dead bears. Mattson 2017 at 16; Haroldson & Frey 2011–2017.

Displacing bison with domestic livestock limits the "biological suitable" habitat of grizzly bears and the "potential for a self-sustaining population of grizzly bears" in the Greater Yellowstone bioregion. 82 Fed. Reg. 30502, 30510 (June 30, 2017).

> Because wild bison herds no longer exist in these areas, and are mainly contained within YNP in the GYE, they are no longer capable of contributing in a meaningful way to the overall status of the GYE grizzly bear DPS [Distinct Population Segment]. Thus, we did not include drier sagebrush, prairie, or agricultural lands within our definition of suitable habitat because these land types no longer contain adequate food resources (*i.e.*, bison) to support grizzly bears.

82 Fed. Reg. 30502, 30510 (June 30, 2017).

For detailed evidence and analysis on how displacing bison with cattle is harming grizzly bears and the ability of bison to fulfill their keystone and ecological engineering roles in the ecosystem, *see* factor 8.A. and section 2.

***Displacing bison, a keystone species and ecological engineer, depletes biological diversity in the ecosystem.***

"The migration of bison in Yellowstone, with thousands of animals consuming tons of biomass as they move in unison, is a unique movement and foraging strategy now sustained in only a handful of migratory taxa worldwide." Geremia et al. 2019 at 2.

> Bison . . . act as "ecosystem engineers" by creating and responding to heterogeneity across the landscape (Gates et al. 2010). They create greater plant diversity by preferentially feeding on grasses and avoiding some flowering plants, while preventing plant community succession through hoof action and horning or rubbing on trees and shrubs (Meagher 1973; Coppedge and Shaw 1998; Knapp et al. 1999). Their heavy bodies and sharp hooves combine to till the soil and disturb roots of grasses and grass-like plants (Frisina and Mariani 1995). This prevents grassland succession to shrubs or trees and provides grasses with greater access to sunlight, which is important for growth (Knapp et al. 1999). Large groups of bison contribute to natural disturbances that influence plant species composition and distribution across large portions of grasslands and shrub steppe, similar to fire, windthrow, and mass soil erosion events (Augustine and McNaughton 1998; Turner et al. 2003; Collins and Smith 2006; McWethy et al. 2013).

Auttelet et al. 2015 at 108.

> The migrations of large herbivores are dwindling across the globe, and their absence has likely caused significant alterations to ecosystems. A century and a half ago, the American West was occupied by tens of millions of bison moving seasonally across its big landscapes. With their aggregated grazing across vast areas, phenological patterns would have been radically different from what they are today. Currently, only 20,000 bison remain protected in conservation herds, and only 8,000 of those are allowed to freely move across large landscapes. Moreover, today's model of bison conservation involves maintaining small bison populations within fenced areas and actively managing their abundance for light to moderate grazing. The massive bison migrations that existed before European settlement are gone. Conserving North American ecosystems as a semblance of what they were prior to the loss of bison will involve the restoration and protection of large herds. Restoring lost bison migrations will require that these animals be allowed to freely aggregate, intensely graze, and move in sync with landscape-level patterns of plant phenology.

Geremia et al. 2019 at 3–4 (endnotes omitted).

PHOTO: BFC Archives

**8.D. The inadequacy of existing State and federal regulatory mechanisms threatens or endangers Yellowstone bison in the wild.**

• The conservation status of bison is "Near Threatened" with few populations "functioning as wild" in North America.

• Inadequate or nonexistent State and federal regulatory mechanisms threaten or endanger Yellowstone bison in the wild.

• The State of Montana's and Yellowstone National Park's bison management plan is an inadequate regulatory mechanism because it is not based on the best available science.

• State and federal livestock management and veterinary policy is a threat to Yellowstone bison in the wild.

• The States' statutory framework threaten or endanger Yellowstone bison in the wild.

• There is no regulatory mechanism in place ensuring Yellowstone bison persist as a self-sustaining population on National Forests in the bioregion.

• Bison are a critically imperiled species in the State of Idaho. Under Idaho law, migratory Yellowstone bison are eradicated.

• The State of Wyoming manages for the extirpation of limited numbers of migratory Yellowstone bison in restricted areas. In enforcing Wyoming law, Yellowstone bison are eradicated.

• Despite credible and relevant scientific evidence raising substantial concern about Yellowstone bison's ability to persist as a viable population on the National Forest, the Regional Forester denied bison met the criteria for listing as a species of conservation concern in Region 1.

• Bison are a species of concern in Montana. Despite the designation, the Custer Gallatin has adopted the State's intolerant regulatory framework for Yellowstone bison on National Forest lands in Montana.

• The Custer Gallatin has erected or permitted barriers thwarting Yellowstone bison's natural migrations on the National Forest. These barriers disrupt habitat connectivity the National Forest planning rule requires be maintained or restored.

• Ineffective and inadequate regulatory mechanisms on National Forests in the bioregion threaten or endanger Yellowstone bison in the wild.

PHOTO: Jack Bayles

• The State of Montana abandoned its' duty to restore bison in the wild.

• Nonexistent and inadequate laws threaten or endanger Yellowstone bison in the wild.

• The U.S. Fish & Wildlife Service has a duty to restore threatened or endangered species in the wild.

***The conservation status of bison is "Near Threatened" with few populations "functioning as wild" in North America.***

Bison are "Near Threatened" with few populations "functioning as wild" in North America. Aune, Jørgensen & Gates 2018 at 1.

Bison nearly qualify as "Vulnerable" and "therefore considered to be facing a high risk of extinction in the wild." Aune, Jørgensen & Gates 2018 at 1; International Union for Conservation of Nature 2012 at 15, 20–22.

"Only 2 remnant populations of migratory bison remain" in North America: the plains bison in Yellowstone and the wood bison in Wood Buffalo National Park in Canada. Harris et al. 2009 at 69 (citing Meagher 1973, Van Vuren & Bray 1986, Gates et al. 2001).

In the 48 contiguous States, bison in the wild are regionally extinct in 40 States including Montana and Idaho, and possibly extinct in Texas. Aune, Jørgensen & Gates 2018 at 2–3.

Only 1 population remains in Mexico with bison subject to "adverse policies" as they migrate across the border into the United States where they are classified as livestock. Aune, Jørgensen & Gates 2018 at 1.

Existing threats to bison in North America include:

- habitat loss;
- genetic manipulation of commercial bison for market traits;
- small population effects in most conservation herds;
- few herds are exposed to a full range of natural limiting factors (natural selection);
- cattle gene introgression;
- loss of genetic non-exchangeability through hybridization between bison subspecies; and
- the threat of depopulation as a management response to infection of some wild populations hosting reportable cattle diseases.

Aune, Jørgensen, & Gates 2018 at 6.

Of 12 plains bison populations assessed in North America, only 5 are classified as functioning as wild, and only 2 meet the large population criteria (> 1,000) of the International Union for Conservation of Nature. Aune, Jørgensen, & Gates 2018 Supplemental Material (Tables 1 and 2).

Boyd's status review found trends warranting consideration for listing the entire plains bison subspecies.

> Plains bison are currently not recognized at the subspecific level on any international or national list for species at risk. This survey reveals trends in plains bison status demonstrating that plains bison warrant consideration for a listing. . . . there are few plains bison populations within original range that exist under natural conditions, and none that

are considered viable by the current benchmark. Conservation issues related to genetic diversity, hybridization with domestic cattle, and domestication also support consideration of plains bison for listing.

Boyd 2003 at 93.

Boyd's finding is still valid today.

"In May 2004, Canada's Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recommended" listing plains bison as a threatened species (COSEWIC, 2004) but were not "because of potential economic implications for the Canadian bison industry (Canada Gazette, 2005)."
Freese et al. 2007 at 181.

According to the U.S. Fish & Wildlife Service, the total North American population of threatened wood bison (*Bison bison athabascae*) numbers 11,000 animals. 79 Fed. Reg. 26175, 26177 (May 7, 2014).

Of the 5 wood bison populations "functioning as wild," 8,144 remain in Canada with only 2 subpopulations having more than 1,000 individuals. In comparison, the total North American population of plains bison "functioning as wild" is 8,177 with only 2 subpopulations having more than 1,000 individuals. Aune, Jørgensen & Gates 2018 Supplemental Material (Table 2).

European bison or wisent are "vulnerable" to extinction with less than 1,000 mature reproductive individuals. Olech 2008 at 1.

***Inadequate or nonexistent State and federal regulatory mechanisms threaten or endanger Yellowstone bison in the wild.***

Similar to the nonexistent and inadequate laws in the 1800s and 1900s, the lack of protection in State and federal laws and the present regulatory arc threaten or endanger Yellowstone bison in the wild.

Existing regulatory mechanisms managers choose to implement stand in contradiction to the broad public support locally, regionally, and nationally for honoring, protecting, and restoring Yellowstone bison in their range and habitat in the wild.

PHOTO: Michelle McCarran

Pleas in modern times to halt the destruction of bison in Yellowstone have largely been ignored by State and federal managers despite public sentiment decidedly in favor of protecting the native migratory species and their freedom to roam National public trust lands. Moore Information 2011 (63% of Montanans agree wild bison can be managed the same way as elk and deer); Tulchin Research 2015 (76% and 78% of Montanans support restoring wild bison on public and tribal lands, respectively); Science Daily 2008 (74% of Americans believe bison are an "important living symbol of the American West").

Threats to Yellowstone bison under current management must be contrasted with the environmentally preferred alternative people overwhelmingly favored but State and federal managers rejected over two decades ago:

> The environmentally preferred alternative is defined as the alternative(s) that best meets the criteria set out in Section 101 of the National Environmental Policy Act. The Council on Environmental Quality defines the environmentally preferred alternative as the alternative that "... causes the least damage to the biological and physical environment and best protects, preserves and enhances historic, cultural and natural resources."
>
> As a summary, the public was overwhelmingly in favor of more natural management of the bison herd, with minimal use of actions they felt more appropriate for livestock such as capture, test, slaughter, vaccinating, shooting, corralling, hazing, etc. They also indicated extremely strong support for the management and/or restriction of cattle rather than bison given a choice between the two. The public also supported the acquisition of additional land for bison winter range and/or the use of all public lands in the analysis area for a wild and free-roaming herd of bison. A large number of commenters also expressed opposition to lethal controls, and in particular the slaughter of bison.
>
> Alternative 2 would minimize human intervention, discontinue the use of capture, test and slaughter, focus on managing cattle rather than bison, and result in the largest area of acquired land for winter range. It also would offer the largest benefits to most environmental resources analyzed in the EIS [Environmental Impact Statement], with alternative 3 offering some benefits to many of these same resources as well. The management emphasis and environmental advantages of alternative 2 are most consistent with the overwhelming majority of public comment. In addition, the benefits to environmental resources as analyzed in the FEIS [Final Environmental Impact Statement] as well as those analysis of Section 101 criteria indicate alternative 2 as environmentally preferred. Based on this combination of public commentary, FEIS analysis, and adherence to the principles of Section 101 of the National Environmental Policy Act, alternative 2 is identified as the environmentally preferred alternative.

U.S. Dept. of the Interior & U.S. Dept. of Agriculture 2000 Record of Decision at 21.

The environmentally preferred alternative "involves the purchase of large quantities of land outside the park to provide winter range for many bison, thus allowing the population to increase." Angliss 2003 at 44.

Acquiring winter range outside Yellowstone National Park for wild bison to roam would "conservatively" net "measurable benefits" of over $4 million dollars. U.S. Dept. of the Interior & U.S. Dept. of Agriculture 2000 FEIS Vol. 1 at xxxix-xl.

Despite persistent public pressure on managers and popular support for wild bison in Montana and across the United States, the harmful conditions, trends, and stressors operating on Yellowstone bison under current laws and management policies are certain to continue for the foreseeable future.

Inadequacy of State and federal regulatory mechanisms drove the migratory species to near extinction in the wild over a century ago, impedes recovery today, and threatens or endangers the persistence of wild Yellowstone bison.

The U.S. Fish & Wildlife Service must examine and investigate inadequate and nonexistent regulatory mechanisms for conserving wild Yellowstone bison, and the cumulative threat posed by State and federal regulatory mechanisms to the persistence of wild Yellowstone bison in the agency's threats assessment and status review.

***The State of Montana's and Yellowstone National Park's bison management plan is an inadequate regulatory mechanism because it is not based on the best available science.***

The State of Montana's and Yellowstone National Park's management actions threaten or endanger Yellowstone bison in the wild.

At the outset, monitoring bison's vital rates, population structure, and responses to environmental variation and management interventions has been "poorly defined" and "inconsistent" since 1997. Gates et al. 2005 at xii.

State and federal managers disregard science that does not conform to the government's outdated plan and avoid conducting studies shedding light on how management is harming Yellowstone bison and the ecosystem they are an integral part of.

For example, studying population viability was identified as a high priority in 2000. U.S. Dept. of the Interior & U.S. Dept. of Agriculture 2000 FEIS Vol. 1 at 731.

Over two decades later, this high priority scientific study to ensure the Yellowstone bison persist in the wild as a self-sustaining population with unique herd substructure remains unfulfilled.

The State of Montana and Yellowstone National Park "maintain a target population" of 3,000 bison and management actions are triggered once "tolerance levels" are met or exceeded. U.S. Dept. of the Interior & U.S. Dept. of Agriculture 2000 Record of Decision at 13 (government traps used to control the population size and hazing operations would "ensure no bison remain outside the park after the respective haze-back dates"), at 20 ("strict enforcement" removing bison where cattle may range), at 26 ("intense management" removing bison where cattle may range), at 26 and 31 ("Zone 3 is the area where bison that leave Zone 2 would be subject to lethal removal" in both Gardiner and Hebgen basins); at 32 ("population target for the whole herd is 3,000 bison"); Federal and State Interagency Bison Management Plan Agencies 2011 (the government would "reevaluate the minimum population size when new information became available").

"[A] population target of 3,000 bison was chosen to minimize large migrations . . . rather than being based on assessments of ecological or genetic viability (Cheville et al. 1998, State of Montana 2000)." White et al. 2018 at 2 (unpublished manuscript).

For detailed evidence and analysis of how disease management jeopardizes Yellowstone bison and the population's genetic viability, *see* factors 8.C and 8.E.

State and federal managers do not recognize the best available evidence of Yellowstone bison's genetically distinct subpopulation structure identified by Halbert in 2012. *See* White & Wallen's 2012 response.

Nor has any data been published by any scientist refuting Halbert's findings or other distinctions found by additional scientists. *See* Christianson et al. 2005, Gogan et al. 2005, Geremia et al. 2011, Olexa & Gogan 2007, Birini & Badgley 2017, Fuller et al. 2007, Gardipee 2007, and Gardipee et al. 2008.

Managing for a spring population limit of 3,000—without regard for subpopulation distinction—also undermines conserving genetic variation and long-term viability of each genetically distinct herd in the Yellowstone bison population. U.S. Dept. of the Interior & U.S. Dept. of Agriculture 2000 FEIS Vol. 1 at 219 ("Overall size: maximum of 3,000" Table 11: Methods Each Alternative Uses to Ensure Each Agreed-Upon Objective Is Met); at 225 ("Manage for overall population limit of 3,000 bison" Table 12: Summary of

Comparison of Alternative Actions). A memorandum signed by the government in 2006 attempted to clarify that "a population size of 3,000 bison is defined as a population indicator to guide implementation of risk management activities, and is not a target for deliberate population adjustment." Yellowstone National Park Aug. 28, 2008.

While managers set a target of 3,000, under the current plan, the Yellowstone bison population can be driven below 2,300 before managers consider "non-lethal management measures," and are required to "increase implementation of non-lethal management measures" if the total population declines below 2,100. U.S. Dept. of the Interior & U.S. Dept. of Agriculture 2000 Record of Decision at 52.

There is no provision triggering cessation of lethal government management actions regardless of the total number of Yellowstone bison, and irrespective of the total number in each subpopulation, a distinction supported by evidence in several scientific studies.

State and federal managers have no provision for conserving minimum herd sizes in the Yellowstone bison population to avoid inbreeding and prevent loss in genetic variation and subpopulation distinction.

The lack of State and federal manager's recognition of the ecological and genetic diversity, and constitution of the Yellowstone bison population is a warning sign unheeded long ago.

> With a "limit" of 2300 bison, we are intentionally managing Yellowstone bison near the brink of genetic extinction; whereas population geneticists and other scholars (cited below) have urged a cautious, conservative approach for this unique herd. With 2300 bison, the slightest deviation of reality from assumptions in population/genetics models will assure loss of rare alleles. Such deviations are already apparent.
>
> . . .
>
> Gross et al. (2006), using population/genetic modeling, estimated that 1000 bison are needed to provide a 90% probability of retaining 90% of allelic diversity for 200 years. However, assumptions of their models do not fit what has occurred in Yellowstone National Park. Deviations from model assumptions, addressed below, provide greater jeopardy to the genetic diversity of Yellowstone bison than indicated in the models. Gross et al. recognized some of these deviations and urged a cautious approach in applying their results to management of Yellowstone bison.
>
> Freese et al. [2007] reviewed Gross et al. (2006) and concluded that, considering the importance of the Yellowstone herd to conservation of bison in North America, a more prudent goal would be retention of 95% of the existing genetic diversity over 200 years. This will require maintaining about 2000 bison, according to the models of Gross et al. (2006).
>
> Deviations of reality from assumptions in the Gross et al. (2006) models are:
> 1. *Uncertain knowledge of lifetime male breeding success.* Genetic diversity would be jeopardized if a greater proportion of breeding were being accomplished by fewer males.
> 2. *Shorter generation times.* Emphasis on removing older bison in Yellowstone control programs has reduced lifetime breeding success of individual bison and jeopardizes the retention of genetic diversity. (At the August 2008 meeting of the IBMP, Rick Wallen, Park

biologist noted that, whereas 12-13 year-old bison were once fairly common, it is now hard to find an animal older than 8 years.) In contrast, in modeling the effects of control programs, Gross et al. limited the taking of bison in the oldest age classes.

3. *Non-random culling of bison.* Other than cow-calf pairs, Gross et al. modeled a random selection of animals for slaughter. In reality, many bison have been captured in groups of probably related animals and there has been emphasis on taking of cows and calves. Removal of extended matrilineal groups of bison increases jeopardy to retention of genetic diversity.

4. *Population substructure.* There are at least two major subpopulations of bison in Yellowstone, the Central breeding herd and the Northern breeding herd (and genetic studies suggest the possibility of 3 subpopulations). Gross et al. (2006) stated that a more complex modeling analysis would be needed to deal with this substructure. Assuming 2 Yellowstone subpopulations, if there were no interchange of breeding bison between them, the Gross et al. estimate of needing 1000 bison to preserve 90% of genetic diversity, and the Freese et al. estimate of needing 2000 bison to preserve 95% of genetic diversity, would apply to *each* herd.

5. *Herd interchange is unknown.* Gross et al. (2006) estimate that "transfer of about 10 bison per generation should be adequate to maintain genetic similarity in subpopulations." Note this implies a need for 20 emigrants per generation, 10 each way between the two subpopulations. Note also, that generation times have been shortened by culling practices in Yellowstone, so that more frequent transfer of animals is needed to maintain genetic similarity. The Park biologist has found 6 emigrants from the Central to the Northern herd, and recent growth of the Northern herd suggests augmentation by animals from the Central herd. Trapping operations at [Stephens] Creek may be encouraging this transfer of animals. Apparently, there is no evidence of movement of breeding animals from the Northern to the Central herd.

6. *Model predictions uncertain*. Gross et al. (2006) note that their models show rather high variation of results during the 2$^{nd}$ century of simulation. Precision of their predictions is therefore not great, and they suggested caution in their application.

Bailey 2008 at 1–3 (emphasis in the original).

In spite of new scientific information identifying substructure and genetically distinct subpopulations with a third not being discounted by the evidence produced to date, managers continue to take actions contrary to, and without regard for, the best available science.

According to population geneticist and conservation biologist Philip W. Hedrick, "Individual herds or clusters should have an effective population size of 1,000 (census number of 2,000–3,000) to avoid inbreeding depression and maintain genetic variation." Hedrick 2009 at 419.

Based on Halbert's (2012) evidence of subpopulation division in Yellowstone bison, an effective population size of 1,000 for each cluster or herd requires a census of 2,000–3,000 for each genetically distinct herd to avoid inbreeding and maintain variation in genetic diversity.

Yet managers have not allowed the "full range of natural, unimpaired dynamics of Yellowstone bison" and herd size "has never been allowed to reach natural limits," according to wildlife biologist James A. Bailey, PhD.

> With current population levels and lesser population goals, the significance of a gradual loss of alleles due to natural genetic drift is uncertain. A bison herd of 2000-3000 animals has been estimated to lose 5% of its alleles, due to drift, each 100 years. However, at important immune-system loci, and at other loci with relatively rare alleles, this loss may be at least 10% (Perez-Figueroa et al. 2010). We do not know what alleles or functions will be lost.
>
> The most important concern for current genetic adequacy of Yellowstone bison is the replacement of much natural selection by hunting and by capture for slaughter and other removals. These practices contribute to drift for many alleles and replace much natural selection for post-juvenile animals.
>
> . . .
>
> While Park Service policies (Appendix 2) and its definition of wild bison (White et al. 2015:174 and elsewhere) emphasize animals "subject to" natural selection, there has been little evaluation of the effectiveness of natural selection compared to drift and artificial selection. That is, providing for a predominance of natural selection has not been addressed.

Bailey 2017, *Genetic Adequacy of Yellowstone Bison*, at 2–3.

Furthermore, with managers restricting Yellowstone bison's migrations, an important factor in the natural evolution of the wild species, human predation, has become "less natural" requiring solutions such as:

> maintaining a very large herd to (1) counteract genetic drift, (2) stimulate competition and other natural evolutionary processes associated with fluctuating ecological density, (3) provide a relatively large number of bison to mortality that is not human-caused; and (4) perhaps cause bison recruitment to decline in a density-dependent manner, thereby diminishing the number of animals that must be removed to maintain a given herd size;
>
> allowing for natural mortalities other than human removals, including disease, predation and winter losses;
>
> excluding management interventions, such as vaccinations and artificial birth control, that weaken or replace natural selection;
>
> expanding the bison range to allow some mobile bison to escape human-caused mortality, while providing a more diverse environment with more diverse natural selection.

Bailey 2017, *Genetic Adequacy of Yellowstone Bison*, at 3 (detailing management actions required, but lacking, to avoid impairing the Yellowstone bison population).

State and federal management actions also jeopardize the wild characteristics enhancing bison's fitness by interfering with and weakening natural selection and the evolutionary adaptation of the Yellowstone bison population as a wildlife species.

With only 5 bison populations "functioning as wild" and only 2 meeting the large population criteria in North

America according to the International Union for Conservation of Nature, the intensive management regime under which managers intend to subject Yellowstone bison to for the foreseeable future is a threat to the population's wild genome.

> Effects of the comparative weakening of natural selection upon the wild bison genome will occur gradually over decades and may defy detection. But evolutionary theory predicts such negative effects upon wildness. For the nation's only wild plains bison herd, extremely conservative prudence is justified. The ultimate goal should be to limit the effects of a preponderance of human-caused mortality and to maintain the irreplaceable wildness of Yellowstone bison. But the future of a truly wild Yellowstone bison herd depends largely upon Montana's position on allowing bison outside the Park.

Bailey 2017, *Genetic Adequacy of Yellowstone Bison*, at 3.

On genetic grounds alone, an effective population size of 5,000 or more is needed for Yellowstone bison to withstand, adapt, and persist in an unpredictable and fluctuating environment subject to catastrophic events, rapid climate change and variability.

> [T]o maintain normal adaptive potential in quantitative characters under a balance between mutation and random genetic drift (or among mutation, drift, and stabilizing natural selection), the effective population size should be about 5000 rather than 500 (the Franklin-Soulé number). Recent theoretical results suggest that the risk of extinction due to the fixation of mildly detrimental mutations may be comparable in importance to environmental stochasticity and could substantially decrease the long-term viability of populations with effective sizes as large as a few thousand. These findings suggest that current recovery goals for many threatened and endangered species are inadequate to ensure long-term population viability.
>
> . . .
>
> Excluding recessive lethal mutations, and whether or not we include stabilizing selection, it therefore appears that the effective population size necessary to maintain a high proportion of the potentially adaptive, additive genetic variance that would occur in a large population requires effective population sizes an order of magnitude larger than the original Franklin-Soulé number, increasing the management goal from $N_e = 500$ to $N_e = 5000$.

Lande 1995 at 782, 786.

> Of course, $N_e = 5000$ should not be regarded as a magic number sufficient to ensure the viability of all species, because of differences among characters and among species in genetic mutability and differences in environmental fluctuations and selective pressures to which populations are exposed. Maintenance of potentially adaptive genetic variation in single-locus traits (such as major disease resistance factors), which have mutation rates on the order of $10^{-6}$ per allele per generation, may require much larger effective population sizes, on the order of $10^4$ or $10^5$ (Lande & Barrowclough 1987; Lande 1988).
>
> . . .

> The above results cast doubt on whether populations of many threatened and endangered species will maintain adequate evolutionary potential and long-term genetic viability unless they recover to much large sizes. Effective population sizes generally are substantially lower than actual population sizes because of fluctuations in population size, high variance in reproductive success, and unequal sex ratios (Wright 1969; Crow & Kimura 1970; Lande & Barrowclough 1987); maintaining effective population sizes of several thousand in the wild therefore will usually require average actual population sizes on the order of $10^4$ or more. Synergistic interactions among different genetic and demographic factors contributing to the risk of population extinction (Gilpin & Soulé 1986) are likely to cause the minimum population sizes for long-term viability of many wild species to be much larger than $10^4$.

Lande 1995 at 789.

Lande's results and Hedrick's recommendations are consistent with Traill's study of population viability who found "both the evolutionary and demographic constraints on populations require sizes to be at least 5000 adult individuals." Traill et al. 2010 at 30 (comparing minimum viable populations rates of hundreds of species while acknowledging "similarities are not strictly equivalent, and are a result of evaluation of some non-overlapping factors, meaning minimum viable population size in many circumstances will be larger still.").

> **Minimum viable population** (MVP) is a lower bound on the population of a species, such that it can survive in the wild. This term is used in the fields of biology, ecology, and conservation biology. More specifically, MVP is the smallest possible size at which a biological population can exist without facing extinction from natural disasters or demographic, environmental, or genetic stochasticity.

U.S. Fish & Wildlife Service 2016 at 20–21 (emphasis in the original).

State and federal managers are driving and increasing the risk of local and regional extinction for wild Yellowstone bison based on an outdated and flawed analysis.

PHOTO: BFC Archives

The State of Montana's and Yellowstone National Park's bison management plan is a flawed plan operating on

an invalid Environmental Impact Statement: the 15-year life of the plan analysis ran its' course in 2015.

The 15-year life of the plan analysis could not and did not foresee impacts to the Yellowstone bison population and the ecosystem beyond this timeframe. *See* e.g., U.S. Dept. of the Interior & U.S. Dept. of Agriculture 2000 FEIS Vol. 1 (enter "life of the plan" into Adobe Reader's find feature).

Furthermore, State and federal managers have avoided undertaking an independent science-based review of the assumptions driving its' outdated regulatory plan.

Indeed, after providing notice of its' intent to prepare a new Environmental Impact Statement in 2015, the State of Montana and Yellowstone National Park failed to produce an updated scientific analysis on the impacts of its' actions. U.S. National Park Service 80 Fed. Reg. 13603 (Mar. 16, 2015).

Belatedly, in 2022, Yellowstone National Park terminated its' prior analysis with the State of Montana and announced its' intent to produce a new Environmental Impact Statement. U.S. National Park Service 87 Fed. Reg. 4653 (Jan. 28, 2022).

In response, Montana's Governor Greg Gianforte requested Yellowstone National Park withdraw its' notice, and defer to the "State as to what management actions may be palatable, and which are unacceptable." Gov. Gianforte 2022 at 2.

Furthermore, the Governor wrote:

- The "success of the proposed alternatives is contingent upon Montana's cooperation and agreement."
- The assumptions of allowing more bison to roam across a larger landscape for public and tribal hunters "are incorrect."
- "Montana's tolerance is limited" and expansion of government-imposed "tolerance" zones "presumes too much."
- "[T]he failure to successfully meet the 3,000 goal does not mean that the goal should be changed, or, worse, revised to embrace failed management." (Demanding the baseline for analyzing "No Action" should be the government's agreed upon overall target population of 3,000 bison as decided in 2000).
- The alternatives for evaluation should include "an in-park disease suppression regime" for bison.

Gov. Gianforte 2022 at 1–4.

In spite of significant changes in federal brucellosis rules benefitting cattle ranchers in the tri-state region, State and federal managers have failed to account for the changed circumstances favoring natural regulation of bison in the wild. *See* e.g., Montana Dept. of Livestock 2013 (approving an 'actionable' zone to pre-emptively haze bison from breaching the "tolerance zone boundaries"); Yellowstone National Park 2011 (permitting the taking of 108 bison for the U.S. Dept. of Agriculture APHIS's evaluation of sterilization using GonaCon, an immunocontraceptive); National Park Service 80 Fed. Reg. 13603–13604 (Mar. 16, 2015) (5 of 6 proposed alternatives would confine migrations, limit and reduce bison range and or abundance in the ecosystem, extensively manage bison rather than cattle using veterinary and livestock management practices, and continue the practice of selecting against disease — and disease resistance — in the bison genome through government trapping for slaughter, vaccination, and sterilization).

In spite of several incidents of Montana, Idaho, and Wyoming cattle testing positive for *Brucella abortus* — none of which came from bison in the wild — the Designated Surveillance Areas continues to protect producers in each State. Yellowstone Center for Resources 2012 at 43; U.S. Dept. of Agriculture 2012 at 6–7.

Several taxpayer-supported programs are in place to assist producers in managing cattle.

Producers in Montana's Designated Surveillance Area are compensated for testing, vaccination, and handling of cattle. Montana Dept. of Livestock, *Economic Analysis: MDOL's DSA Worth Millions to Cattle Producers, State,* (Mar. 4, 2011).

Ranchers statewide have saved $5.5 to $11.5 million annually since the Designated Surveillance Area went into effect in 2010. Montana Dept. of Livestock 2011 at 3.

Wyoming compensates producers in its' Designated Surveillance Area for testing, spaying, and vaccinating cattle. Wyo. Admin. R. ch. 2 §§ 1–17 (2019); Wyo. Admin. R. ch. 6 §§ 1–5 (2020).

In Idaho, there is no charge for testing cattle conducted at the State laboratory, and veterinary costs can be reimbursed for testing cattle within the Designated Surveillance Area. Idaho Dept. of Agriculture 02.04.20; Idaho Dept. of Agriculture 2022.

In the vast Yellowstone ecosystem and Greater Yellowstone bioregion, managing cattle remains the most effective and least costly disease management approach.

> [E]stablishing a local brucellosis infection status zone for cattle in the greater Yellowstone area of Montana and testing all cattle within this area for brucellosis (with a 'split status' for the rest of Montana), has been discussed earlier (USDOI & USDA 2000a). Our results highlight the benefits of this strategy and suggest that transmission of brucellosis from bison to cattle even under a 'no plan' (no management of bison) strategy is likely to be a relatively rare event, and the costs of yearly testing of cattle ($2500 to $5000 a year per test for the cattle in areas shown in Fig. 1) are a thousand-fold lower than the current management plan.

Kilpatrick et al. 2009 at 8, *see also* Table 1 at 4.

Yet, the current power structure has led to introduced cattle being protected to the detriment of bison in the absence of any scientifically documented evidence of disease transmission from Yellowstone bison to cattle in the wild. Lancaster 2005 at 427 (citing National Research Council 1998); *see also* National Academy of Science's 2017 report indicating wild elk — not wild bison — are the source of brucellosis transmission risk to cattle grazing in the range of wildlife populations.

Under the State of Montana's and Yellowstone National Park's bison management plan, managers continue to operate under faulty assumptions and outdated information, in contravention of the National Park Service's mandate to "use the best available scientific and technical information and scholarly analysis" and "actively seekout and consult" the public and Indigenous tribes in all decisions made. National Park Service 2006 at 22, 24–25.

The unproven assumption that bison are a disease risk to managed cattle in the Yellowstone ecosystem—the entire basis for a decades-long series of extensive and intensive management actions targeting bison—was never quantified by any regulatory agency in three volumes of government analysis.

A belated quantitative risk assessment published in 2012 found the exposure risk from wild bison to cattle was miniscule 0.0–0.3% compared to wild elk to cattle 99.7–100% of the total risk. Yellowstone Center for Resources 2012 at 40.

In disregarding the evidence presented in the best available studies and reports cited herein, State and federal managers continue to use governmental powers in prejudicial, arbitrary, and unreasonable management actions directed at killing Yellowstone bison roaming their habitat and range.

Because it is not based on the best available science and jeopardizes the Yellowstone bison population, the U.S. Fish & Wildlife Service must examine and investigate the inadequacy of Montana's and Yellowstone National Park's bison management plan in the agency's threats assessment and status review.

***State and federal livestock management and veterinary policy is a threat to Yellowstone bison in the wild.***

> Proposals to vaccinate animals, use artificial birth control, and to limit numbers of wildlife within parks would impair natural selection and the wild genetic qualities of populations.

Bailey 2016 at 8.

In the late 1960s and early 1970s, Yellowstone National Park capitulated to State and federal livestock and veterinary agencies and signed several "boundary control agreements" with Montana, Idaho, and Wyoming excluding Yellowstone bison from their range and habitat on millions of acres of National public trust lands. Yellowstone National Park 1997 at 83.

Livestock and veterinary control of policy culminated in 1995 with the Montana Legislature transferring authority for wild bison to the Montana Dept. of Livestock (Mont. Code Ann. § 81-2-120), a statute which then Governor Marc Racicot used to sue Yellowstone National Park "because the Park failed to prevent bison migrations into Montana and because APHIS threatened to downgrade Montana's brucellosis-free status based only on the presence of diseased wild bison in the state." Cromley 2002 at 72.

In 2000, the State of Montana and Yellowstone National Park issued separate Records of Decision adopting veterinary policy and the use of livestock management practices in the government's bison management plan.

State and federal livestock management and veterinary policy is a threat to bison because strict application of the rules driving the government's bison management plan destroys the migrants, depletes bison range and habitat, and restricts the native species' access to food, water and cover.

For detailed evidence and analysis of how State and federal veterinary policy threatens Yellowstone bison, *see* factor 8.C.

Ongoing appropriations totaling approximately $600,000 a year from the U.S. Dept. of Agriculture Animal and Plant Health Inspection to the Montana Dept. of Livestock further entrenches the institutional control over bison management in Yellowstone National Park, and the exclusion of Yellowstone bison from millions of acres of range and habitat on National public trust lands. Buffalo Field Campaign 2016.

Because encroachment of livestock and veterinary agency authority over Yellowstone bison has entrenched the policies of managing bison as livestock, the U.S. Fish & Wildlife Service must examine and investigate this institutionalized regulatory scheme in the agency's threats assessment and status review.

***The States' statutory framework threaten or endanger Yellowstone bison in the wild.***

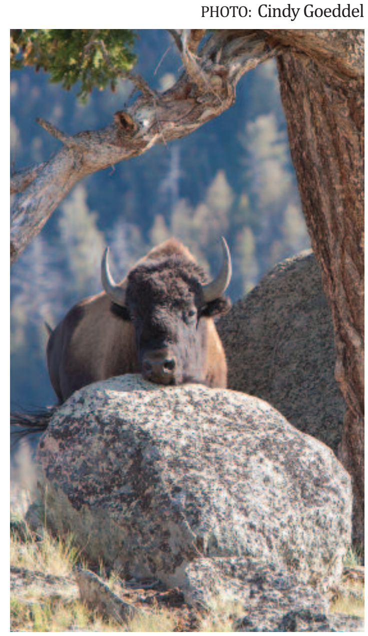
Enforcement of State regulatory mechanisms in Montana, Idaho, and Wyoming threaten or endanger Yellowstone bison in the wild.

State law and policy eliminating Yellowstone bison in their range is codified in Montana, Idaho, and Wyoming statutes.

> [The Montana Department of Livestock] is granted broad and discretionary authority to regulate publicly-owned bison that enter Montana from a herd that is infected with a dangerous disease (YNP bison) or whenever those bison jeopardize Montana's compliance with state or federally administered livestock disease control programs including the authority to remove, destroy, take, capture, and hunt the bison (§ 81-2-120(1)-(4) MCA)).

Montana Fish, Wildlife & Parks and Montana Dept. of Livestock 2013 at 13 (implicitly admitting there is no provision for conserving Yellowstone bison roaming wild in the State; the code is designed to preclude a self-sustaining wild bison population in Montana).

PHOTO: Cindy Goeddel



Montana Fish, Wildlife & Parks is required to cooperate with the Dept. of Livestock "in managing publicly owned wild buffalo or bison that enter the state on public or private land from a herd that is infected with a dangerous disease, as provided in 81-2-120, under a plan approved by the governor." Thigpen 2013 at 4 (footnote omitted).

Under Montana law, the role of Fish, Wildlife & Parks in managing bison is subservient to the Dept. of Livestock and the State veterinarian. For example, hunting wild bison "is permitted only when authorized by the department of livestock under the provisions set forth in 81-2-120." Mont. Code Ann. § 87-2-730 (2021).

Montana law prohibits Fish, Wildlife & Parks from transferring or releasing wild bison "on any private or public land in Montana that has not been authorized for that use by the private or public owner." Thigpen 2013 at 5 (footnote omitted).

In addition, State law requires an extensive list of conditions be met for Fish, Wildlife & Parks to consider any third-party proposal for reintroducing wild bison in Montana. For detailed evidence and analysis of how the State of Montana abandoned its' duty to restore bison in the wild, *see infra*.

Bison's persistence in the wild anywhere in the State hinges on the uncertainty in who is elected Montana's governor, the makeup of Montana's legislature, and the political will to recognize or rollback "tolerance areas" under livestock management authority.

Representations made in court by the State of Montana is evidence of, and reinforces, the lack of protection for Yellowstone bison in any regulatory action that may be taken for the foreseeable future:

> "Montana could manage for *zero* genetic diversity of Yellowstone bison in the state."

*Western Watersheds Project v. State of Montana*, No. DV–10–317A at 18 (Sept. 27, 2012) (quoting Respondents' Reply Brief in Support of Motion for Summary Judgment) (emphasis in the original).

Government intolerance, as expressed in State law and policy, limits and confines the range of migratory bison to less than 0.4% of the habitat in Montana. Montana Fish, Wildlife & Parks and Montana Dept. of Livestock 2013 at 107.

As observed, current and predicted habitat use by bison is a fraction of the 0.4% of their range in Montana. Wallen 2012.

The evidence is transparently written into the law: the State's regulatory arc threatens or endangers Yellowstone bison roaming their range in Montana because the code authorizes the Dept. of Livestock to manage for the near extinction of the only wild population.

The U.S. Fish & Wildlife Service must examine and investigate the regulatory threat set forth in Montana law to the persistence of wild Yellowstone bison in the agency's threats assessment and status review.

***There is no regulatory mechanism in place ensuring Yellowstone bison persist as a self-sustaining population on National Forests in the bioregion.***

Even with its' federal authority to cooperate with States "for the protection of wildlife," (36 C.F.R. § 241.1) there is no regulatory mechanism in place ensuring Yellowstone bison persist as a viable, self-sustaining population on National Forests in Region 1, Region 2 and Region 4.

There is no regulatory refuge for Yellowstone bison migrating on the Custer Gallatin, Shoshone, and Caribou-Targhee National Forests. State codes in Montana, Idaho, and Wyoming call for managing for the near extinction, eradication, and elimination of migratory bison.

The State and federal regulatory arc continues to imperil the biological phenomena of Yellowstone bison's long-distance migrations.

For a migratory species that has lost all 14 long distance migration routes in the Greater Yellowstone bioregion (Berger 2004 at 322), the destruction of pathways and dispersal patterns decrease the size and extent of the ecological settings Yellowstone bison can range.

Losses in geographic variation are compounded by State and federal actions thwarting Yellowstone bison's migrations across their National Forest range, with long-lasting and far-reaching consequences on bison's capacity for surviving and adapting in the wild.

Current government imposed "tolerance zones" effectively cut-off Northern herd bison from migrating to substantial portions of their home range, e.g., beyond Gardiner basin to Livingston, Montana and the Northern Great Plains (Gates et al. 2005 at 79–80 "prehistoric annual range . . . occupied continuously by bison for ca. 10,000 years") and the adjoining Tom Miner basin (Geremia & Cunningham 2018 at 9–10).

The government's "tolerance zones" also cut-off Central herd bison from migrating to substantial portions of their home range, e.g., in and beyond Hebgen basin. Montana Fish, Wildlife & Parks and Dept. of Livestock 2013 maps at 22, 23, 25; Gov. Bullock 2016 (Erratum).

Government regulatory threats doubly harm the Central herd's unique migrations to both the Gardiner and Hebgen basins.

Migration is an essential life-history trait for wild Yellowstone bison allowing for adaptation in an unpredictable and rapidly changing environment, and evolutionary resilience in a climate being disrupted on a regional and global scale.

State and federal regulatory actions are endangering Yellowstone bison's long-distance migrations, corridor use, and connectivity to habitats in their home range.

A fusillade of government action is undermining the Yellowstone bison population's representation and adaptation to changing environmental conditions on National Forests across three regions. Ongoing government action is also striking against bison's resiliency and adaptation to shifting conditions in an environment undergoing rapid climate change.

The essential backup (redundancy) of habitat for the Yellowstone bison population to withstand catastrophic events and sustain diverse herds in the wild is undercut by enforcement of State codes and the lack of federal regulatory mechanisms on National Forests in the bioregion.

The U.S. Fish & Wildlife Service must examine and investigate the inadequacy of National Forest regulatory mechanisms in the agency's threats assessment and status review.

***Bison are a critically imperiled species in the State of Idaho. Under Idaho law, migratory Yellowstone bison are eradicated.***

> It is the purpose of the provisions of this section to provide for the management or eradication of bison . . . .

Idaho Code § 25-618(1) (2021).

Yellowstone bison migrating through and beyond the Custer Gallatin or Yellowstone National Park are purposely eradicated under Idaho law despite being identified as a critically imperiled species in the State.

Wild bison migrate onto the Caribou-Targhee National Forest in Region 4 and elsewhere in Idaho, where the species conservation ranking is S1, a "critically imperiled species at high risk because of extreme rarity . . ." Adams & Dood 2011 at 108.

Under Idaho law, State and federal agents shoot or eliminate any wild bison migrating from the Yellowstone population. Idaho Code § 25-618 (2021).

Based on Buffalo Field Campaign observations and government reports, Idaho law is enforced to eradicate bison migrating onto the Caribou-Targhee National Forest and adjacent lands — the only place the wild species is found in the State. Buffalo Field Campaign 2009 (lone bull shot south of Twin Creek); Associated Press 2012 (two bull bison shot near Island Park); Montana Fish, Wildlife & Parks and Montana Dept. of Livestock 2013 at 39 ("bison have occasionally migrated into Idaho with the most recent occurrence being July 2012 when two bull bison made the 20 mile trek to Island Park" and were shot); Buffalo Field Campaign 2017 (two bulls shot near Henrys Lake Flats).

Government intolerance in Idaho law eradicating Yellowstone bison genetic diversity and eliminating exploratory movements on the Caribou-Targhee National Forest to the Henrys Fork basin and Island Park is certain to continue for the foreseeable future.

The U.S. Fish & Wildlife Service must examine and investigate the regulatory threat set forth in Idaho law to the persistence of wild Yellowstone bison in the agency's threats assessment and status review.

***The State of Wyoming manages for the extirpation of limited numbers of migratory Yellowstone bison in restricted areas. In enforcing Wyoming law, Yellowstone bison are eradicated.***

Beyond Yellowstone National Park, bison migrating into Wyoming's jurisdiction are limited in numbers, confined to restricted areas, and managed for extirpation.

Bison migrations onto the Shoshone National Forest in Region 2 occurred over most of the latter 20th century and became consistent after a major forest fire in 1988. Wyoming Game & Fish Department 2008 at 7, 10–11 (documenting bison movements going back to 1966).

From 1988–1997, up to 30 bison were annually observed on the North Fork of the Shoshone River. Bulls were documented in all years (1988–2007). After two seasons of being hunted, only individual bull bison (less than 10) were observed. Wyoming Game & Fish Department 2008 at 12.

State law calls for Yellowstone bison migrating onto the Shoshone National Forest in Wyoming to be shot by hunters or killed off by government agents.

The limited numbers Wyoming has set limit and reduce Yellowstone bison's exploratory movements and do not allow for female-led groups except in a portion of the Teton Wilderness.

In summary, the fundamental recommendation for the Absaroka Bison Management Area is

> to maintain the current low number and specific distribution of bull bison in the North Absaroka and Washakie Wilderness Areas (no more than 25), and on Shoshone National Forest (SNF) lands along the North Fork of the Shoshone River (no more than 15). In addition, the WGFD [Wyoming Game & Fish Department] may allow up to 25 bison in the Yellowstone River drainage within the Teton Wilderness. The WGFD should not allow cow bison to occupy this management area except in the Yellowstone River drainage within the Teton Wilderness. Removing bison would be accomplished by hunters when possible, or by Department personnel when hunting is not possible.

Wyoming Game & Fish Department 2008 at 3 (explicitly admitting the "fundamental" course of action is for Wyoming to manage for the elimination of Yellowstone bison).

Under State law, the migratory species falls under Wyoming Livestock Board authority who, by rule, can order Wyoming Game & Fish to kill bison. Wyo. Stat. Ann. § 23-1-302(a)(xxvii) (2020); Wyoming Game & Fish Department 2008 at 15.

The outcome of enforcing Wyoming law and placing the native species under livestock authority limits exploratory movements on the Shoshone National Forest and eliminates Yellowstone bison genetic diversity to near zero.

In 2011, Region 2 proposed listing bison as a sensitive species, the precursor to today's species of conservation concern.

On April 1, 2011, Regional Threatened Endangered & Sensitive Species Program Leader Nancy Warren recommended American bison be listed to "encourage consideration of restoration opportunities in the future" writing that the loss of bison, a keystone species, "may have had cascading effects on grassland ecosystem function and the diversity of native plant and animal species."

On April 7, 2011, Deputy Regional Forester Antoine L. Dixon sent a letter to Forest Supervisors proposing wild plains bison be added to the sensitive species list in Region 2.

On May 2, 2011, Shoshone National Forest Forest Supervisor Joseph G. Alexander requested bison be removed from the proposed list, citing "[e]xisting state management plans may conflict with how the Shoshone would manage for species viability. Until further evaluation of this situation can occur, I respectfully ask for the species to be removed from the list."

On April 29, 2011, Region 2's Threatened Endangered & Sensitive Species Program Leader withdrew her recommendation writing: "At this time no self-sustaining herds of wild plains bison exist on National Forest System lands. Forests should consider working towards the possibility of restoring wild plains bison where feasible on NFS lands in the future."

The record shows Region 2 ceded the National Forest's regulatory authority and duty to manage for bison viability and list the sensitive species because of *potential conflict* with Wyoming's "management plans" calling for the taking of all bison migrating onto the Shoshone National Forest.

Without federal legal protection or effective regulatory action, government intolerance in Wyoming law limiting exploratory movements on the Shoshone National Forest and reducing Yellowstone bison genetic diversity to zero is certain to continue for the foreseeable future.

The U.S. Fish & Wildlife Service must examine and investigate the regulatory threat set forth in Wyoming law to the persistence of wild Yellowstone bison in the agency's threats assessment and status review.

***Despite credible and relevant scientific evidence raising substantial concern about Yellowstone bison's ability to persist as a viable population on the National Forest, the Regional Forester denied bison met the criteria for listing as a species of conservation concern in Region 1.***

"The American plains bison (*Bison bison bison*) is a keystone and iconic wildlife species. It is also a species of conservation concern (Redford and Fearn 2007; Sanderson et al. 2008; Gates et al. 2010)." Licht 2017 at 83 (citing the "severe population bottleneck" and small, isolated populations of bison which are prone to inbreeding and reductions in fitness).

The National Forest planning rule identifies a species of conservation concern as:

> a species . . . that is known to occur in the plan area and for which the regional forester has determined that the best available scientific information indicates substantial concern about the species' capability to persist over the long-term in the plan area.

U.S. Forest Service 77 Fed. Reg. 21162, 21265 (Apr. 9, 2012); 36 C.F.R. § 219.9(c).

Listing Yellowstone bison as a species of conservation concern would have imposed a duty on the Custer Gallatin to include a publicly enforceable standard "to provide the ecological conditions necessary to maintain a viable population" on the National Forest. Northern Region Regional Forester Leanne M. Marten Feb. 7, 2019 (citing 36 C.F.R. 219.9(b)(1)).

The National Forest planning rule defines a viable population as "a species that continues to persist over the long term with *sufficient distribution to be resilient and adaptable to stressors* and likely future environments" (§ 219.19) (emphasis added)." 77 Fed. Reg. 21162, 21217 (Apr. 9, 2012) (citing definition of viable population at 21272).

Furthermore, federal rules provide authority for the Chief, working through Regional Foresters and Forest Supervisors, to "determine the extent to which national forests or portions thereof may be devoted to wildlife protection," and to cooperate with States in formulating plans for "securing and maintaining desirable populations of wildlife species." 36 C.F.R. § 241.2.

The federal rules for protecting wildlife are ineffective for Yellowstone bison and their National Forest range and habitat in the bioregion.

It is not publicly transparent how Regional Forester Marten's assessment and evaluation for not listing Yellowstone bison as a species of conservation concern considered all public comment and the best available science, in contravention of National Forest planning rules requiring consideration of all public comment, documenting "the use of the best available scientific information," and ensuring "the rationale for decisions is transparent to the public." 77 Fed. Reg. 21162, 21192 (Apr. 9, 2012).

For example, the record does not demonstrate how the Regional Forester considered a report detailing evidence of threats and stressors undermining the migratory species' capability to persist over the long-term as a viable population on the National Forest. The report supporting listing bison as a species of conservation concern was endorsed by the Piikani Nation (2018) and Crow Creek Sioux Tribe (2018), twenty-three businesses, fifty-seven nonprofit and two ecumenical organizations, and 2,221 individuals. Signatories' Report 2018 entire.

The Rocky Mountain Tribal Leaders Council (2019) and Northern Cheyenne Tribe (2019) also supported listing bison as a species of conservation concern on the National Forest in Region 1.

Instead of transparently analyzing the best available science and evidence Regional Forester Marten released an unsubstantiated and conclusory statement:

> The species is secure and characteristic seasonal migrations are expected to continue in the plan area over the long-term. The GYA bison population has increased in recent years, reproduction and survival have been high, genetic diversity is significant, genetic connectivity appears to be increasing, and habitat is readily available and could support additional numbers and distribution of bison. Redundant security is provided by the the watchful, diverse eyes that adminster the adaptive interagency bison management plan.

U.S. Forest Service Northern Region, Rationale (species evaluations) used to identify animal and plant species as Species of Conservation Concern for the Custer Gallatin National Forest (April 22, 2021) (quoted passage in the original).

While Regional Forester Marten determined there is sufficient scientific information to conclude there is substantial concern about the long-term persistence of bison on the Custer Gallatin, her rationale is riddled with error and supposition and hangs on the unspecified "security" measures provided by the "watchful" eyes of the administrators of the government's bison management plan.

Yellowstone bison's genetic diversity has always been significant to the conservation of the wild species to which they belong. What is unknown is the rate and extent of loss in bison genetic diversity for each distinct herd under current management.

Management actions are likely driving changes that are contributing to the loss of bison genetic distinction on the Northern range through, for example, trapping bison from both herds who form social bonds in captivity and retain them upon release.

Erosion of genetic distinctiveness and loss of genetically distinct bison subpopulations is a serious cause for concern because overall variation is expected to increase in the presence of Yellowstone bison's subpopulation structure. Halbert et al. 2012 at 368.

There is no examination of loss of distinct bison subpopulation structure or genetic variation as a result of management actions that are driving or contributing to changes in the constitution of the Yellowstone bison population.

There is also no genetic connectivity for the isolated Yellowstone population because there is no other wild bison population elsewhere that is naturally contributing genetic diversity to the herds in Yellowstone.

The Central bison herd was decimated under the "watchful" eyes of the administrators of the government's current plan, and the genetically distinct subpopulation's numbers continue to be far below what is needed (census of 2000–3000) to prevent inbreeding and maintain genetic diversity according to population geneticists and conservation biologists referenced herein.

While National Forest habitat could support additional bison it is not "readily available" because the U.S. Forest Service has precluded availability by permitting cattle grazing in the bison's range, fencing schemes and highway guards that thwart bison's natural migrations and connectivity to habitat on the Custer Gallatin.

Regional Forester Marten's rationale is flawed. As a result, the regulatory mechanism of designating bison a species of conservation concern is not available to ensure a viable self-sustaining population on the National Forest.

***Bison are a species of concern in Montana. Despite the designation, the Custer Gallatin has adopted the State's intolerant regulatory framework for Yellowstone bison on National Forest lands in Montana.***

In Montana, the migratory species is listed as a "species of concern" and "considered to be 'at risk' due to declining population trends, threats to their habitat, and/or restricted distribution . . . making it vulnerable to global extinction or extirpation in the state." Adams & Dood 2011 at 32 (citations omitted).

Furthermore, Montana's Comprehensive Fish and Wildlife Conservation Strategy lists bison as Tier 1, a native species in "greatest conservation need. Montana Fish, Wildlife & Parks has a clear obligation to use its resources to implement conservation actions that provide direct benefit to these species, communities, and focus areas" (FWP, 2005, pp. 32)." Adams & Dood 2011 at 32.

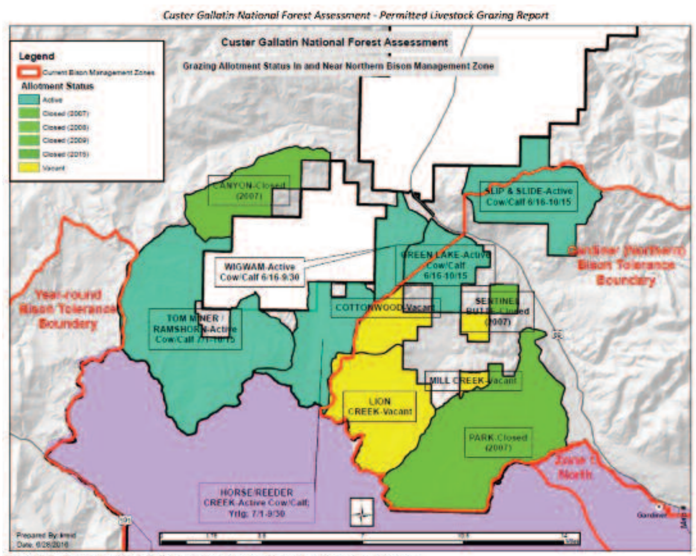


Figure D-8. General location of allotments in or near northern bison management zones

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Yet, the Custer Gallatin's forest plan provision for Yellowstone bison follows in lock step with Montana's regulatory intolerance by agreeing to "state-approved tolerance zones" for bison migrating in their home range. Custer Gallatin Proposed Action–Revised Forest Plan 2018 at 53–54.

For a migratory "at risk" species, the Custer Gallatin's guidelines call for following government "management zones" and "management zone boundaries" imposed on Yellowstone bison. Custer Gallatin National Forest Land Management Plan 2022 at 58.

For a migratory species facing more loss of and threats to habitat and government restricted range, the Custer Gallatin's guidelines permit imposing barriers on Yellowstone bison movements "to achieve interagency targets for bison population size and distribution." Custer Gallatin National Forest Land Management Plan 2022 at 58.

The Custer Gallatin's provisions for bison are a weak and insignificant regulatory mechanism written to justify an unsatisfactory state of affairs.

Through its' voluntary participation in the State of Montana's and Yellowstone National Park's bison management plan, the Custer Gallatin has adopted arbitrarily imposed State "tolerance zones" that destroy Yellowstone bison naturally migrating beyond the Zone 3 boundary on the National Forest.

It is unknown how much National Forest habitat Yellowstone bison are excluded from in Zone 3. The ecological impact of Zone 3 on bison migration corridors and habitat connectivity is also unknown because evidence is not being systematically examined for publication.

The Custer Gallatin cannot reconcile adopting Zone 3 as a State-enforced regulatory standard with the National Forest planning rule requirement to maintain or restore connectivity for migratory bison.

Even with the regulatory framework of the National Forest planning rule, as practiced and interpreted by the Custer Gallatin, it cannot be relied on to ensure the persistence and viability of Yellowstone bison herds on the National Forest.

The lack of regulatory mechanisms to ensure Yellowstone bison persist is preventing the native species from occupying four out of five landscapes on the Custer Gallatin.

At the same time, the National Forest's cattle grazing program and permitting activities are degrading habitat and depleting bison in the remaining landscape on the Custer Gallatin.

For detailed evidence and analysis of how the National Forest's permitting program threatens or endangers Yellowstone bison's range and habitat, *see* factor 8.A.

As such, the Custer Gallatin's provision for bison is an inadequate regulatory mechanism and must be viewed and examined as a threat to the persistence of Yellowstone's bison herds as a viable, diverse, and self-sustaining population on the National Forest.

Clearly, the Custer Gallatin has ceded managing a migratory species and their habitat to a State regulatory scheme that is threatening Yellowstone bison diversity, viability, and connectivity to their home range on National Forest lands.

The National Forest's authority to provide habitat for viable and diverse herds and a self-sustaining Yellowstone bison population is overshadowed by the Custer Gallatin's voluntary participation in a plan dictated by Mont. Code Ann. § 81-2-120 (2021).

There are no publicly enforceable forest plan standards for bison and the Custer Gallatin National Forest has specifically disavowed any regulatory requirement providing for bison diversity. *See infra, Western Watersheds Project v. Salazar*, No. 9-09–cv–00159–DWM Defendants' Answer to Complaint (Feb. 18, 2010); *Western Watersheds Project v. Salazar*, No. 11–35135 Federal Defendants–Appellees' Response Brief (Feb. 3, 2012).

"Vague, voluntary, speculative, and unenforceable measures found in plans are generally not considered a sufficient regulatory mechanism." Nie & Schembra 2014 at 10284 (quoting *Oregon Natural Resources Council v. Daley*, 6 F. Supp. 2d 1139, 1153–56, 29 ELR 20514 (D. Ore. 1998) (footnote omitted).

The Custer Gallatin's forest plan provision for Yellowstone bison is voluntary, speculative, and unenforceable.

It is also an inadequate regulatory mechanism for conserving a self-sustaining population of the migratory species because it excludes Yellowstone's bison herds from substantial portions of their National Forest habitat and range.

***The Custer Gallatin has erected or permitted barriers thwarting Yellowstone bison's natural migrations on the National Forest. These barriers disrupt habitat connectivity the National Forest planning rule requires be maintained or restored.***

> The best opportunity for maintaining species and ecological integrity is to maintain or restore the composition, structure, ecological functions, and habitat connectivity characteristics of the ecosystem. These ecosystem components, in essence, define the coarse-filter approach to conserving biological diversity.

U.S. Forest Service Final Programmatic Environmental Impact Statement 2012 at 126.

> The reason for movement also plays a role in the assessment of habitat connectivity. For example, long-range dispersal movements may contribute to gene flow between populations, genetic rescue of small or isolated populations, and/or colonization of new areas (Parks et al. 2012).
>
> . . .
>
> Given the importance of habitat connectivity for maintaining species viability and associated biological diversity, a great deal of attention has been devoted to identifying potential movement corridors, as well as potential barriers to movement, for terrestrial wildlife species (USDA Forest Service 2006; Hansen 2006; WGA 2008; Cushman et al. 2010; Parks et al. 2012; Haber and Nelson 2015).

Custer Gallatin Draft Terrestrial Wildlife Report 2016 at 12.

> A commitment to restore or maintain landscape connectivity to facilitate movement, migration, and dispersal is a significant addition to the planning rule.

Schultz et al. 2013 at 5.

Despite the National Forest regulatory requirements providing for diversity, viability of native species, and habitat connectivity, the Custer Gallatin has adopted the State of Montana's intolerant regulatory framework.

"The framework for management of Yellowstone bison is found in the Interagency Bison Management Plan, which delineates management zones where bison presence is tolerated and management is emphasized." Custer Gallatin National Forest Land Management Plan 2022 at 57.

> The Custer Gallatin National Forest's involvement in management of bison is primarily through participation in the Interagency Bison Management Plan. There are three permitted activities associated with Custer Gallatin National Forest lands relative to bison. These include a permit for a portable temporary trapping facility on Horse Butte (issued in 1999

> and renewed for 10 years in 2009, which was used 5 of the first 10 years and not since), a permit for Montana Fish, Wildlife & Parks to construct and maintain a fence associated with the bison guard at Yankee Jim Canyon, and most currently and in progress, a permit to construct and maintain a fence (Montana Department of Highways) associated with the bison guard on Highway 287 near Hebgen Dam.
>
> . . .
>
> Bison movements in areas of no tolerance are controlled by strategically placed "bison guards" on the highways which block movement of bison on the northern range from entering Yankee Jim Canyon on U.S. Highway 89 and from leaving the Hebgen Basin to the west on U.S. Highway 287 near Hebgen Dam. Bison are also hazed from areas of no tolerance such as private lands in the Hebgen Basin and areas south of the Madison River.

Custer Gallatin Draft Terrestrial Wildlife Report 2016 at 122, 128.

In addition to the State of Montana carrying out "hazing" or harassment operations removing bison from the National Forest, the Custer Gallatin has approved erecting several barriers in migration corridors to purposefully thwart bison migration.

> The fence installation will be more or less perpendicular to the river with the goal of preventing bison from moving further downstream.

Gallatin National Forest 2011 at 1 (approving 900 feet of jackleg fencing uphill from both sides of the Yellowstone River, associated gates and "cattle guards" on highway 89 near Yankee Jim Canyon in Gardiner basin).

> The only identified effect to wildlife is to prevent bison from migrating further west, toward the Madison Valley, which is exactly the purpose of the fence.

Custer Gallatin National Forest 2016 at 3 (approving 30 feet of jackleg fencing, gate, and associated "Bison Cattle Guard" on highway 287 in Hebgen basin).

> [T]he Holder is authorized to construct and maintain a bison corridor fence . . . .

Gallatin National Forest 2009 at 1 (approving 695 feet of electrified fencing, associated gates and "cattle guards" in Gardiner basin).

Unless the Custer Gallatin withdraws the agency's special use permits, these barriers to habitat connectivity in wildlife corridors will have harmful long-term consequences on bison's viability and accelerate the associated loss of biological diversity bison provide as a keystone species and ecological engineer in the Yellowstone ecosystem.

***Ineffective and inadequate regulatory mechanisms on National Forests in the bioregion threaten or endanger Yellowstone bison in the wild.***

There are 8,103,157 acres of habitat contiguous to Yellowstone National Park on the Custer Gallatin, Shoshone, and Caribou-Targhee National Forests. However, National public trusts lands are primarily allocated for grazing cattle and for the killing or eradication of Yellowstone bison.

Habitat on National Forests in the Yellowstone region is key to the survival of the only bison population continuously inhabiting their indigenous range in the wild. "The Custer Gallatin National Forest is the only national forest occupied by wild bison for a portion of the year." Custer Gallatin Final Terrestrial Wildlife Report 2017 at 125.

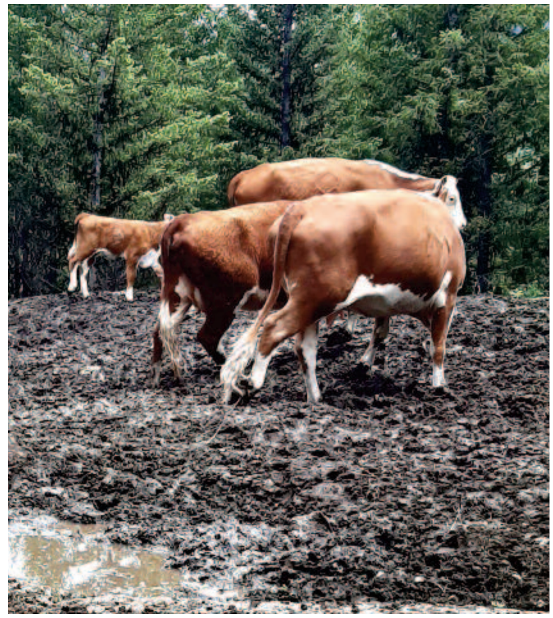

PHOTO: Western Watersheds Project

The Custer Gallatin, Shoshone, and Caribou-Targhee National Forests are unique in having native bison that have continuously ranged the Yellowstone ecosystem since the recession of the last glaciers 10,000 to 12,000 years ago. Gates et al. 2005 at vi.

Yet, there is no adequate regulatory mechanism in place to ensure bison persist as a self-sustaining population with unique herds on National Forests in the Yellowstone ecosystem or the Greater Yellowstone bioregion.

Regulatory intolerance for wild Yellowstone bison embedded in the State codes of Montana, Idaho, and Wyoming is in conflict with the National Forest Management Act's requirement providing for native species diversity and viability.

In Region 2, the Forest Service's Threatened, Endangered & Sensitive species program leader's recommendation to list bison as a sensitive species was squelched based on the perception such a designation *could* conflict with Wyoming law.

In Region 4, there is no regulatory mechanism to preserve any migratory bison who are eradicated as a matter of law in Idaho.

In Region 1, the Regional Forester rejected evidence Yellowstone bison met the "substantial concern" criteria for listing as a species of conservation concern.

> *Federal land management agencies have an obligation, and not just the discretion, to manage and conserve fish and wildlife on federal lands. We debunk the myth that "the states manage wildlife and federal land agencies only manage wildlife habitat." The myth is not only wrong from a legal standpoint, but it leads to fragmented approaches to wildlife conservation, unproductive battles over agency turf, and an abdication of federal responsibility over wildlife. Another problem exposed is how the states assert wildlife ownership to challenge the constitutional powers, federal land laws, and supremacy of the United States. While the states do have a responsibility to manage wildlife as a sovereign trust for the benefit of their citizens, most states have not addressed the conservation obligations inherent in trust management; rather,*

> *states wish to use the notion of sovereign ownership as a one-way ratchet—a source of unilateral power but not of public responsibility. Furthermore, the states' trust responsibilities for wildlife are subordinate to the federal government's statutory and trust obligations over federal lands and their integral resources.*

Nie et al. 2017 at 798 (emphasis in the original).

As public trustees, National Forests in three regions are neglecting their obligation to conserve imperiled bison and the migratory species' range and habitat, and are failing to "stop the practice of reflexively acquiescing to state claims of wildlife authority." Nie et al. 2017 at 905.

Without clear direction classifying bison as a species of conservation concern and enforceable standards providing for connectivity to habitat and diversity of wild bison herds, forest plans cannot be relied on for ensuring the viability and persistence of Yellowstone bison on National Forests in the tri-state region of Montana, Idaho, and Wyoming.

In addition, representations made in court by the U.S. Forest Service is evidence of, and reinforces, the lack of protection for Yellowstone bison in any regulatory action that may be taken for the foreseeable future:

> Defendants deny that the Forest Service is required by applicable law to provide or maintain a viable population of bison on the GNF [Gallatin National Forest] or determine what a minimum viable population would be.
>
> . . .
>
> Defendants deny the Forest Service is excluding bison from the GNF and deny it is failing to fulfill Forest Plan direction.

*Western Watersheds Project v. Salazar*, No. 9:09–cv–00159–DWM, Defendants' Answer to Complaint at 30–31, 33 (Feb. 18, 2010) (similar statements of regulatory commitment are made at 29 and 34).

> Neither NFMA [National Forest Management Act] nor the Forest Plan require the Forest Service to ensure a viable population of bison on the Gallatin.

*Western Watersheds Project v. Salazar*, No. 11–35135, Federal Defendants–Appellees' Response Brief at 15 (Feb. 3, 2012).

Representations of the regulatory authority's duty in court must be taken at face value. As such, there is no regulatory mechanism providing for the migration, natural adaptation, and persistence of Yellowstone bison herds as a viable and diverse population on National Forests in the bioregion.

***The State of Montana abandoned its' duty to restore bison in the wild.***

Montana's statewide plan for reintroducing bison as wildlife was abruptly abandoned in 2015. The principal biologist leading the planning effort since 2009 was forced to accept re-assignment as a brucellosis technician (and a pay cut) or retire after 40 years with Fish, Wildlife & Parks. Wright 2015; Lundquist 2015.

When Arnie Dood's Endangered Species Coordinator position with Montana Fish, Wildlife & Parks was eliminated, it also terminated the statewide bison reintroduction planning effort which was halted in the summer/fall of 2015. Montana Fish, Wildlife & Parks, Ken McDonald letter to Arnie Dood (May 11, 2015).

> The purpose of this Environmental Impact Statement (EIS) is to determine if bison restoration is appropriate and if so, what potential opportunities are feasible and consistent with Montana's laws, policies, rules, and regulations. It is Montana Fish, Wildlife and Parks' (FWP) desire to fulfill its statutory obligations to manage all wild ungulates in the state, while recognizing that bison management presents additional challenges compared to other species.
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> . . .
>
> The only bison currently considered wildlife in Montana are those bison that come from Yellowstone National Park.
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> . . .
>
> By law, FWP needs to "enforce all the laws of the state regarding the protection, preservation, management, and propagation of fish, game, fur-bearing animals, and game and nongame birds within the state" (§ 87-1-201 MCA). Furthermore, FWP is required to manage wildlife, fish, game, and nongame animals in a manner that prevents the need for listing under the state list of endangered species (§ 87-5-10 MCA) or under the federal Endangered Species Act (16 U.S.C 1531, et seq.), and in a manner that assists in the maintenance or recovery of those species (§ 87-1-201 MCA). Within this context, FWP implements positive conservation and management strategies that fulfill these directives to preserve and restore wildlife species in Montana.

Montana Fish, Wildlife & Parks 2015 at 4, 9.

Belatedly, Montana Fish, Wildlife & Parks released its' record of decision on reintroducing bison as a wildlife species in 2020. If it ever comes to fruition, it is designed by law and policy to reproduce a small, isolated bison herd on a limited range.

In examining Montana's approach, one striking fact stands out: the State is subcontracting its' public trust duties by only considering proposals from a third party who must meet stringent and costly criteria.

Montana Fish, Wildlife & Parks does not have a bison restoration proposal of its' own. Because Montana has no proposal, and is not taking the lead, it's an institutional barrier in getting National public land agencies involved in any bison reintroduction effort that may come to pass.

Three alternatives Montana Fish, Wildlife & Parks is willing to consider accepting proposals from a third party include:

• Restoration of a Publicly Managed Bison Herd on the Private and/or Public Lands of Willing Landowner(s).
• Restoration of a Publicly Managed Bison Herd on Tribal Lands.
• Restoration of a Publicly Managed Bison Herd on a Large Landscape Where there are Minimal Conflicts with Livestock.

Montana Fish, Wildlife & Parks January 2020 at 2.

"FWP is aware that bison cannot be managed in the same free roaming fashion as other ungulates and intends to follow state statute that clearly directs tighter control of bison managed as wildlife (87-1-216, MCA)." Montana Fish, Wildlife & Parks 2019 at 10 (Purpose and Need for the Proposed Action).

PHOTO: BFC Archives

Under the "Large Herd" alternative, 400 bison would be the population management goal for a publicly managed bison herd on a large landscape where there are minimal conflicts with livestock. Montana Fish, Wildlife & Parks 2019 at 99.

Any proposal submitted to Fish, Wildlife & Parks must meet stringent and costly criteria imposed by law including Mont. Code Ann. § 87-1-216 which sets the legal parameters for reintroducing bison.

Any third party proposal must include:

• Herd containment in a specific area, and a plan to reduce the area if bison "escape" and cannot be contained.
• Animal identification and tracking.
• Disease testing and monitoring.
• A costly range survey and detailed management plan.
• A contingency plan to eliminate or decrease the size of the designated reintroduction area if bison cannot be contained.
• An exit strategy if reintroduction becomes "unacceptable" or the costs "impractical" or there is a disease outbreak, all bison would be removed.
• Secure short- and long-term funding, and a budget.
• Compliance with a 29-point bullet list (not including sub-bullets) of parameters detailed in Chapter 7 of the Final Programmatic Environmental Impact Statement (pages 206–210).

Montana Fish, Wildlife & Parks 2019 at 63–78.

For reintroduced bison, Montana Fish, Wildlife & Parks takes on all liability for public safety and property, a policy at odds with Montana Supreme Court precedent. Montana Fish, Wildlife & Parks 2019 at 70.

> Montana is one of the few areas in the nation where wild game abounds. It is regarded as one of the greatest of the state's natural resources, as well as the chief attraction for visitors. Wild game existed here long before the coming of man. One who acquires property in Montana does so with notice and knowledge of the presence of wild game and presumably is cognizant of its natural habits. Wild game does not possess the power to distinguish between fructus naturales and fructus industriales, and cannot like domestic animals be controlled through an owner. Accordingly, a property owner in this state must recognize the fact that there may be some injury to property or inconvenience from wild game for which there is no recourse.

*State of Montana v. Rathbone*, 110 Mont. 225, 100 P.2d 86, 1940 Mont. LEXIS 84, at 92–93 (1940).

Based on State law and regulatory policy, it is likely insurmountable for any third party to restore a bison herd "functioning as wild" in Montana for the foreseeable future.

***Nonexistent and inadequate laws threaten or endanger Yellowstone bison in the wild.***

The near extermination of bison provoked the first federal effort to protect a species in the United States. Peterson 1999 at 75.

All of the Acts Congress proposed to protect bison failed or were pocket vetoed by President Grant. Peterson 1999 at 75–79.

> [T]he bison's fate illustrates how quickly the forces of modernization can drive one species to the brink of extinction. The forces relevant to the bison included westward expansion and settlement, the introduction of competing species such as cattle, and the gruesome efficiency of market hunting.
>
> . . .
>
> Eventually, federal protection for the bison came not from laws prohibiting their taking, but from the creation of preserves and parks. The establishment of Yellowstone National Park in 1894, for example, provided crucial habitat for the few remaining bison, preventing them from becoming completely extinct in the United States.

Peterson 1999 at 75, 79 (footnote omitted).

State, federal, and provincial laws enacted to protect bison were not enforced or were ineffective in providing legal protection.

In 1857, a Plains Cree grand council formed to "impose a collective policy forbidding white men from killing bison on Cree hunting grounds. Approximately twenty years later, Sweetgrass, a Cree Chief, pleaded with the British North American government to protect the bison. Both efforts failed." Zontek 2003 at 218 (endnote omitted).

> Pleas in the early 1800s to halt the destruction of bison in North America were largely

> ignored (Dary, 1989). Protective legislation in Canada and the United States was not enacted until much later when bison were near extinction. In Canada, the 1877 Buffalo Protection Act was the first attempt to legislate protection (Hewitt, 1921). However, this measure was ineffective because of a lack of enforcement. It was reinforced in 1894 when the Dominion Government passed a law protecting the surviving wood bison (Soper, 1941). By this time, plains bison had been extirpated from the wild in Canada.
>
> . . .
>
> The states of Idaho, Wyoming, and Montana implemented statutes to reduce the killing of game, including bison, between 1864 and 1872, but these were largely ineffective due to limited enforcement.

Freese et al. 2007 at 176.

State and territorial laws introduced and passed to regulate bison hunting between 1864–1881 were ineffective and not enforced. Moloney & Chambliss 2014 at 323–324.

The Territory of Idaho outlawed buffalo hunting in 1864, followed by the Territory of Wyoming in 1871, and Nebraska in 1875. Sprung 2010 at 80. These laws and others were not enacted until after the bison's demise or bison no longer existed in the State or Territory. Sprung 2010 at 81.

> Those states that did support bison populations during the 1870s, Kansas, Nebraska, Texas, and Colorado, did nothing to protect the bison until it was too late. For example, the Texas State Legislature rejected outright a bill to impose a closed hunting season because of the belief that eradicating the bison would facilitate the pacification and removal of hostile Indian tribes. Colorado and Kansas adopted closed seasons on buffalo hunting in 1875, but only after few individual bison remained within their borders.

Peterson 1999 at 75 (footnote omitted).

One member of Congress concluded national legislation was required "because bison are migratory animals, moving from state to state and through the territories so that no one state could regulate for their protection." Peterson 1999 at 77 (footnote omitted).

Six Congressional bills were proposed for bison between 1871 and 1876. The only law that Congress passed was pocket vetoed by President Grant in 1874 which would have made it unlawful for any person who was not an American Indian to kill female bison on public land. Moloney & Chambliss 2014 at 324–325.

President Grant's pocket veto nearly spelled the end of bison with only 86 remaining in the United States in 1896, according to William T. Hornaday. Peterson 1999 at 76, 78.

Given his cabinet appointments, President Grant likely agreed with the opponents of the bill that protecting bison would interfere with the war, pacification, and relocation of Indigenous tribes to reservations. Peterson 1999 at 77.

In arguing against passage of the bill into law, James A. Garfield of Ohio cited Grant's appointee to the Secretary of the Interior, Columbus Delano, stating:

> "The best thing which could happen for the betterment of our Indian question — the very best thing which could occur for the solution of the difficulties of that question — would be that the last remaining buffalo should perish. . . . So long as the Indian can hope to subsist by hunting buffalo, so long will he resist all efforts to put him forward in the work of civilization . . . he would never cultivate the soil, never take a step toward civilization, until his savage means of support were cut off; and . . . his support . . . out of which he secures the very meat he feeds on, is the herds of buffalo which roam the plains of the west."

Dolph & Dolph 1975 at 16 (quoted in the 1874 Congressional Record, 43rd Congress, 1st Session) (footnote omitted).

Similar sentiments in favor of the extinction of bison and Indigenous peoples were penned in newspaper editorials:

> "Let the buffalo go—the faster the better—and let the grassy hills and plains . . . be covered with herds of good, honest, civilized cattle. When the buffalo disappears Indian savagery will disappear . . . the Indian will have to lay down the rifle and take up the plow. He will never work as long as he can hunt and draw government rations. If he is ever to advance in civilization he must have the same incentive to work that impels white men—the love of property and comfort and the dread of starvation."

Moloney & Chambliss 2014 at 333–334 (quoting the St. Louis Globe-Democrat, June 9, 1882).

President Grant, his military advisors and Cabinet members, viewed Indigenous peoples and bison as a threat and barrier to the fulfillment of Manifest Destiny, and ranchers, farmers, and settlers colonization of hundreds of millions of acres on the western frontier. Dolph & Dolph 1975 at 16; Moloney & Chambliss 2014 at 324–325, 330.

From 1860–1890, 430 million acres of land in the western territories was taken from Indigenous peoples and colonized by settlers. Moloney & Chambliss 2014 at 330.


Destroying bison also undermined and destroyed the basis for Treaties between the U.S. government and Indigenous tribes as hunting outside reservations would be permitted "only so long as the bison may range . . . in numbers sufficient to justify the chase." Moloney & Chambliss 2014 at 323 (citing language in the Treaty of Medicine Lodge, Art. 11, 1867 and Treaty of Fort Laramie, Art. 11, 1868).

The Medicine Lodge Treaty of 1867 reserved for the Kiowas, Comanches, Southern Cheyennes, and Arapahoes "the right to hunt on any lands south of the Arkansas so long as the buffalo may range thereon in such numbers as to justify the chase." Smits 1994 at 327.

The Fort Laramie Treaty of April 1868 created the Great Sioux Reservation with relocated bands retaining "the right to hunt on any lands north of North Platte, and on the Republican Fork of the Smoky Hill River, so long as the buffalo may range thereon in such numbers as to justify the chase." Smits 1994 at 322.

Without protection in the law and effective enforcement of the law, wild bison were completely destroyed in the United States except in Yellowstone National Park.

> The Act to Protect the Birds and Animals in Yellowstone National Park and to Punish Crimes in Said Park was signed by President Grover Cleveland in 1894, thereby halting the extirpation of the last free-ranging plains bison population in North America (Gates et al., 2005). In 1902, fewer than 25 bison remained in the remote Pelican Valley in Yellowstone National Park (Meagher, 1973).

Freese et al. 2007 at 176.

It was not until U.S. Army patrols were deployed in the backcountry that the poachingof bison was effectively halted in Yellowstone National Park. For evidence on the role of poaching in the demise of Yellowstone bison in the wild, *see* Meagher 1973 at 17–22.

> The buffalo or bison have so narrowly escaped extinction, and the number which now find a refuge in this park is so limited, that they should be protected by every possible method. Hunters, stimulated by the high price offered by taxidermists for specimens, are now lying in wait beyond the borders of the Park, ready to pounce upon any unfortunate animal which may stray beyond its limits.

Strung 2010 at 108 (quoting Captain Moses Harris, 1st U.S. Cavalry reporting to the Secretary of the Interior, published in Field & Stream, September 13, 1888) (footnote omitted).

In passing the National Bison Legacy Act in 2016 recognizing American bison as our country's National Mammal, the U.S. Congress specifically ruled out relying upon it to protect bison at all:

> Nothing in this Act or the adoption of the North American bison as the national mammal of the United States shall be construed or used as a reason to alter, change, modify, or otherwise affect any plan, policy, management decision, regulation, or other action by the Federal Government.

Public Law 114–152, 130 Stat. 373, (36 U.S.C. note prep. 301) Sec. 3(b) Rule of Construction.

> Should this herd [of Yellowstone buffalo] be permitted to separate and be destroyed the extermination of the race would be final and complete. . . This generation has destroyed the buffalo. If it is possible to do so it is the duty of the same generation to in some degree make amends to posterity for the mistake which may almost be denounced as a national crime.

Sprung 2010 at 105 (quoting U.S. Representative Erastus Turner of Kansas, May 3, 1890 speaking in support of legislation to provide a legal apparatus to stop poachers from killing bison and other game in Yellowstone National Park) (footnote omitted).

The present-day attempt to honor, protect, and restore the distinct population segment of Yellowstone bison in the wild as a threatened or endangered species is warranted given the lack of legal protections in State statutes and federal laws.

There is no regulatory relief in sight for Yellowstone bison for the foreseeable future.

***The U.S. Fish & Wildlife Service has a duty to restore threatened or endangered species in the wild.***

The U.S. Fish & Wildlife Service has previously distinguished wild bison populations from domestic or commercial herds finding wild bison populations "contribute to species conservation in a listing evaluation… consistent with the intent" of the Endangered Species Act. 76 Fed. Reg. 10299, 10301 (Feb. 24, 2011).

> Yellowstone bison are a valuable conservation population because they represent the largest wild population of plains bison and are one of only a few populations to continuously occupy portions of their current distribution and show no evidence of hybridization with cattle in their genomic ancestry (Meagher 1973, Halbert and Derr 2007). Perhaps more importantly, Yellowstone bison are part of an intact predator–prey–scavenger community and move, migrate, and disperse across a vast, heterogeneous landscape where the expression of their genes is subject to a full suite of natural selection factors including competition (for food, space, and mates), disease, predation, and substantial environmental variability. As a result, Yellowstone bison likely have unique adaptive capabilities compared to most bison populations across North America that are managed like livestock in fenced pastures with forced seasonal movements among pastures, few predators, selective culling for age and sex classifications that facilitate easier management (e.g., fewer adult bulls), and selection for the retention of rare alleles—the importance of which has not been identified. Modern society has placed restraints on wild bison distribution and, therefore, has an overarching influence on which evolutionary processes will be allowed to persist for this species. Given existing habitat loss and social concerns across the continent, it is unlikely that many additional populations will be allowed to increase in abundance and move across the landscape at a scale similar to Yellowstone bison (Boyd 2003). Thus, a few bison populations in the greater Yellowstone ecosystem (Jackson, Yellowstone), Canada (Pink Mountain, Prince Albert), the Henry Mountains of Utah and, potentially, Badlands and Wind Cave National Parks in South Dakota assume great importance and managers should be promoting the conservation of wildness and natural selection to retain adaptive capabilities, rather than preconceived notions of "natural" genetic or population substructures that were likely created or exacerbated by human actions.

White & Wallen 2012 at 752–753 (ignoring the preponderance of intensive domestication and artificial selection processes, and extensive livestock and veterinary practices imposed on Yellowstone bison under current management).

What characteristics define a bison population in the wild?

> Accounts from 1796–1881 suggest bison were plentiful and widespread in the GYE prior to Euro-American colonization (Whittlesey et al. 2015). However, the number of bison that spent time in the mountainous area now encompassed by YNP is unknown. Based on the

timing of historical observations and the current behavior of bison and other ungulates such as deer, elk, and pronghorn, it is likely many bison in the area migrated seasonally between productive grasslands in the mountains during summer and lower elevation valleys in outlying areas during winter (Plumb et al. 2009, Geremia et al. 2015c). Therefore, the environmental reference point for evaluating cumulative impacts is one where animals roam freely within a conservation area large and heterogeneous enough to sustain ecological processes such as migration and dispersal, has sufficient animals to mitigate the loss of existing genetic variation, and is subject to the forces of natural selection (White et al. 2015d). In this context, wild bison can be characterized as untamed, free-roaming animals living in an environment not dominated by humans and whose behaviors, movements, survival, and reproductive success are primarily affected by their own daily decisions and natural selection (White 2015).

Yellowstone National Park 2016 at 81.

According to the free dictionary, the definition of wild means "occurring, growing, or living in a natural state; not domesticated, cultivated, or tamed." *The Free Dictionary* (Farlex, Inc. 2023).

"Natural selection, with no or minimal influence by humans, is the benchmark of wildness." Bailey 2013 at 78.

PHOTO: Peter Dettling

"[P]reservation of the innate characteristics of bison is important to their future as a wild species. Wild, in simple terms, means having the necessary traits to survive and reproduce under natural conditions in their natural ecosystem (Knowles et al. 1998)." McDonald 2001 at 106.

According to the International Union for Conservation of Nature group discussion (undated), the principles underlying the definition of wild bison are:

- free ranging/not in captivity,
- maintaining ecological processes,
- expressing ecological function,
- lack of selective culling by humans/natural selection is operating,
- minimal management intervention,
- ownership is in common or typically public,
- maintaining "natural" sex and age ratios,
- genetic integrity, and
- occurring within the original range of bison.

The International Union for Conservation of Nature's Red List Process key and criteria for classifying bison populations functioning as wild considers:

> • the physical environment in which bison exist, including the range area within which a wild population "roams and is sustained by range resources without human-imposed spatial limits on movements,"
> • that can sustain a functioning wild population exceeding 1,000 bison "in the range area without nutritional supplementation," and
> • with "unrestricted access to resources within the entire range area."

Aune, Jørgensen, & Gates 2018 Supplemental Material at 1–5, *infra*.

The range area includes a significant caveat, and "excludes locations where population distributional limits are imposed for management purposes."

In addition to physical environment and range resources, the International Union for Conservation of Nature's criteria also consider "species patterns, (e.g. genetics, demography), reproductive and natural selections processes (e.g. mating system, resource competition, resource selection, predation), and social factors that may influence the persistence of a wild population (e.g. laws, policies, societal support)."

The International Union for Conservation of Nature's definition of a wild bison population includes the "patterns of adaptation and geographic variation arising from species formational processes and occurs in locations where ecological and socio-ecological conditions support reproductive and natural selection and continued evolution of the species in the long term (centuries)."

In the United States, only four bison populations meet the International Union for Conservation of Nature's criteria for functioning as wild: Yellowstone, Jackson-Grand Teton, Apsáalooke (Crow Tribe), and UTE Tribal–Book Cliffs.

Of these four, only two bison populations meet the International Union for Conservation of Nature's large population criteria of > 1,000 bison older than one-year: Yellowstone and Apsáalooke.

The authors of the Green Status Assessment could not find data to assess whether the Crow Tribe's bison population can fulfill their ecological functions on a 22,000-acre range. Rogers, Ranglack, & Plumb 2022.

The plains bison subspecies is nearly "Vulnerable" and "considered to be facing a high risk of extinction in the wild." Aune, Jørgensen, & Gates 2018 at 1; International Union for Conservation of Nature 2012 at 15, 20–22.

Contrary to misleading claims made by Yellowstone National Park and other officials, in Montana, bison in the wild that are reduced to captivity for quarantine are not wild according to the Montana Supreme Court:

> A "wild buffalo or bison" is defined as a bison "that has not been reduced to captivity and is not owned by a person." Sections 81-1-101(6) and 87-2-101(1), MCA. The brucellosis quarantine bison involved in this case have been reduced to captivity for a number of years and therefore arguably are not "wild buffalo or bison" as defined in Montana law . . .

*Citizens for Balanced Use v. Montana*, No. DA 12–0306, 2013 MT 166 at ¶ 15.

While the Fort Peck and Assiniboine Tribes view and respect Yellowstone bison received from quarantine as wildlife, the management requirements imposed decidedly indicate the animals will be subject to domestication for the foreseeable future. Fort Peck and Assiniboine Tribes 2014 at 2.

Quarantined bison taken from the wild in Yellowstone and received by Turner Enterprises Inc. are unequivocally domestic livestock used for commercial production.

The recent passage of a new law in Montana, codified in 2021, changed the criteria and definition of a wild buffalo or bison in a manner that appears to no longer recognize any buffalo or bison as wild under State law, i.e., no bison population in North America unequivocally meet all the regulatory criteria:

> 81-1-101. Definitions. Unless the context requires otherwise, in Title 81, the following definitions apply:
>
> (1) (a) "Bison" means domestic bison or feral bison.
>
> (b) The term does not include:
>
> (i) wild buffalo or wild bison; or
>
> (ii) for the purposes of chapter 9, buffalo.
>
> (2) "Board" means the board of livestock provided for in 2-15-3102, except as provided in Title 81, chapter 23.
>
> (3) "Department" means the department of livestock provided for in Title 2, chapter 15, part 31.
>
> (4) "Domestic bison" means a bison that is not a wild buffalo or wild bison.
>
> (5) "Feral bison" means a domestic bison or progeny of a domestic bison that has escaped or been released from captivity and is running at large and unrestrained on public or private land.
>
> (6) "Wild buffalo" or "wild bison" means a bison that:
>
> (a) has not been reduced to captivity;
>
> (b) has never been subject to the per capita fee under 15-24-921;
>
> (c) has never been owned by a person; and
>
> (d) is not the offspring of a bison that has been subject to the per capita fee under 15-24-921.
>
> History: En. 46-103.1 by Sec. 48, Ch. 310, L. 1974; R.C.M. 1947, 46-103.1; amd. Sec. 1, Ch. 361, L. 2009; amd. Sec. 2, Ch. 403, L. 2011; amd. Sec. 2, Ch. 507, L. 2021.

While the State of Montana will continue managing for the near extinction of Yellowstone bison regardless of whether the migratory species meet all of the criteria to be recognized as "wild," legal definitions have consequences.

On its' face, Montana law appears to redefine "wild" bison in a manner so no population will ever be recognized as wild, thereby absolving the State of its' duty to restore bison as a "wild" species.

For the distinct population segment of bison in the Yellowstone ecosystem, government intolerance as expressed through law and regulatory mechanism, confines bison and limits their range to State imposed "tolerance areas," subjects them to stress and injuries in captivity, and harasses them from habitat, including calving grounds, in a series of ongoing management interventions.

Furthermore, ongoing federal regulatory action is subjecting Yellowstone bison to selective nonrandom culling in an artificial population sinkhole in Yellowstone National Park that is differentially harming subpopulation structure and the population as a whole, and negatively operating on and skewing sex and age ratios.

Bison in the Central herd have not recovered from the severe population decline management has inflicted upon the genetically distinct subpopulation and hover below census sizes to prevent inbreeding and maintain genetic diversity.

While Yellowstone bison are held in the public trust for the American people and Indigenous peoples, State and federal management practices decidedly favor grazing cattle in the native species range, disrupting and limiting the keystone ecological roles bison perform that increase biological diversity throughout the ecosystem.

Wild bison are "entirely dependent upon conservation interventions," and without the anchor provided by large protected landscapes in National Parks, Refuges, and Sanctuaries, bison "would not likely survive and the future survival of American bison would be in serious jeopardy." Aune, Jørgensen, & Gates 2018 at 3.

As examined herein, the anchor of Yellowstone National Park can no longer be considered a protected area for wild bison.

National Forests contiguous to Yellowstone National Park are preferentially managed for grazing cattle, and there is no publicly enforceable standard to support Yellowstone bison as a self-sustaining population with distinct subpopulation structure across three Regions.

Without substantive conservation actions and large protected ranges of habitat on National public trust lands to support the migratory species' adaptation and recovery in the wild, Yellowstone bison will not persist.

**8.E. A number of human-made factors threaten the persistence of a wild self-sustaining Yellowstone bison population with distinct subpopulation structure.**

• Climate change is a threat to Yellowstone bison in the wild.

• Yellowstone bison's natural generation times limit their ability to adapt body size in response to rapid climate change.

• Climate change could halve the body size of bison in North America by the end of the 21st century.

• Rising temperatures and increasing drought severity drive a decline in bison body size.

• Rising temperatures decrease bison body size, growth rates, and alter life-history characteristics.

• The role and threat of climate change in the declining nutritional value of native plants in Yellowstone bison's range is unknown. A warmer, dryer climate will result in a significant loss in wetlands, and reduce sedge and rush species bison depend on for food.

• Changes in climate and rainfall patterns cause a reduction or regional shift in bison range.

• Extreme weather patterns drive changes in bison movement patterns.

• Drought reduces grassland ecosystem function and drives a decline in the condition of Yellowstone bison.

• State and federal management actions, winter severity, and snow crusting significantly reduces Yellowstone bison's resiliency to withstand such events, and is a threat to the population in the wild.

• State and federal management actions reducing Yellowstone bison's range and population, and climate-driven shifts in the range of bison outside "protected areas" is a threat to the migratory species.

• Climate change was a factor in the extinction of *Bison* species in the Pleistocene.

• Few founders, hybridization, population bottleneck and isolation threaten or endanger Yellowstone bison in the wild.

PHOTO: Don Murray

• State and federal manager's use of artificial selection and domestication processes infringe on natural selection, and threaten or endanger the persistence of wild Yellowstone bison.

• Current management threatens or endangers retention of the wild genome and the persistence of Yellowstone bison as a wild population.

• Population viability for Yellowstone bison is unknown.

• State and federal managers are jeopardizing genetic variation in wild Yellowstone bison.

• Yellowstone bison are unlikely to persist in the wild without a minimum of 5,000 or more adults.

• Current management is undermining natural selection of Yellowstone bison. Evidence of effects from the loss in ecological choice (natural selection) for Yellowstone bison is not being systematically examined for publication.

• In restricting the range and habitat for Yellowstone bison to naturally evolve and adapt to rapid climate and environmental change, State and federal managers are placing the distinct population segment at increased risk of extinction in the wild.

• State and federal managers are increasing the risk of inbreeding by confining and limiting migratory range and managing bison in small populations in isolated ranges. Evidence of the risk of inbreeding in Yellowstone bison is not being systematically examined for publication.

• In managing Yellowstone bison for a limited population size in a restricted and isolated range, it is unknown how management is transforming mutation rates and maintenance of adaptive genetic variance.

• State and federal management actions are driving the loss or extinction of Yellowstone bison family groups (generational parent-offspring). Evidence of the extent and rate of loss in Yellowstone bison family groups is not being systematically examined for publication.

• The unknown extent and rate of loss or extinction of family groups (generational parent-offspring) is a threat to Yellowstone bison's adaptive potential and resilience to adverse events in a rapidly changing climate and environment.

• The long-term viability, fitness, and evolutionary potential of wild Yellowstone bison is not secure and at risk of extinction. Under current State and federal management, inbreeding in the Yellowstone bison population may not be evident for a century.

***Climate change is a threat to Yellowstone bison in the wild.***

> The North American Bison may be sentinels of global climate change impacts on the Great Plains and prairies.

Martin & Barboza 2020 at 347.

> Body size of bison (*Bison bison*) has shrunk by 31% . . . with rising mean global temperature since the last Ice Age, and over the last 5 decades, body size of Bison has declined by 11–23% . . .

Martin & Barboza 2020 at 1 (citation omitted).

Human exploitation of fossil fuels and the resulting pollution threatens the biosphere. Fossil fuel pollution is driving rapid changes in the Earth's climate with far reaching consequences for ecosystems and the survival of species.

As used herein, "climate change" refers to "persistent, multidecadal deviations from long-term averages" in temperature and precipitation; "climate variability" refers to "interannual or interdecadal fluctuations in temperate and precipitation." Malpeli et al. 2020 at 2.

Climate change is a threat because the rapidity and magnitude of harmful effects is likely to outpace Yellowstone bison's ability to adapt in the wild to the combined stressors the migratory species is facing, and will be facing, in the 21st century and beyond.

The collective global science on climate change predicts "increasingly drier conditions," "precipitation variability and associated drought risk will increase in many areas . . . [d]rought-affected areas will increase over low latitudes and mid-latitude continental interiors in summers" with "substantial increases in drought severity and coverage" in the Western United States, and reduction in mountain glacier and snow cover, among the high confidence projections. Kallis 2008 at 95.

"It is the speed of change relative to adaptation and the magnitude of drought extremes in relation to evolved baseline conditions that are of paramount importance." Kallis 2008 at 96.

> Climate is an important driver of ungulate life-history characteristics, population dynamics, and migratory behaviors and changes in climate can directly or indirectly affect the growth, development, fecundity, dispersal, demographic trends, and long-term viability of populations as well as the timing and locations of migratory movements.
>
> . . .
>
> Direct impacts can include changes in the costs of thermoregulation or locomotion, while indirect impacts can include shifts in forage quality and quantity. Studies have documented, for example, that winter temperatures can directly affect juvenile survival and have population-level effects. . . Precipitation and temperature, through their effects on plant production and nutritional quality, can also directly and indirectly affect ungulate life-history characteristics.
>
> . . .
>
> The effects of changes in the timing of spring green-up and winter severity, two key drivers of ungulate migration in North America, have also been documented.

Malpeli et al. 2020 at 2 (endnotes omitted).

Using remote sensing data scientists found the "climate change signal in Yellowstone was pronounced, including substantial warming, an abrupt decline in snowpack, and more frequent droughts." Notaro et al. 2019 at 1.

> The projected warming and drought-related water shortages for the Western United States are expected to alter terrestrial ecosystems and induce pronounced shifts in species ranges and biodiversity patterns, although with such studies placing a greater focus on the water-limited Southern Rockies than the temperature-limited Middle Rockies. Climate change and associated global-change-type droughts pose an unprecedented risk to all lands of the Western United States, including the many resource-based national parks therein.
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> . . .
>
> Yellowstone National Park has experienced distinct environmental changes in the last century, including rising air temperatures, earlier spring onset, declining snowpack and earlier snowmelt, expanding growing season and fire season, shrinking wetlands, declining amphibian species richness, an eruption of mountain pine beetle outbreaks and whitebark pine mortality (*Pinus albicaulis*), upslope shift of lodgepole pine (*Pinus contorta*), and upslope expansion of seedling aspen (*Populus tremuloides*) after the 1988 fires.

Notaro et al. 2019 at 2, 5 (endnotes omitted).

A key conclusion of the scientist's remote sensing study was the need for assessing "species' and landscape vulnerabilities to climate variability and change, including ecological droughts" at meaningful time scales in National Parks, and identifying "potential drought refugia" for species to adapt to a "highly variable and rapidly changing climate." Notaro et al. 2019 at 23.

Under current management, there is no designated or identified refuge for Yellowstone bison.

Instead, State and federal managers thwart bison's migration inside Yellowstone National Park and connectivity to National Forest habitat, and exclude bison from their range and habitat in government "tolerance" zones by trapping bison for slaughter and quarantine inside the Park and hunting on National Forests.

There is no provision managing for the resiliency of bison in the face of rapid climate change or climate variability in the Yellowstone ecosystem.

Instead, State and federal managers subject Yellowstone bison to a chain of artificial selection, veterinary and livestock management processes limiting and reducing the migratory species' abundance, distribution, and diversity in the ecosystem and bioregion they are an integral part of.

"Whitlock (1993) estimates that between ~14,000 and ~11,500 BP, the climate in Yellowstone National Park was ~5-6°C colder than present." Cannon 2008 at 62.

> Climate has changed notably in YNP over the past 30 years. Annual average temperature has increased by nearly 1 °C in Yellowstone since the 1988 fires, and this warming may be affecting the phenology of vegetation (Hansen et al. 2016; Notaro et al. 2019). Potter (2019) reported that climate stations records from YNP indicate that 2005 and 2015 were the warmest years in the past two decades, whereas 2004–2005 and 2009–2010 were the driest overall. Nonetheless, Notaro et al. (2019) reported that areas on YNP which were unburned by the 1988 fires have showed no apparent sign of warming-induced greening, [possibly] due to the mitigating impacts of periodic droughts.

Potter 2020 at 374.

Between 1895–2012, "the annual mean monthly minimum temperature increased" by 2.9 degrees Fahrenheit, "while the annual mean monthly maximum temperature increased" by 1.2 degrees Fahrenheit in the Greater Yellowstone bioregion. By 2100, the annual mean monthly minimum temperature is projected to increase 5 to 10 degrees Fahrenheit, and the annual mean monthly maximum temperature is projected to increase 7 to 12 degrees Fahrenheit. Halofsky et al. 2018 at 41.

Between 1950–2018, the Greater Yellowstone bioregion experienced an increased warming of 2.3 degrees Fahrenheit, a 25% loss in snowfall (23 inches less), with peak stream flow occurring 8 days earlier. Hostetler et al. 2021 at III.

Additionally, the "average temperature of the last two decades (2001-2020) is probably as high or higher than any period in the last 20,000 yr, and likely higher than previous glacial and interglacial periods in the last 800,000 yr. Research suggests that the current level of carbon dioxide in the atmosphere is the highest in the last 3.3 million years." Hostetler et al. 2021 at VI.

Even with "significant intervention . . . beginning in the next few years" to mitigate greenhouse gases, mean annual temperature in the Greater Yellowstone bioregion is projected to increase 5 degrees Fahrenheit by the period 2061–2080; with "little to no mitigation" mean annual temperature is projected to increase by more than 10 degrees Fahrenheit by the end of the 21st century. Hostetler et al. 2021 at VIII.

A study of intermountain grasslands in western Montana found the Gardiner climate station "had the most warming over the 30 years of any location" experiencing "increases of 0.5 to 2.5° C for each season." Sikkink 2005 at 29.

Each of the ecoregions, including the south ecoregion encompassing Yellowstone National Park, experienced drought conditions during at least twenty of the years between 1958 and 2002.

In addition, the south ecoregion "was warmer and drier than either the 1970 sampling seasons or the 30-year mean conditions (Fig. 1-5)." Sikkink 2005 at 98.

> Several compositional trends in the community data suggest that the plant communities may have experienced enough warming and drying during the past 30 years to cause significant change over the three decades. The dominant trends in the south include:
> 1. Bare soil and exposed rock increased three-fold from 6% to 19% and 11% to 27%, respectively (Table 1-1).

2. Surface litter decreased from 51% to 12% between sample periods.
3. Diversity indices remained stable, although the mean number of species per plot actually declined (Table 1-1). Diversity is strongly correlated with the moisture gradient along NMS axis 1 (Shannon index $R^2$=0.50 and Simpson's index $R^2$ =0.46), but it is also correlated with the difference between historic and current plots on NMS axis 3 ($R^2$=0.16 and $R^2$ =0.11). Some diversity loss was attributed to a significant reduction in the frequency of non-native species (Table 1-1), which also correlates with plot distribution along axis 3 ($R^2$=0.237) in the NMS. The south region is the only region in this study where non-native species declined during the 30 years, although introduced species were not a significant problem in the region during either time period.
4. Species with drought-resistant physiology, like cacti and sedum, more than doubled in frequency.
5. Species with deeper root systems (i.e. several species of shrubs) increased significantly during the drought conditions. In general comparisons, all invader, decreaser, and increaser shrubs more than doubled in the past 30 years, although most of the increases were not significant within the limits of this study (Table 1-1). Within ordination space, shrub increases and/or invasion were second only to differences in the abiotic variables and introduced species as important factors for separating historic and contemporary plots along NMS axis 3 ($R^2$=0.19).
6. All non-shrub grazing indicators showed only minimal differences with past conditions.

Sikkink 2005 at 29–30.

Changes in community "correlates with the variations in spring and winter mean temperatures" with an increase in shrub frequency in the south ecoregion (+8% to +20%) and a decrease in grass frequency (-11% to -28%). Sikkink 2005 at 99.

Since 1900, the Yellowstone ecosystem experienced an increased warming of 2 degrees Fahrenheit with climate scientists projecting a far more rapid warming wave from 6 to 11 degrees Fahrenheit by 2100. Human demand for resources is increasing while habitats for wildlife to adapt to a rapidly changing environment are decreasing in the Yellowstone ecosystem. Hansen 2016 (Bozeman Daily Chronicle, Guest columnist).

The cumulative and synergistic effects of changes in land use (740% average increase in housing density since 1940, an additional 255% increase projected by 2100), spread of invasive species and displacement of native species (noxious nonnative plants account for 13% presently), and rapid climate change "are expected to dramatically impact ecosystem function and biodiversity in national parks." Hansen et al. 2014 at 484.

At least 219 non-native plant species have spread across the Yellowstone ecosystem. Hansen et al. 2014 at 490 (Table 2).

Yellowstone is among the protected areas projected to transform into unsuitable climates for the entire community of plant and wildlife populations living in the ecosystem.

Fourteen protected-area centered ecosystems:

> in the mountain and southwestern United States are projected to experience unsuitable climates for their present biome types across 50–86% of their areas by 2030 and up to 96% by 2090. It is places with high projected climate change and places with topographic complexity where climate-driven biome shifts are projected to be most prevalent (e.g., Glacier, Greater Yellowstone, and Rocky Mountain in the Rocky Mountain region and Petrified Forest in the southwestern deserts).

Hansen et al. 2014 at 492–493.

A vulnerability assessment for the Custer Gallatin National Forest "projected rapid changes in climate will impact the vegetation of the GYE in myriad ways both directly by shifts in growth, mortality, and regeneration, and indirectly by changes in disturbance regimes, hydrology, snow dynamics, and exotic invasions." Hansen et al. 2018 at 2.

> Climate projections indicate average temperature and precipitation will both likely increase across the GYE (Gross et al. 2016) (Figure 5A). However, increases in precipitation will not be sufficient to offset increases in drying caused by warming (Figure 5B). On an annual basis snow water equivalent and soil moisture will decline, while deficit will increase over time (Melton et al. 2016). The changing seasonality will affect vegetation primarily by initiating earlier start of growing season and imposing late season moisture deficits at lower elevations and lengthening growing seasons at higher elevations. An important consequence of warm temperatures in the future results from increased evapotranspiration causing "hotter drought" that increases relative seasonal water deficit regardless of precipitation amount.

Hansen et al. 2018 at 11.

There is "high agreement" among scientists that future climate trends will be marked by increased "fire, reduced soil moisture at lower elevations, warming effects at upper treeline, reduction in snowpack and river flows, and increased levels of disease and pests." Hansen et al. 2018 at 30.

> [T]he legacy of snowmelt timing on soil moisture can persist through late-summer dry periods in western U. S. mountain watersheds. If snowmelt occurs after plant evaporative demand increases, then the shallow soil layers can capture more of the slowly melting water. Conversely, earlier water transfer from the melting snowpack into the soil can induce a water deficit that persists throughout the growing season.

Potter 2020 at 383 (citing Blankinship et al. 2014).

"In years when snowmelt timing has been unusually early, such as 2015, the growing season ended earlier in these areas and the TIN metric declined to its lowest level in many years." Potter 2020 at 384 (TIN is the Total Integrated Normalized Difference Vegetation Index used in remote sensing to measure the difference between near-infrared (reflected strongly by vegetation) and red light (which vegetation absorbs), according to gisgeography.com).

"Potter (2019) reported that climate stations records from YNP indicate that 2005 and 2015 were the warmest years in the past two decades, whereas 2004–2005 and 2009–2010 were the driest overall." Potter 2020 at 374.

PHOTO: Joanne Murray

It is not well understood how the short-term trends Potter found (lower snow water equivalent, earlier snow melt, and extended fall snow-free conditions during 2000–2017) will change grassland forage productivity and the nutritional value of forage on Yellowstone bison's Northern range.

One study found "the benefits of increased precipitation are offset by warming temperatures, CO2 fertilization, and increased evapotranspiration (Polley et al., 2013). Further, significant hydrological changes in snowpack are suggested, including alterations to the timing of precipitation events and early runoff (Ojima et al., 2015). Changes to the timing and seasonality of precipitation have the potential for devastating impacts to range condition as spring and early summer precipitation drives forage production (Smart et al., 2007)." Beeton et al. 2019 at 52.

Scientists have not assessed how rapid climate change and variation in climate is driving ecological change on Yellowstone bison's Central range.

It is unknown and uncertain how climate-driven changes on the Northern range are reflected in climate-driven changes in migration patterns for the Central bison herd, and how management is transforming migration patterns for each herd.

What is known is current management is driving significant changes in Yellowstone bison's population structure:

- 2000 census of 2,060 bison in the Central herd, 553 bison in the Northern herd.
- 2005 census of 3,553 bison in the Central herd, 1,266 bison in the Northern herd.
- 2010 census of 1,652 bison in the Central herd, 2,246 bison in the Northern herd.
- 2015 census of 1,323 bison in the Central herd, 3,628 bison in the Northern herd.
- 2020 census of 1,251 bison in the Central herd, 3,437 bison in the Northern herd.

Geremia 2020 at 7–8 (Appendix B) (highest census count is used).

Management boundaries restricting Yellowstone bison's long-range dispersal movements is certain to harm or impair the migratory species' current and future ability to adapt to climate-driven changes in the ecosystem.

Restricting migrations amidst ever increasing housing densities will shrink habitat available for bison to disperse and adapt to climate variation and rapid climate change.

The ecological consequences of managers preventing bison from dispersing in response to ecosystem-level change not only jeopardizes the health and well-being of bison, but the grasslands and native species that benefit from the migratory species' freely roaming the ecosystem.

Projected future change in housing density, climate, and biome suitability in Yellowstone include:

- An increase in housing of 30.03% (2000–2030), 60.87% (2000–2060), and 91.71% (2000-2090).
- An increase in temperature °C of 1.85 (2000–2030), 3.01 (2000–2060), and 3.89 (2000-2090).
- An increase in precipitation (mm) of 18.23 (2000–2030), 64.13 (2000–2060), and 36.87 (2000-2090).

Hansen et al. 2014 at 492 (Table 3).

In the Greater Yellowstone bioregion, human population is expected to double from 425,000 in 2010 to 725,000 in 2040 with the expansion of human homes in riparian habitat, valley bottoms, and migration corridors having "longer distance effects" and "fairly strong impacts on migration and spatial distribution of ungulates, including the time they spend in the park, in ways that strongly influence policy." Hansen 2010 at 39, 40, 41, 42.

"It's an example of where land-use intensification, in this case 40–60 miles away from the park, could be affecting population viability within the park." Hansen 2010 at 42.

Climate change is a threat to Yellowstone bison in the wild because harmful effects from multiple factors currently operating on the migratory species and their habitat will be additive, synergistic, and cumulative throughout the ecosystem they depend on for survival.

Effects of these rapid and profound changes in the Yellowstone ecosystem will be additive (further reductions in habitat from management actions, climate change, and intensification of human land use), synergistic ("greater than their additive effects due to interactions between them," e.g., loss of migration corridors and connectivity to habitat exacerbated by climate-change induced drought), and cumulative (past, present, and future effects from multiple factors acting on bison's adaptability in the wild). Hansen et al. 2014 at 498 (acknowledging the effects of climate change will be more than the sum of its' parts).

It is unknown how sensitive or susceptible bison will be to these harmful effects and stressors, and the ecological processes bison are a part of, what the adaptive capacity for bison is, and the degree and scope of vulnerability the migratory species faces from changes in intensifying land use and corresponding fragmentation of habitats, rapid climate change, effects on the availability and nutritional quality of forage, and the role and expansion of invasive plants and nonnative species in the ecological degradation of the Yellowstone ecosystem.

What is known is the life support system for bison is at risk in the Yellowstone ecosystem.

The U.S. Fish & Wildlife Service must examine the best available science and investigate the foreseeable threat to Yellowstone bison from rapid climate change in the agency's threats assessment and status review.

***Yellowstone bison's natural generation times limit their ability to adapt body size in response to rapid climate change.***

It is unknown and uncertain if bison can adapt body size in time to match the rapid increase in temperatures underway and forecast for the Yellowstone ecosystem.

It required over 3,000 years (325–1,080 generations) for bison to decrease body size by one-fourth to adapt to a warming climate.

The best available science predicts bison have 80 years — within 10 generations — to reduce body size by one-half to adapt to a rapidly warming climate by the end of the 21st century.

Another way of expressing this risk is bison must reduce body size in half in less than a century, when it required more than three millennia to reduce body size by one-fourth.

Rapidly increasing temperatures is more likely than not to outpace bison's natural generation times and adaptation to multiple stressors resulting from and exacerbated by climate change.

Can bison adapt body size to withstand a rapidly warming climate by the end of the century?

> Changes in body size of *Bison* could be a result of migration or disease but those effects are geographically local and not likely to persist over the long time scale of the fossil record (Hamel et al., 2016). Wilson, Hills, and Shapiro (2008) postulate the decrease in body size of *Bison* is a consequence of dispersal theory, that is, expansion of range, over the last 80,000 years (Wilson, 1996). A more cogent argument explaining decrease in body size is the rapidly warming global climate, characterizing the termination of the Younger Dryas period.
>
> This study demonstrates a strong inverse correlation between increasing global temperatures and body size of bison over the last 40,000 years. We hypothesize that increasing temperature alters both metabolic demands and available resources (Figure 1).
>
> The IPCC Working Group 1 (2014) predicts 4°C rise in global temperatures by year 2100. While the absolute increase in 4°C is not unprecedented in the evolutionary history of *Bison*, the rate of temperature change is 30 times faster than the Bølling–Allerød period, the transition from the Last Glacial Maximum to Holocene climate conditions. The Last Glacial Maximum corresponds with a global temperature 6°C cooler than the 20th century, when *Bison* mass was 910 kg. If global temperature warms to +4°C as predicted for the 21st century, *Bison* body mass will likely decline from 665 kg to 357 kg (Figure 6), if body size declines at the long-term average. The greatest decline in body size of *Bison* apparently occurred between 12,500 and 9,250 years ago, when mass declined by 26% (906 kg to 670 kg) in approximately 3,000 years. If generation time of *Bison* is 3–10 years (Evans et al., 2012; Gingerich, 1993), the change in body size occurred in 325–1,080 generations producing an average rate of change of 0.2–0.7 kg per generation. It is unclear whether

> *Bison* can adapt body size to a 4°C warming within 10 generations by year 2100.
>
> *Bison* today express a 30% body mass gradient from north to south, that is, *Bison* in Saskatchewan (52°N) are at least 30% larger than those in Texas (30°N (Craine, 2013, p. 3)). This body size gradient is likely associated with latitudinal variation in timing of reproduction and parturition as well as windows for growth (Barboza et al., 2009). Quantifying and comparing physiological thresholds and mechanisms driving body size change are imperative for managing *Bison* and other large herbivores (Figure 1). Conservation goals among latitudinally disparate *Bison* herds in North America should consider that resident *Bison* will likely grow smaller and more slowly in the south than in the north, which will impact management strategies at both regional and continental scales.

Martin et al. 2018 at 4570–4571.

The U.S. Fish & Wildlife Service must examine and investigate the probability, outcomes, and ability of Yellowstone bison to withstand adapting body size in response to rapid climate change in the agency's threats assessment and status review.

***Climate change could halve the body size of bison in North America by the end of the 21st century.***

The best available science indicates rapid climate change may induce and outpace evolutionary changes required for Yellowstone bison to survive and adapt in the wild.

"Understanding the causes driving changes in body size has important implications for reconstructing size-related relationships in ancient faunal communities, size selection, and modeling extinction probabilities in contemporary settings (Peters 1983; Tomiya 2013: E196)." Dalmas 2020 at 3.

> It appears that male and female bison are in fact decreasing in body size over time, as is evident from size plots over time and the meta-regression results (Figure 3.7).
>
> . . .
>
> Considering the changes in bison body size through time . . . it appears that body size trends towards smaller bison but not linearly . . . size changes variably with the climate (Figure 3.6). . . . Bison body size may be responding to the same millennial scale variability in the climate or more likely to the corresponding environmental shifts.

Dalmas 2020 at 48, 49.

"Not only does the archaeological data support climate driven diminution but so does the ecological theory." Dalmas 2020 at 62.

> This hypothesis beckons the question; if the environment is so unfavorable for numerous megafauna presiding in North America, then why is it that bison did not go extinct while many similar species did? It may be supposed that environmental effects and selection for shorter gestation time and earlier age at maturity were great enough in North American

> bison to respond to changes in the climate. It is evident that body size changed rapidly during the Early Holocene, suggesting that selection for body size was strong and an effective response to climate variability. It may also be posited that bison mobility allowed for more effective movement between resource patches in a resource-limited environment.

Dalmas 2020 at 50–51.

> The relationship between body size and temperature of mammals is poorly resolved, especially for large keystone species such as bison (*Bison bison*). Bison are well represented in the fossil record across North America, which provides an opportunity to relate body size to climate within a species. We measured the length of a leg bone (calcaneal tuber, DstL) in 849 specimens from 60 localities that were dated by stratigraphy and $^{14}C$ decay. We estimated body mass (*M*) as *M* = (DstL/11.49). Average annual temperature was estimated from $\delta^{18}O$ values in the ice cores from Greenland. Calcaneal tuber length of *Bison* declined over the last 40,000 years, that is, average body mass was 37% larger (910 ± 50 kg) than today (665 ± 21 kg). Average annual temperature has warmed by 6°C since the Last Glacial Maximum (~24–18 kya) and is predicted to further increase by 4°C by the end of the 21st century. If body size continues to linearly respond to global temperature, *Bison* body mass will likely decline by an additional 46%, to 357 ± 54 kg, with an increase of 4°C globally. The rate of mass loss is 41 ± 10 kg per°C increase in global temperature. Changes in body size of *Bison* may be a result of migration, disease, or human harvest but those effects are likely to be local and short-term and not likely to persist over the long time scale of the fossil record. The strong correspondence between body size of bison and air temperature is more likely the result of persistent effects on the ability to grow and the consequences of sustaining a large body mass in a warming environment. Continuing rises in global temperature will likely depress body sizes of bison, and perhaps other large grazers, without human intervention.

Martin et al. 2018 at 4564 (endnote omitted).

> During the Holocene in North America, *Bison* had the largest distribution of any contemporary ungulate; from Pacific to Atlantic coasts and from arctic to the tropical ecoregions (Feranec, Hadly, & Paytan, 2009; McDonald, 1981; Skinner & Kaisen, 1947). Although it is often assumed that *Bison* are obligate grazers (occasionally referred to as hyper-grazers (MacFadden & Cerling, 1996; Leng, 2006)), *Bison* have shown to be adaptable and variable in diet selection (Bergman, Fryxell, Gates, & Fortin, 2001; Feranec & MacFadden, 2000; Miquelle, 1985; Widga, 2006). *Bison* have inhabited North America (south of 55°N latitude) for approximately 200,000 years (Barnosky et al., 2014; Bell et al., 2004; Pinsof, 1991) and have occupied Beringia for nearly 300,000 years (Froese et al., 2017; McDonald, 1981; Shapiro et al., 2004).
>
> Despite conservation efforts, modern bison face increasing temperatures and increasing variability in climate (IPCC Working Group 1, 2014). Global temperature in the 21st century is expected to rise between 1 and 4°C above the 20th-century average (IPCC Working Group 1, 2014).

. . .

> Species that are affected by climate change may alter their distribution and adapt through changes in morphology, physiology, behavior, and life history (Smith, Murray, Harding, Lease, & Martin, 2014; Smith et al., 2010). Small mammals appear to be able to adapt morphology and life history to environmental shifts within one to three generations (Crews & Gore, 2012; Mifsud et al., 2011). However, the adaptive responses of large mammals to climate change are poorly understood. In comparison with small mammals, large species can better avoid harsh environments by moving long distances, tolerate austere conditions with large bodies, and recover over multiple seasons to reproduce over long lifespans (Barboza, Parker, & Hume, 2009). Impacts of climate change on animals are twofold: direct effects of temperature on the animal (i.e., energetic load as heat) and indirect effects of temperature on the animal's food supply (Figure 1). Warm temperatures advance the seasonal growth of grasses to reduce the availability of nitrogen for growth of cattle and bison (Craine, 2013; Craine, Elmore, Olson, & Tolleson, 2010; Craine, Towne, Joern, & Hamilton, 2009; Craine et al., 2012). Ambient air temperature directly affects the costs of thermoregulation of the animal in cold winters and the ability to lose excess heat in warm summers (Long et al., 2014; Speakman & Król, 2010). Seasonal patterns of air temperature affect the onset, duration, and intensity of plant production that sets the quantity and quality of food for growth and reproduction of herbivores from spring through autumn (Albon et al., 2017; Huston & Wolverton, 2011).

Martin et al. 2018 at 4565.

> Our data supported our hypothesis that global climate change drives body size of *Bison* spp., that is, as temperatures warmed, *Bison* became smaller. Generally, described as Bergmann's Rule (Bergmann, 1847), endotherms increase in body size with increasing latitude (Huston & Wolverton, 2011). It is likely that negative correlation between temperature and latitude is driving Bergmann's rule (i.e., body size) because even though we found that bison are larger at cooler temperatures, we were unable to correlate a significant effect of latitude over the geologic record ($p > .94$). The negative relationship between body mass and global temperature may reflect underlying relationships between body size and net primary production as well as heat loads (Speakman & Król, 2010; Huston & Wolverton, 2011; Figure 1).

Martin et al. 2018 at 4569–4570.

Because rapid climate change is likely to drive significant changes in the morphology, physiology, behavior, and life history of Yellowstone bison, the U.S. Fish & Wildlife Service must examine and investigate the ability of the migratory species to withstand the effects of rapid climate change in the agency's threats assessment and status review.

***Rising temperatures and increasing drought severity drive a decline in bison body size.***

> Our data indicate that temperature and drought drive *Bison* ABM [asymptotic body mass, i.e., mature body size] presumably by affecting seasonal mass gain. *Bison* body size is likely

to decline over the next five decades throughout the Great Plains due to projected increases in temperatures and both the frequency and intensity of drought.

. . .

[C]hange in body size of animals has long been used to indicate large-scale environmental processes over geological timescales for both small-bodied and large-bodied taxa.

For example, fossil bison (*Bison bison*: Artiodactyla, Bovidae, Bovini; Linnaeus, 1758) shrink with global warming (−41 ± 10 kg/°C global MAT; Martin, Mead, & Barboza, 2018) probably because large-bodied grazers are disadvantaged both by heat dissipation and by the phenological shifts in plant quality and abundance in warming conditions (Craine, Towne, Joern, & Hamilton, 2009; Speakman & Król, 2010). Our ability to predict the response of large grazers to projected drying and warming during the 21st century is limited by the coarse scale of fossil records. We expect that local warming will diminish body size of extant large herbivores, which may alter their role as keystone species in ecological communities and as the basis of livelihoods in human communities. Droughts cause declines in number and body size of large herbivores due to constraints on water availability and both the quality and quantity of forages (Craine et al., 2012; Craine, Towne, & Elmore, 2015; Gadbury, Todd, Jahren, & Amundson, 2000; Sinclair, Mduma, & Arcese, 2000).

. . .

Recent studies on North American bison . . . support Bergmann's premise over geologic timescales with respect to global temperature.

Local and interannual drying during spring and summer advance plant senescence to negatively affect *Bison* body size (Craine et al., 2009; Craine, Towne, Tolleson, & Nippert, 2013). Thus, we expect body size of large herbivores to decrease with warming and drought across large scales of space and time.

. . .

Under the two emission scenarios, RCP4.5 and RCP8.5, annual average temperature of the northern Great Plains is projected to rise 2–3°C in the near term and 3–6°C in the long term (Wuebbles et al., 2017).

Droughts compound the effects of rising temperature on both plant and animal growth. Heatwaves, which predispose droughts, are increasing in frequency in the Great Plains, and as a result, droughts are increasing in both frequency and intensity, even though precipitation has also increased across the Great Plains (Wuebbles et al., 2017). Increasing precipitation would normally abate increasing evapotranspiration rates. However, according to Wuebbles et al. (2017), temperature on the Great Plains is predicted to increase more rapidly than precipitation to cause more frequent and intense droughts. For a historical perspective, Cook, Ault, and Smerdon (2015) evaluated the last 1,000 years of the Great Plains using the Palmer Drought Severity Index (PDSI). The record included

> "megadroughts" that endured for approximately 35 years. Droughts projected for late 21st century are likely to be more frequent and intense than 20th-century averages with the probability of decadal droughts increasing from ~40% to >95% and the probability of multidecadal droughts increasing from ~10% to >80% under the RCP8.5 model (Cook et al., 2015).

Martin & Barboza 2020 at 336, 337 (citing Representative Concentration Pathways of atmospheric concentrations of greenhouse gases projected by the Intergovernmental Panel on Climate Change and U.S. Global Change Research Program).

Scientists studied bison mass, height, and age at Wind Cave National Park over five decades, and bison height and age at 19 sites along the Great Plains in association with drought severity, temperature, and precipitation. Wind Cave bison are "genetically unique representatives of small populations from the greater Yellowstone," being in part descendants of the distinct population segment of Yellowstone bison. Martin & Barboza 2020 at 337–338, *see also* Figures 1 and 2.

> In this temporally variable climate from the 1960s to the 2010s, female ABM declined by 10.7% (47.5 kg) from 444.5 ± 8.6 kg ($n$ = 338) to 397.0 ± 6.5 kg ($n$ = 274), respectively, whereas male ABM declined by 23.3% (186.1 kg) from 797.9 ± 41.9 kg ($n$ = 252) to 611.8 ± 47.5 kg ($n$ = 190; Table S1), respectively.
>
> In the spatial dataset of the Great Plains, from 1895 to 2018 (Figure 5a), average MDT [mean decadal temperature] increased by 0.7°C from 9.1 to 9.8°C, average MDP [mean decadal precipitation] decreased by 45.8 mm from 685.7 to 639.9 mm, and (Figure 5b) average dPDSI [decadal Palmer Drought Severity Index] worsened by 0.62 from 1.03 to 0.41 ± 2.41. In this geographically variable climate, female ($n$ = 579) ABM averaged 362.2 ± 3.6 kg, whereas males ($n$ = 194) ABM averaged 532.5 ± 12.3 kg (see Table S1 for specific outputs).
>
> . . .
>
> Temporal dynamics of climatic change drove *Bison* ABM: mass (whole model *SD* ± 27.2 kg) decreased with MDT (−114.7 ± 26.7 kg/ 1°C MDT, $p < .001$) and increased with drought index (16.6 ± 6.1 kg/ 1 dPDSI, $p \le .007$; Table 1; Figure 8a and Figure 8b) from an intercept of 1,501.4 ± 173.1 kg. In comparison, the estimated mass of 849 fossil bison ranged between 1648 and 124 kg (Martin et al., 2018).
>
> . . .
>
> In summary, the means for study sites along the Great Plains have risen in temperature by 0.9°C, increased annual precipitation by 16.1 mm, and increased in drought severity (Figure 5).

Martin & Barboza 2020 at 340–341, 342.

The scientist's results indicate rising temperature and drought negatively reduce bison body mass and predicted climate change will likely drive further declines in body size in the coming decades.

As a result of rapid climate change, bison's life history traits and physiological processes will be harmed through decreases in body size and mass, declining reproduction and growth rates, and reduced life span.

> Our data indicate that increasing temperature and drought negatively affect ABM of *Bison*. Additionally, our temporal and spatial mixed models contextualized variation of ABM of *Bison* explained by climatic changes in MDT and dPDSI. Specifically, MDT has a greater effect on *Bison* ABM (−114.7 ± 26.7 kg/ 1°C MDT, p < .001) temporally at one location—WICA [Wind Cave National Park]—than spatially (−1.1 ± 0.0 kg/ 1°C MDT, p < .001) across multiple study sites along the Great Plains. However, dPDSI decreased *Bison* ABM (~16 ± 6 kg/ 1 dPDSI, p ≤ .007) both temporally and spatially likely due to declines in plant productivity (i.e., eNPP) [ecological/evolutionary net primary production] and water availability (i.e., evapotranspiration) across both space and time. On a finer resolution, interannual variation in primary productivity, water availability, and heat stress may be direct causes for declines of *Bison* ABM at each site. Given climatic predications for the Great Plains for the next five decades, our models suggest *Bison* body size and ABM are likely to decline due to increases in local mean annual (and thus decadal) temperature and the worsening conditions of drought (i.e., increasing frequency and intensity). As a consequence, some life history traits that are dependent on ABM will likely shift in response to decreasing ABM, including decreases in age of maturity, declining reproduction rates, and growth rate reduction (Peters, 1983). Preliminary data suggest female *Bison* at WICA are reducing life span, potentially reducing age of maturity and thus reducing growth duration. Because ABM is an outcome of environmental conditions for this large herbivore, it is reasonable to expect that trends of increasing warming and drought may also apply to other large herbivores. Although sex explained the largest variance in both temporal and spatial models, sexual dimorphism was less pronounced in the spatial dataset than in the temporal data from WICA.

Martin & Barboza 2020 at 344.

While the scientists observed harmful changes in bison's life history traits connected to climate change, artificial selection from management actions may also be contributing to the harm.

> [L]arge extant *Bison* may be underrepresented in long-term datasets such as those collected at WICA because mature bulls are dangerous to handle and destructive to handling systems and scales (Licht & Johnson, 2018). Reduction in observations of large, mature bulls at WICA since the 2000s may have reduced the expected ABM and age due to artificial selection bias.
>
> . . .
>
> [T]he spatial model of GP *Bison* ABM change explains 80.4% of variance, several additional factors may explain remaining variance including herd management differences, error of photogrammetric estimates, number of generations to adapt to local climate, and genetic heterogeneity. Body size of *Bison* has been related to genetics (Derr et al., 2012) and changes in foraging conditions (Tieszen, Stretch, & Kooi, 1998), which may be affected by timing and variability of precipitation (Craine et al., 2013; Licht & Johnson, 2018). Derr et al.

> (2012) present that *Bos taurus* introgression with Bison appears geographically widespread throughout North America, yet at low levels of detection (~10%)—citing early conservationists cross-breeding tactics . . . However, other authors (Licht, 2017; White & Wallen, 2012) indicate that genetic introgression, when present, only accounts for 2%–9% of body mass variation in *Bison*. It remains unclear whether changes in forage composition affect body size change of *Bison* even though diet selection varies between males and females (Mooring et al., 2005; Post, Armbrust, Horne, & Goheen, 2001).
>
> . . .
>
> Changes in climate and land use/land cover are a growing concern for conservation of grasslands in *Bison* ecosystems.

Martin & Barboza 2020 at 345, 346.

Results from a survey of bison fecal material sampled across seasons and 50 broad geographic gradients on commercial bison ranches in the United States "show that bison are likely to suffer increased nutritional stress in a warmer climate." Jorns et al. 2020 at 77.

Climate change is exacerbating multiple factors driving the risk of extinction for bison in the wild.

> Many conservation and management consequences result from changes in ABM, below are some detailed examples. Changes in body size have profound effects on both life history traits and physiological processes (Barboza et al., 2009; Hudson & White, 1985; Peters, 1983). Reduced body size is an outcome of slower growth that affects productivity (i.e., offspring size or mass, offspring number, frequency of reproduction, rates of growth, age at first reproduction (maturity), maintenance requirements), life span, and sexual dimorphism. Moreover, large body sizes of mammals have been associated with greater rates of extinction in the last 100 million years and a greater vulnerability to climate change (Barnosky et al., 2017; Dietl & Flessa, 2011; Nogués-Bravo, Ohlemüller, Batra, & Araújo, 2010). Large variations in body size—not related to sexual dimorphism—within extant populations may also increase extinction probabilities (Bolnick et al., 2011; Isaac, 2009). Additionally, negative climate–body size relationships reinforce feedbacks that may increase extinction risks (Isaac, 2009; Smith, Smith, Lyons, & Payne, 2018). For example, both excessive heat (> 40°C) and excessive cold (<−30°C) directly increase demands for energy, water, and nutrients because thermoregulation outputs increase, whereas indirect effects of rising temperature decrease forage quantity and quality—ultimately affecting the supply of energy, water, and nutrients to animals, and specifically *Bison* (Martin et al., 2018). Droughts that decrease water availability compound biotic consequences of rising temperatures on plants and animals.
>
> We would expect that changes in body size of *Bison* would be associated with changes in life history (Peters, 1983). Korec et al. (2019) reported median life span of North American Bison for females at 6.6 years ($n$ = 1,612) and males at 2.1 years ($n$ = 1,300). We estimate median life span for females was 5.5 years ($n$ = 714; average 7.0 ± 5.4 years) and males was 2.5 years ($n$ = 307; average 2.8 ± 1.6 years) in the WICA dataset based on the last observed

record of each individual. Longevity of *Bison* may be shifting with declining body size at WICA because the 90th percentile of maximum age declined from 21.5 years in 1970s to 17.5 years in the 1980s and 16.5 years in the 1990s. Reproductive strategies may also shift as female *Bison* decline in body size. Famoso, Hopkins, and Davis (2018) derived a threshold of 300 kg for mammals below which strategies for reproduction tended to r-selection. The SCI [Santa Catalina Island] female population (ABM = 321 kg) is approaching this threshold, and we predict that body size may decline further to 252 kg if temperature and drought rise as projected (MDT = 25°C; dPDSI = −5.0). Moreover, similar warming and drought conditions are projected for the southern Great Plains, which may result in local extinction because of challenges from shifting reproductive strategies, declining forage quality, and reducing water availability (Nogués-Bravo et al., 2010; Rozzi, 2018).

Martin & Barboza 2020 at 346–347.

Because Yellowstone bison are an age-structured population and rising temperatures and extended droughts decreases body size and mass, and reduces life span, the U.S. Fish & Wildlife Service must examine and investigate the long-term outcomes of declining reproduction and growth rates as a result of rapid climate change over the next century in the agency's threats assessment and status review.

PHOTO: BFC Archives

The U.S. Fish & Wildlife Service must also examine and investigate negative feedbacks resulting from climate change-induced stresses such as a decline in the nutritional value of native forage species and an increase in demands for energy, water, and nutrients for Yellowstone bison.

Decreasing body size and mass in a highly competitive mating population, and a reduction in life span in an age-structured population together with increased nutritional stress are factors increasing the likelihood of extinction for Yellowstone bison.

***Rising temperatures decrease bison body size, growth rates, and alter life-history characteristics.***

Cooler summers are more optimal for *Bison* growth because of reduced heat loads during the growing season. Rising temperatures constrain body size and productivity of *Bison*.

. . .

Body size of bison (*Bison bison*) has shrunk by 31% (Martin et al. 2018) with rising mean global temperature since the last Ice Age, and over the last 5 decades, body size of *Bison* has declined by 11–23% (Martin and Barboza 2020) with rising mean annual temperature along the Great Plains of North America, but what are the mechanisms driving temperature response?

> Body size depends on growth, which depends on maximizing net energy and nutrient flows for the production of tissues at seasonal scales across the range of the species.
>
> . . .
>
> Maximum body size of endotherms depends on optimal growth of individuals and thus populations. Optimal growth depends on low costs of maintenance for the efficient production of tissues, especially in seasonal environments when food availability and environmental demands constrain the annual window for growth. High thermal loads increase costs of body maintenance to balance internal and external heat loads through thermoregulation, which ultimately reduces the energy available for growth.

Martin & Barboza 2020 at 11, 1.

Scientists studied thermoregulation costs of body surface temperature and heat exchanges of "350 adult and 345 adolescent *Bison* from 19 herds in summer and winter along the Great Plains from Saskatchewan (52° N) to Texas (30° N)" including 3 herds in western Montana. Martin & Barboza 2020 at 1, *see also* Table 1 at 5.

The scientist's findings on bison confirm the theories of Kooijman, Schmidt-Nielsen, Speakman & Król, and Bergmann, on the role of "heat flux as a common currency" in driving and selecting for body size with corresponding influences on annual growth, reproduction, and life history traits.

> Kooijman's dynamic energy budget theorized that energy balances and thus micro-climates and weather affected heat transfer and energy use of animals on the landscape to ultimately affect life history. Schmidt-Nielsen theorized that allometric scaling of surface-area-to-volume ratio ($b = 0.67$) increased heat retention as animals increased body size, which would favor survival in cold environments for larger animals. Speakman and Król theorized that heat dissipation limits to thermoregulatory costs under rising heat loads limited reproduction and growth and affects life history and body size of animals. Bergmann's rule predicts thermal conservatism of animals for cooler climates at higher latitudes will produce larger individuals within and across species than warmer climates at lower latitudes.
>
> The theories of Bergmann and Schmidt-Nielsen emphasize selection for survival by reducing heat flux that results in a net loss of energy from the body during extreme cold and prolonged winters. The theories of Kooijman, Speakman and Król emphasize selection for growth and reproduction by controlling excessive heat flux during a short summer window of food availability with heat waves and drought. Bergmann and others predict that environmental selection is driven from north to south by winter bottlenecks in survival, whereas Kooijman and others predict that environmental selection is driven from south to north by summer bottlenecks in production and reproduction. All the above theories ultimately are related to thermoregulation and heat exchange. While the above theories are not mutually exclusive, the integration of each may help understand and better predict endotherm response to a changing climate.
>
> Thermoregulation is the cost of achieving heat balance. Thermoregulatory processes

> usually increase energy use by increasing heart rate and blood flow (e.g., vasodilation and metabolism). In hot weather, thermoregulation increases the flux of body water because water is used for evaporative cooling (e.g., panting and, to a lesser extent for *Bison*, perspiration). In cold weather, thermoregulation generates body heat (e.g., shivering, increasing metabolic heat production, and muscular activity) and conserves core body heat through control of blood flow to the periphery. Thermoregulation affects the use of energy, water, and nutrients such as electrolytes and organic nitrogen, which ultimately affects resting and foraging behaviors (Clarke 2017). High costs of energy are associated with high levels of heat transfer (e.g., thermal windows; Fig. 1) and are quantified as heat flux ($W/m^2$).

Martin & Barboza 2020 at 2.

Moreover, rising temperatures and drought severity increases demands on bison for energy, nutrients, and water while simultaneously reducing the availability of nutritional forage for Yellowstone bison to meet these increased demands.

> *Bison* are resilient to short duration extreme weather events such as blizzards, dry spells, heat waves, or wildfires; however, chronic droughts and warming may affect long-term life-history traits (Martin and Barboza 2020). Moreover, anticipated warming and drying along the Great Plains will shift the distribution of vegetation types by mid- and late-century to alter the supply of digestible energy and digestible nitrogen available to *Bison*, native wildlife, and domestic livestock (Tieszen et al. 1998, Craine et al. 2015, Briske 2017).

Martin & Barboza 2020 at 2.

The majority of variation in bison body size is driven by temperature and drought, which are projected to increase and become more severe across seasons in the Yellowstone ecosystem. Hansen et al. 2014 at 492 (projecting a rise in temperatures of 3.89 degrees Celsius by 2100); Hansen 2016 (Bozeman Daily Chronicle, Guest columnist) (citing climate scientists projecting a rapid warming of 6 to 11 degrees Fahrenheit by 2100).

> *Bison* grow over several years to achieve asymptotic body size—typically by 3 yr of age for females and by 5 yr of age for males (Martin and Barboza 2020). Environmental demands during growth of *Bison* affect asymptotic body size. Although genetic variation among bison herds exists, merely 1–2% of height variation derives from genetic variation (Musani et al. 2006, White and Wallen 2012, Licht 2017). Moreover, height and body mass are tightly related and have little variation (Martin and Barboza 2020), with 80–96% variation of body mass explained by temperature and drought; that is, large phenotypic variation is not likely due to the existing small variations in genetic makeup. Here, we focused primarily on adolescent female *Bison*, between their birth and their third year, because they shape the foundation for subsequent generations and cohorts of the population, but, when explicitly stated, adults are included as a comparison group for analyses.

Martin & Barboza 2020 at 5.

The scientist's results may be inferred for Yellowstone bison seasonally occupying range in latitudes of 44° N to 45° N.

> South of 43° N (e.g., South Dakota-Nebraska border), adolescent *Bison* between the ages of 3 months and 3 yr ($n$ = 214) have a smaller surface area (7.8 ± 2.1 $m^2$), lower total surface heat transfer (—221 ± 78 W), lower body mass (271 ± 94 kg), and more heat loss (—286 ± 76 $W/m^2$) than their northern ($n$ = 131) counterparts (8.9 ± 2.1 $m^2$; —224 ± 72 W; 324 ± 105 kg; —254 ± 67 $W/m^2$, respectively).

Martin & Barboza 2020 at 5.

Yellowstone bison must adapt to and withstand a number of climate-induced stressors during all seasons.

"Unseasonably warm winter days appear to raise surface temperatures of *Bison* (Fig. 4). The frequency of these warmer winter scenarios is expected to increase in the coming decades (Wuebbles et al. 2017), which may be stressful for large animals that are well insulated with a woolly underfur and a layer of subcutaneous fat." Martin & Barboza 2020 at 9.

"Our data support Kooijman's dynamic energy budget theory (Figs. 4 and 5) because body surface temperatures were directly related to radiative loads and convective losses of energy. Schmidt-Nielsen's rule predicts that surface-area-to-volume ratio decrease with increasing body size to slow heat transfer from large animals. We found that increasing body mass increased total surface heat transfer in both an isometric and an allometric fashion (Fig. 6)." Martin & Barboza 2020 at 9–10.

> Speakman and Król's heat dissipation limit theory predicts that production is suppressed when heat loads from the environment and metabolism divert energy to thermoregulation. Our data demonstrate that growth of *Bison* is limited by heat loads because the slowest annual growth rates were associated with the greatest heat transfer (Fig. 7). However, we acknowledge that the temporal resolution of growth data is too large to resolve the relationship of growth and excessive heat loads within a growing season. Bergmann's rule predicts that selection favors large animals at higher latitudes. The ability to retain heat in cold winters (sensu Schmidt Nielsen; Fig. 6) has been invoked as an explanation for Bergmann's rule. Our data provide some support for thermal conservatism, because heat flux from the smallest 5% of *Biso*n (≤164 kg; —248 + 58 $W/m^2$) was greater than that of the largest 5% of Bison (≥511 kg; —230 ± 30 $W/m^2$). However, Bergmann's rule is also explained by summer growth and the net primary production of food (Huston and Wolverton 2011). Asymptotic size of *Bison* on the Great Plains declines with high decadal temperatures and droughts that suppress growth of both the animal and the forages they consume (Martin and Barboza 2020). In this study, high annual growth rates were observed at high and low latitudes at sites with mean annual precipitation above 450 mm (Table 1; Fig. 7), which suggests that growth is dependent on thermal exchanges as well as forage supplies.
>
> Our study of heat transfers in bison provided support for all four theories of body size, which suggests that body size is an outcome of consistent effects across temporal and organizational scales from instantaneous heat balance through seasonal growth of this

> long-lived animal. Reinforcement between levels of organization multiplies the effect of body size of individuals in a population on other ecological processes especially for large keystone species such as bison that influence the composition of plant and animal communities in their ecosystem (White 1983, Knapp et al. 1999, Beschta et al. 2020).

Martin & Barboza 2020 at 10–11.

> Annual and seasonal mean temperatures are expected to rise over the next eight decades, and this will increase heat loads and thus increase negative heat transfer. Increasing negative heat transfer will further decrease growth rates and likely alter life-history traits (Martin and Barboza 2020) including reproduction rates. Special conservation and management considerations by organizations like the IUCN-SSC Bison Specialist Group, conservation NGOs like The Nature Conservancy, state and federal bison herd managers like the National Park Service, and private bison herd managers will need to be given to the central and southern Great Plains where the number of extremely hot days (>32°C) is expected to rise to 87 d/yr from 32 d/yr (Weatherly and Rosenbaum 2017). Marginal habitats will also challenge conservation plans in places like the arid desert regions of the American southwest where drought is expected to be persistent, lengthening, and intensifying and expanding into new areas like the central Great Plains (Cook et al. 2015).

Martin & Barboza 2020 at 11.

***The role and threat of climate change in the declining nutritional value of native plants in Yellowstone bison's range is unknown. A warmer, dryer climate will result in a significant loss in wetlands, and reduce sedge and rush species bison depend on for food.***

While rapid climate change is projected to result in more shrub-grassland and less forest, there is no unexploited grasslands for Yellowstone bison to roam because human appropriation of habitat, government imposed "tolerance zones" and management actions severely restrict the migratory species' range and intentionally disrupt connectivity to habitat and access to resources.

The declining availability and nutritional value of native plant species and connectivity to habitat for Yellowstone bison is likely to be doubly harmed and reduced by climate-induced changes in vegetation communities and manager's imposing limited ranges on the migratory species.

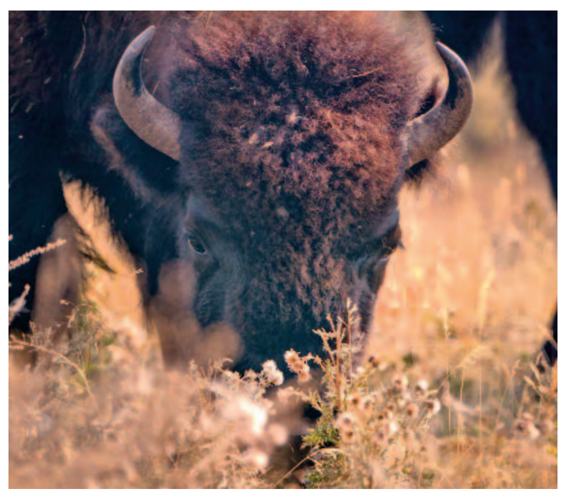

PHOTO: Bridget Sandoval

The ecological effects of rapid climate change on the availability and nutritional value of native plants is of utmost concern.

An increase in atmospheric carbon dioxide is known to reduce plant nitrogen content resulting in "poorer quality forage and reduced landscape carrying capacities." Stewart et al. 2021 at 8 (citing Faith 2011 who found evidence of an ecological mechanism for population collapse and extinction of North American megafauna in the late Pleistocene connected to a "climatically driven nitrogen sink" acting in association with other mechanisms).

Scientists project "increased climate-induced stress and further exotic species invasions" and uncertainty about the resiliency of grasslands in Yellowstone to withstand rapid climate driven changes in the ecosystem. Sikkink & Alaback 2006 at 155.

Furthermore, climate-driven change is projected to expand nonnative winter annual species such as desert alyssum into Lamar and Hayden valleys resulting in "potentially irreparable change to critical habitat" for native grassland-dependent species such as bison. Wacker 2019 at 66, *see also* Figure 1 showing the proportion of the "extremely invasive" desert alyssum spreading at nine long-term monitoring sites.

According to Yellowstone National Park, alyssum's early germination saps available spring moisture before other species have a chance to sprout, and exude a chemical inhibiting soil bacteria needed by native plants.

State and federal managers are placing additional stress on Yellowstone bison in restricting movements to a portion of an ecosystem without regard for how climate change is driving changes in the availability and nutritional value of native forage within the limited range managers enforce.

Brookshire and Weaver studied a four-decade record of grassland production in an extensive Idaho fescue meadow system in the Bangtail Mountains of the Greater Yellowstone bioregion "to assess the extent of climate-induced change over the recent historical period." Brookshire & Weaver 2015 at 5, 2.

The scientists documented "a >50% decline in production of a native $C_3$ grassland" from 1969–2012 assigning "the forcing and timing to increasing aridity and specifically to declining late-summer rainfall." Brookshire & Weaver 2015 at 1.

> Most remarkably, we report a previously undocumented >50% decline in August and September rainfall that parallels the long-term ANPP [above-ground net primary production] decline and increasing regional PDSI [Palmer Drought Severity Index] dryness (Fig. 1e, Supplementary Fig. 2) and declining late-summer stream flows. No other climate variable, including snowfall (Fig. 1f) and snowpack, showed significant directional change (Supplementary Fig. 3) despite documented decreases in snowpack in the wider Northern Rockies region.

Brookshire & Weaver 2015 at 3 (endnotes omitted).

> Part of their dietary strategy involves foraging and moving over large areas to acquire adequate food and a digestive system that allows them to subsist under circumstances of limited supply. A major component of this strategy is to consume seasonally nutritious grasses. Cool season (C3) grasses are consumed in the late fall into the late spring, followed by warm season (C4) grasses that become available in the late spring increasingly through summer and into early fall. These seasonal changes in feeding chronology are recorded [in] the stable carbon isotope values in their tissues.

Cannon 2008 at 184, *see also* Table B1 at 226–228 (identifying C3 and C4 plants bison consume).

"[A]t the continental scale, bison weight gain is greater in cool, wet climates than in hot, dry climates. 6.5-year-old male bison in Ordway Prairie, South Dakota were 260 kg heavier than those in the hotter and drier Wichita Mountains, Oklahoma." Craine 2021 at 1 (endnotes omitted).

Reproduction is dependent on the mother's body mass and interannual variation in reproduction is tied to the "variation in timing and amounts of precipitation" with dietary needs peaking in early summer in the same period of time "of greatest nutritional demands for lactating bison." Craine 2021 at 1, 2.

"Nutrition is one of the most important keys to understanding the ecology of North American plains bison (*Bison bison*). Many factors such as mineral concentrations and secondary compounds affect grazer nutrition, but protein and energy concentrations of the plants bison eat determine their performance and reproduction, regulate their fine-scale movements as well as long migrations, and structure their interaction with vegetation." Craine 2021 at 1 (endnotes omitted).

Craine's study sampling diets in 50 bison herds found forbs and legumes contributed over half the protein across their range.

> Comparing the relationships between climate and dietary quality between 2018 and 2019 reveals that cooler, wetter sites generally have higher forage quality for bison than warmer, drier sites. . . . bison from cool, wet climates have the highest weight gain.
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> . . .
>
> In all, the research presented here illuminates one of the reasons that bison might have migrated long distances in the Great Plains, similar to the Green Wave Hypothesis. Bison that began the spring in southern ranges would have experienced higher protein concentrations than those in northern ranges. Assuming they could have migrated fast enough to follow phenological development, this would have provided them with higher total protein intake than those that did not migrate. A migration rate of ~ 20 km $d^{-1}$, which is similar to the migration rate of caribou and saiga, would be sufficient to cover the distance between central Texas and southern Nebraska over a 2-month period. Given the interannual variation in dietary quality observed between 2018 and 2019 in June and September, it is likely that this benefit to migration would have varied among years, although more years of monitoring with data covering the entire growing season is required to more fully evaluate this question.

Craine 2021 at 8, 9 (endnotes omitted).

"Climatic warming is likely to exacerbate nutritional stress and reduce weight gain in large mammalian herbivores by reducing plant nutritional quality. Yet accurate predictions of the effects of climatic warming on herbivores are limited by a poor understanding of how herbivore diet varies along climate gradients." Craine et al. 2015 at 1.

Craine compared variation in bison diet in two grasslands that differ in mean annual temperature by 6 °C showing an associated "greater nutritional stress in warmer climates, bison consistently consumed fewer graminoids and more shrubs and forbs, i.e. eudicots. Bison in the warmer grassland consumed a lower proportion of $C_3$ grass, but not a greater proportion of $C_4$ grass. Instead, bison diet in the warmer grassland had a greater proportion of $N_2$-fixing eudicots, regularly comprising >60% of their protein intake in spring and fall. Although bison have been considered strict grazers, as climatic warming reduces grass protein concentrations, bison may have to attempt to compensate by grazing less and browsing more." Craine et al. 2015 at 1.

In addition to driving a decline in the nutritional value of grasses, climate change is likely to drive a decline in the availability of additional plants bison consume such as sedges and rushes.

Because sedge and rush species are found in wet habitats, rising temperatures, earlier spring runoff, and increasing drought severity is going to disrupt the availability of these bison foods. For an overview of grasses and grass-like plants in bison's range and habitat, *see* Meagher 1973 at 150–152 (Appendix VII) online at npshistory.com/series/science/1/app7.htm.

A warmer, dryer climate will result in a significant loss in wetlands — up to 40% — in the Yellowstone ecosystem. Yellowstone National Park April 2018.

A decline in wetland habitats will also drive a decline in sedges and rushes — all important bison foods.

The forecast for ecosystem-level change and projected declines in the nutritional value of grasses and sedge and rush species associated with wetland loss due to rising temperatures and increasing drought, is a significant factor the U.S. Fish & Wildlife Service must examine and investigate in the agency's threats assessment and status review.

The rapidity and magnitude of ongoing and projected changes for protected areas is unprecedented. More importantly, the fixed boundaries of protected areas cannot "migrate" in response to climate-driven changes in the ecosystem.

Whatever protection Yellowstone National Park may or may not provide, by itself, park forage is unlikely to meet Yellowstone bison's nutritional needs at the end of the century as evident in the migration and dispersal pathways bison use today.

A study of the potential adjustments in the distributions of major tree taxa to simulated future climates in the region of Yellowstone National Park found presently protected areas may not be suitable for taxa to survive.

> These analogues illustrate the general concept that high-elevation habitats will become restricted or even eliminated as warming occurs, while low-elevation habitats will expand and move to the middle elevations: the present high-elevation Gallatin Range climate is almost eliminated from the region, while the low-elevation Lamar Valley climate becomes widespread within the region. The analogues also reveal, however, that the replacement climate may be far removed from a site, particularly in the case of low-elevation locations, and that the pattern of the projected climate changes does not consist of simple upward or northward displacements of climate zones.

. . .

> Parks and preserves with geographically fixed administrative boundaries face the problem of not being able to "migrate" with the species they presently protect. As a result, cooperative management across administrative boundaries will be necessary to address the effects of climate change.
>
> Conservation reserve theory advocates the creation and preservation of habitat corridors to connect reserves and provide pathways for migration and dispersal (Hunter et al. 1988; Shafer 1990; Noss & Cooperrider 1994). As climate changes and the areas of potentially suitable habitat for individual taxa move across the landscape, however, corridors designed to facilitate the movement of organisms across the present landscape may no longer be optimal.

. . .

> The rapidity of the projected climate change, coupled with the size and character of the projected vegetation changes, presents a challenge to current management philosophies and preservation goals. Strategies that emphasize intensive species-level protection, such as mandated by the U.S. Endangered Species Act, will have to consider the implications of intervention and assisted migration to facilitate the movement of taxa into new ranges (Orians 1993). Strategies that promote natural regulation of ecosystems, such as practiced by many national parks, will have to consider the consequences of major extirpations and invasions as taxa adjust their range limits. Current difficulties in coordinating the management of federal, state, and private lands in the Yellowstone region only portend the scope and complexity of the debate that will ensue in formulating an appropriate response to the vegetation changes projected in the future.
>
> The projected climatic changes resulting from the increases of greenhouse gasses are large and rapid, and equally dramatic is the attendant response of vegetation. In the Yellowstone region the potential range adjustments are unprecedented in magnitude during the Quaternary; they are counterintuitive, with southward and downward adjustments in the potential ranges of some taxa possible; and the potential responses of individual taxa are unique, making it likely that present assemblages of taxa will not survive into the future. The widespread extirpations, latitudinal and altitudinal displacements, and the appearance of new communities under the potential future climate may shift the location and change the character of current centers of biodiversity. This possibility complicates present efforts to protect these areas. Potential reserves and the corridors linking reserves, designed on the basis of the uniqueness of present environments or biota (Scott et al. 1993; Kareiva 1993; Prendergast et al. 1993), may not be suitable under future climate conditions.

Bartlein et al. 1997 at 786, 789–780.

The declining nutritional value of grasses and availability of bison foods, the inability of protected areas to migrate, the loss of migration corridors, and management actions thwarting Yellowstone bison's pathways and dispersal to range in response to climate change and environmental stressors are cumulative threats the

U.S. Fish & Wildlife Service must examine and investigate in the agency's threats assessment and status review.

***Changes in climate and rainfall patterns cause a reduction or regional shift in bison range.***

In forecasting the future, examine the past.

Huebner's study provides insight into how changes in climate, rainfall, and drought can lead to a reduction or regional shift in the range of bison.

> Local conditions of grass, topography and access to water would be limiting factors that could mean many bison in some areas and none in others.
>
> . . .
>
> [I]ncreased bison visibility is a result of, not a direct indicator of, paleoclimatic change.
>
> . . .
>
> The explanation offered for this periodicity are changes in climate, and rainfall patterns that either caused reduction or regional shifts in bison range.

Huebner 1991 at 351, 345–346.

> As the western Cross Timbers in Oklahoma and northern Texas experienced the transition from Oak Woodlands to more open, grassy oak savannahs ca. 1000 BP, bison would have started to utilize this more hospitable environment. This initial movement into Central Oklahoma and northcentral Texas prior to 750 BP is supported by the conclusions reached by Baugh (1986) and Lynott (1979). As drought conditions began to peak ca. 700 to 600 BP in the Southern Plains, the expanding bison populations continued their movement south into Central Texas and the Coastal Prairies. The period of roughly 250 years from the onset of the xeric trend to the appearance of bison in Southern Texas accounts for the time necessary for community succession (cf. Davis 1986) in the Cross Timbers and the increase in bison populations from expanded habitat range.

Huebner 1991 at 352–353.

> This study has presented evidence for climatic change and the associated expansion of bison herds in Southern Texas ca. 750 BP. In the examination of Dillehay's Presence/Absence model, it was found to be fundamentally correct in timing for Southern Texas, but it failed to explain the ecological events that lead to the expansion of bison populations. From the data presented, it is possible to summarize the events that lead to favorable range conditions that permitted the expansion of bison populations.
>
> 1) *Dessication Event Starts ca. 1000 BP*. Drier climate favors grasses over trees and begins the eastward movement of the line between the shortgrass and mid- and tall-grass prairies

(cf. Risser et al. 1980).
2) *Bison Populations in Southern Plains Increase*. The drier climate favored the growth of bison populations in the Southern Plains.
3) *Cross Timbers and Post Oak Savannah Become Grassier*. The more open understory permits enlarged bison herds greater access to the prairies of Southern Texas. This point is in effect the threshold at which bison begin to be visible in the archaeological record of Southern Texas.
4) *Bison Populations Expand Into Southern Texas ca. 750 BP*. Movement through the "Bison Corridor" continues through prehistoric times.

In effect this is a push-pull model. As the climate of the Southern Plains became drier and more favorable for bison, their populations grew. As population growth expanded to and beyond carrying capacity, herds were drawn into the prairies of Southern Texas where the grassland econiche that had been underexploited for centuries was now accessible.

Huebner 1991 at 354–355.

In contrast to the availability of range and habitat allowing bison to adapt to climate change, drought, and reduced rainfall 1,000 years ago, State and federal management confines and reduces bison's natural migrations and range, and intentionally disrupts connectivity to habitat.

PHOTO: BFC Archives

As a consequence of depriving bison of the ability to naturally disperse across significant portions of their range to cope with rapid climate change and random environmental stressors, managers are increasing the risk of local and regional extinction.

Without protected range and habitat elsewhere, and the ability to disperse through restored migration corridors outside reserves or protected areas, State and federal managers have no backup to guard against ecosystem failure or environmental stress that would drive bison beyond the limited range and habitat available today.

Under current management, one severe decade-long drought would be disastrous for Yellowstone bison.

Because rapid climate change and random environmental stressors such as a shift in rainfall patterns are likely to shift the range of bison outside government imposed boundaries, the U.S. Fish & Wildlife Service must examine and investigate management actions that could jeopardize distinct subpopulations and persistence of the Yellowstone population in the agency's threats assessment and status review.

***Drought reduces grassland ecosystem function and drives a decline in the condition of Yellowstone bison.***

Drought can lead to the degradation and loss of connectivity to resources by reducing the amount and quality of suitable habitat available for Yellowstone bison as conditions become drier. Ecological responses will vary "depending on the frequency, duration, severity or intensity, and recurrence intervals of drought events." Albright et al. 2021 at 10.

Even a one-year drought severely effects grassland ecosystem function, reduces the base of the food web, and drives a decline in the condition of bison.

> There was a 19% reduction in ANPP [net aboveground primary production] from 1988 to 1989, likely caused by death or injury to plants during the 1988 drought. Drought also appeared to be partially responsible for reductions in elk and bison from 1988 to 1989, which were coincident with declines in *C* [large herbivore consumption] and *D* [dung deposition]. Results indicate direct effects and suggest indirect effects of a single-season drought on grassland function that will persist for several years after the event.
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> Grasslands supporting abundant herds of large mammalian herbivores sustain the highest chronic rates of herbivory of any terrestrial ecosystem (Detling 1988, McNaughton et al. 1989). The effects of grazers on grasslands are profound and cascade through all trophic levels (McNaughton 1985, Detling 1988, McNaughton et al. 1988). When herbivores are migratory, their effects include additional spatial and temporal components (Senft et al. 1987, McNaughton 1989, 1990). A variety of large herbivores have been shown to exhibit habitat preferences with landscapes, including bison, *Bison bison* (Coppock et al. 1983, Norland et al. 1985), feral horses, *Equus caballus* (Turner and Bratton 1987), eastern gray kangaroos (*Macropus giganteus*), wallaroos (*M. robustus robustus*) (Taylor 1984), and both resident (McNaughton 1988) and migratory (McNaughton 1990) African ungulates. As a result, large herbivores can play an important role in determining landscape patterns of energy and nutrient fluxes. Furthermore, since the composite effects of herbivores are partially dependent on other trophic processes (McNaughton 1985) that vary temporally (e.g., soil processes; Birch 1958, Burke 1989, Burke et al. 1989), the timing of herbivore use is an important determinant of the impact of grazers on ecosystem processes.

Frank & McNaughton 1992 at 2043.

> Drought had a severe effect on grassland and shrub grassland ecosystem function. Results indicate large direct and indirect effects of drought on net energy and nutrient flux in Yellowstone. Direct drought-induced death and injury of plants reduced the base of the food web, and, thus, the energy- and nutrient-capturing capacity of the ecosystem. Direct effects on ungulate condition and indirect effects through wildfire were likely involved in the decline in elk and bison numbers, which in turn meant reductions in both consumption and nutrient flux through grazers (indexed with dung deposited at sites). The decline in grazers probably had indirect cascading effects on trophic processes that should be expected to reverberate in this grazing-dominated ecosystem until herbivore populations recover. These

results show how dramatically a severe drought of one-year duration can alter ecosystem function.

Frank & McNaughton 1992 at 2056.

In forecasting the future, examine the analogies of past events occurring elsewhere in bison's range.

> Effective moisture, frost-free days, and temperatures combine to have an impact on the quality of grasses available as bison forage and consequently on the nature of bison populations (McHugh 1972:20; Reher 1978; Bamforth 1988:67-84). Periods of protracted drought or regular episodic drought reduce the quality of grasses and access to drinking water. Cool drought conditions compound the problem by limiting the length of an already poor growing season. Severe climatic deterioration can result in plant biomass reductions of 70-80% (Coupland 1958:288).
>
> Forage quality affects bison herd responses. Bamforth (1988:Table 6-1) proposed bison response to poor forage would be low population density, small herds, and herds which move faster, farther, and more frequently with larger home ranges. Response to high forage production would lead to high population density, large herds, and herds which move slowly, over shorter distances, and within smaller home ranges.
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> The strongest conclusion that can be drawn from the data is that Central Plains bison population levels fluctuated significantly during the late prehistoric and protohistoric periods. Furthermore, these changes were likely precipitated by climate shifts and the most dramatic fluctuation occurred between the Pacific [cool, dry AD 1150–1550] and Neo-Boreal episodes [cool, moist AD 1550–1880] (see Blakeslee 1993 and Lensink 1993 for counterarguments).

Bozell 1995 at 154, 159.

> On the Southern High Plains, where drought was most severe, surface and groundwater sources dried and bison populations were diminished, prompting substantial adaptive changes, including local abandonment, well-digging to tap underground water, and a widening of the diet breadth to incorporate higher-cost, lower-return seed and plant resources.
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> Among the species that may have become locally rare or absent during this period [middle Holocene] were the birds that seasonally or annually inhabit the surface lakes and marshes of the Plains, and bison. Bison during this time also underwent accelerated species evolution from *Bison antiquus* to *Bison bison* (Frison, 1991, p. 272, Fig. 5.5; Johnson and Holliday, 1989, p. 158; McDonald, 1981, p. 250; Toomey *et al*., 1993, p. 308). The drop in bison numbers, most pronounced further south (Ferring, 1995, Fig. 3; McDonald, 1981, p.

255), was likely a function of scarce surface water and forage. If the Altithermal was marked by summer drought, it would have especially impacted the warm season ($C_4$) grasses that dominate the short-grass plains—buffalo grass and blue grama grass (Weaver and Albertson, 1956, pp. 79–80). This, and the fact that the grass crop that did survive would not have been as rich and nutritious, would have reduced bison health and numbers (Frison, 1975, p. 296; Meltzer and Collins, 1987).

. . .

Overall, the middle Holocene Plains was marked by a general north to south gradient of decreasing effective moisture, surface water, and resource abundance (particularly, bison abundance); along that same gradient there was increasing resource patchiness, sediment weathering, erosion, and aeolian activity.

. . .

Drought conditions—the Altithermal, as classically envisioned—were most pronounced on the Southern High Plains. Correspondingly, that area provides the most direct and secure evidence of forager responses to drought. There seems little doubt that hand-dug wells on the floors of drainages (within which were one-time spring-fed lakes and ponds), were prompted by a region-wide decline in the water table, which in turn was produced by a long-term rainfall deficit, high temperatures, or both. Under such climatic conditions, bison numbers were also reduced, and though they clearly remained a highly ranked resource for human foragers, their scarcity required an expansion of the diet to include other, lower ranked animal and plant resources.

Meltzer 1999 at 404, 406, 413.

Reher and Frison (1980:41) argue that bison populations with a generation span of only three years, high mobility rate, and fertility rate dependent on the individual's condition should be quite sensitive to fluctuations in grassland productivity at a time scale of less than a decade. Under drought conditions bison populations should have increased mortality and lower fertility which would be reflected in irregular age pyramids. Age structure and survivorship rates would also be influenced by how close the population is to carrying capacity. Behavioral responses would include migration to river valleys, foothills, or montane areas. Longer drought cycles (ca. 200 years) would drastically depress survivorship rates and regional population levels.

Cannon 2008 at 77.

Bison herds respond in a number of ways to drought: older individuals are more likely to die while the fertility of cows and survival of young decrease. Since droughts reduce the availability of annual plants, thereby making perennial plants more readily available, bison reproduction can suffer. Bison obtain necessary nutrients from both annuals and perennials, but the former fosters better reproduction. Herds shift their migration patterns during droughts as well, sometimes moving to areas with better forage quality and

> sometimes breaking into smaller groups to alleviate pressure on grazing areas. General deprivations of essential forage and nutrients, however, could weaken and even kill off some bison.

Hodge 2012 at 372–373 (endnote omitted).

PHOTO: Peter Dettling

Climate change is forecast to significantly impact snowpack, altering "the timing of precipitation events and early runoff (Ojima et al., 2015). Changes to the timing and seasonality of precipitation have the potential for devastating impacts to range condition as spring and early summer precipitation drives forage production (Smart et al., 2007)." Beeton et al. 2019 at 52.

Indeed, a drought in western South Dakota (2002–2007) reduced "the reproductive capacity of bison and elk, which was attributed to reduced forage quality and quantity," prompting Wind Cave National Park staff to make "unprecedented inquiries about water rights and delivery in the bison enclosure." Beeton et al. 2019 at 56.

Whether the enclosure is a boundary fence or a government imposed boundary prohibiting bison migrations to cope with random environmental stressors such as drought, the end result is a reduction in bison abundance with cascading trophic effects on grasslands and native species benefitting from bison freely roaming the Yellowstone ecosystem.

Because climate change is driving changes in the frequency, duration, and severity of drought, the U.S. Fish & Wildlife Service must examine and investigate drought and the additive stressors resulting from management actions depriving Yellowstone bison of suitable habitat in the agency's threats assessment and status review.

***Extreme weather patterns drive changes in bison movement patterns.***

A study of the Wichita Mountains Wildlife Refuge and Tallgrass Prairie Preserve bison herds in Oklahoma found air temperature, severe drought, and soil conditions influence bison movement patterns.

The study is significant for bison populations with limited or restricted ranges as many "large ungulates are also predicted to experience climate change-induced range boundary shifts (Thomas, 2010), which further complicates ongoing conservation efforts for those species already restricted to small areas due to human encroachment." McMillan et al. 2022 at 2.

The forecast for rapid climate change and a shift in weather patterns has far reaching consequences for "the feasibility of maintaining bison herds," according to the study's authors. McMillan et al. 2022 at 3.

Climate change driven increases in the "intensity and frequency of extreme weather and drought events" will add to the already intensified conflict of Yellowstone bison migrating beyond government restricted ranges to cope with environmental stressors. McMillan et al. 2022 at 2.

The author's data supports the finding that extreme weather patterns drive changes in bison movement patterns.

Scientists analyzing 715,344 movements of 33 female bison across the two sites found the "additive effect of air temperature, wind speed, and daily rainfall best predicted plains bison movement distance" while the distances bison moved "were also better explained by severe drought (i.e., drought conditions deeper in the soil profile) than moderate drought conditions." McMillan et al. 2022 at 10.

> [A]ir temperature best explained the variation in distance moved compared to any other single parameter we measured, predicting a 48% decrease in movement rates above 28°C. Moreover, severe drought (as indicated by 25-cm depth soil moisture) better predicted movement distance than moderate drought. The strong influence of weather and drought on plains bison movements observed in our study suggest that shifting climate and weather will likely affect plains bison movement patterns, further complicating conservation efforts for this wide-ranging keystone species. Moreover, changes in plains bison movement patterns may have cascading effects for grassland ecosystem structure, function, and biodiversity. Plains bison and grassland conservation efforts need to be proactive and adaptive when considering the implications of a changing climate on bison movement patterns.

McMillan et al. 2022 at 1.

The data documenting the effects of extreme weather and severe drought on bison movement patterns may "reflect a general physiological response across the *Bison* genus" that needs to be verified elsewhere. McMillan et al. 2022 at 9.

> Air temperature and plant-available soil moisture (a drought indicator), in particular, can both strongly influence forage distribution, quantity, and quality. Severe drought is characterized by low soil moisture that extends deep within the soil profile (Basara et al., 1998), and likely has a significant influence on plains bison movement. As ungulate grazers, forages can also provide plains bison with most of their daily water requirement (Kay, 1997; King, 1983). Forage moisture content is tied to soil moisture, and during severe drought, ungulate grazers largely depend on permanent or ephemeral water sources to meet their physiological needs (Kay, 1997). Historical accounts of movement patterns in plains bison suggest they may have traveled long distances, and for multiple days without water (Hornaday, 1889).

McMillan et al. 2022 at 3.

Air temperature, daily rainfall, wind speed and soil conditions drive increases and decreases in bison movements, and distance moved.

> Air temperature better explained plains bison movement distances compared to the other

> weather parameters we tested in our single fixed-effect models. Air temperature also had the strongest effect of any single weather parameter we tested (R2 = 0.019; Table 2). Movement increased 92.5% with every 10°C increase in air temperature from −21.3°C to 28.2°C (β = 0.023, 95% CI = 0.023, 0.024; Table 3; Figure 3). However, movement decreased 48.5% with every 10°C increase from 28.3°C to 44.3°C (β = −0.012, 95% CI = −0.015, −0.010; Table 3; Figure 3).
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> Movement distance increased 149.7% with every 0.1 cm increase in daily rainfall from 0.00 to 0.18 cm per day (β = 1.305, 95% CI = 1.090, 1.521), but decreased 1.1% with every 0.1 cm increase in daily rainfall from 0.19 to 6.68 cm per day (β = −0.019, 95% CI = −0.034, −0.004; Table 3; Figure 3). Movement distance decreased 0.35% with every 1 $ms^{-1}$ increase in wind speed from 0.00 to 6.60 $ms^{-1}$ (β = −0.006, 95% CI = −0.009, −0.003), but increased 0.72% with every 1 $ms^{-1}$ increase from 6.70 to 21.00 ms−1 (β = 0.012, 95% CI = 0.008, 0.017; Table 3; Figure 3).
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> . . .
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> We found that plains bison movement distance was highest (est. = 74.96 m) when soils were powdery dry (i.e., FWI = 0.00), and decreased 23.2% with every 0.10 increase in FWI (Table 3; Figure 3).

McMillan et al. 2022 at 7.

A shift in weather directly affects where and how bison move across the landscape.

> Plains bison movements were the shortest at extremely low temperatures (i.e., <−20°C), perhaps due to physiological demands of movement during those times (Sheppard et al., 2021). However, plains bison moved further with increasing air temperature (i.e., −21°C to 28°C), suggesting that they may be tracking thermally dependent, fine-scale, changes in photosynthesis (Pilarski, 1999; Sage & Kubien, 2007)—that is, forage quality—as well as favorable physiological conditions. We also found that during times of excessive heat (i.e., 28°C to 44°C), plains bison movements declined, suggesting a physiological threshold on movement. Excessive heat has been shown to restrict plains bison movement on the landscape as they seek thermal refugia—often riparian areas—to escape extreme heat (i.e., >39°C; Allred et al., 2013). Our plains bison response was also similar—both in direction and effect size—to the reported effects of air temperature on wood bison in Canada (Sheppard et al., 2021), potentially suggesting a similar response, regardless of subspecies, across North America. Air temperature has strong direct (via physiological effects, through increased energetic and nutrient demands; Martin & Barboza, 2020) and indirect (e.g., temperature-driven changes in forage quality; Sage & Kubien, 2007) effects on where and how other ungulates move across landscapes as well (Schmidt et al., 2016; van Beest et al., 2012; van Beest et al., 2013). Our results add to a growing body of evidence supporting that weather not only directly affects where animals move, but also how they move across

> landscapes (Rivrud et al., 2010; Schmidt et al., 2016; van Beest et al., 2011; van Beest et al., 2013).

McMillan et al. 2022 at 8.

Bison are not immune from the effects of severe drought.

> Although drought can influence forage quantity and quality, forages can also provide ungulate grazers with some (or nearly all) of their daily water requirement (Kay, 1997; King, 1983). Plant moisture content is contingent upon soil moisture, and during severe drought, ungulate grazers must obtain their water requirements from permanent or ephemeral water sources (Kay, 1997). As drought becomes more intense, plant growth and photosynthesis rates decline (Chaves et al., 2003), and high-quality forage becomes spatially limited through time. Therefore, plains bison experiencing severe drought conditions likely move greater distances in search of areas to balance their energetic (nutrient and water) requirements.

McMillan et al. 2022 at 9.

In restricting Yellowstone bison's range and migrations, State and federal managers are not only diminishing the distances bison can move to escape environmental stressors, but contributing to the inhospitable conditions undermining bison's resiliency to withstand and adapt to extreme weather and a changing ecosystem.

> When confronted with ambient physiological stress, plains bison are faced with two choices to mitigate that stress: (1) move to a new place on the landscape where the stress is relieved or avoided (Allred et al., 2013) or (2) acclimate to the current condition. Prior to development and westward expansion, when extreme drought or inhospitable weather patterns occurred across expansive landscapes, plains bison would have been able to freely move great distances in search of more hospitable conditions. However, plains bison are now relegated to relatively small, homogenously managed, fenced landscapes that are often privately owned. As we move through the Anthropocene, changes in climate are predicted to accelerate beyond the ability of many species to adapt, resulting in range shifts (Cahill et al., 2013; Thomas, 2010) and local species extinctions (Duncan et al., 2012). However, for large ungulates like plains bison that are adapted to a wide range of ecosystems, the threat may be more related to restrictions to movement (e.g., fragmentation, urbanization), as long distance movements to avoid or moderate weather extremes are no longer an option. Even in vast landscapes like Yellowstone National Park (899, 116 ha) where a considerable portion of the nearly 5000 resident plains bison annually disperse from the park, such movements are restricted or discouraged through culling or hazing (Plumb et al., 2009).
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> . . .
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> Our results suggest that facilitating increased movement may be key to sustaining plains bison and other large ungulates in the future, even across vast landscapes (e.g., Yellowstone National Park or Kruger National Park), as they will likely move greater distances

> (potentially beyond park boundaries) as temperatures warm, and droughts become more frequent, severe, and longer lasting. Many of the world's existing large conservation areas are arranged, or managed, in ways that harbor very little ecological resiliency under a changing climate (Fuhlendorf et al., 2018; Holling & Meffe, 1996). Moreover, as new ambitious rewilding and restoration efforts are proposed and implemented (Fuhlendorf et al., 2018), few include actions based around increasing ecological resiliency (Holling & Meffe, 1996) through restoring ecological processes (e.g., fire) as well as keystone species. In the case of keystone species such as plains bison and other large ungulates, the impact of weather, especially under a changing climate, may significantly limit grassland restoration efforts. In particular, weather-driven alterations in ungulate movement have the potential to affect grassland structure and function via changes to disturbance frequency, timing, and intensity. Changes to grassland herbivory-vegetation feedbacks, for example, can have cascading effects relevant to ecosystem function and conservation (e.g., increased fire threat, woody plant encroachment; Fuhlendorf & Engle, 2001; Werner et al., 2020). Therefore, understanding how large ungulates respond to climate change will critically inform many biodiversity conservation efforts throughout the Anthropocene.

McMillan et al. 2022 at 9–10.

The U.S. Fish & Wildlife Service must examine and investigate the inability of Yellowstone bison to move long distances to withstand severe drought amidst the constraints imposed by the government's boundary scheme in the agency's threats assessment and status review.

The U.S. Fish & Wildlife Service must also examine and investigate the effects of severe weather-driven events together with government imposed restrictions undermining Yellowstone bison's resiliency to adapt to an inhospitable climate in the agency's threats assessment and status review.

***State and federal management actions, winter severity, and snow crusting significantly reduces Yellowstone bison's resiliency to withstand such events, and is a threat to the population in the wild.***

Climatic stress, as expressed by drought frequency (multiple years) and snowfall characteristics (freezing or crusting due to higher water content) "influenced the pattern of historical bison occurrence across the Northwest United States. . . . The locations of highest combined snow and drought frequencies coincide with locations of low bison occurrence" west of the Continental Divide in the Northwest United States in suitable grassland/steppe habitats. Williams 2005 abstract.

PHOTO: Anna Day

The annual probability of snow crusting events varies across Yellowstone bison's winter ranges. Snow crusting events make forage inaccessible due to the buildup of ice and snowpack. In response to snow crusting events, bison must continue migrating to find forage or die in the attempt.

Climate change is likely to drive more frequent freeze-thaw conditions and snow crusting events thereby increasing stress on bison and their ability to migrate and find forage.

One result of imposing State and federal manager's boundary scheme is large-scale government slaughter of bison migrating in response to snow crusting events, a strike against Yellowstone bison's resiliency to withstand harsh winters.

While unpredictable, snow crusting events and management imposed boundaries is a significant source of mortality and threat to the Yellowstone population as evidenced by a major crusting event in 1996–1997 resulting in the government slaughtering 1,084 bison. Gates et al. 2005 at 47; Cromley 2002 at 135.

Government slaughter of bison migrating in response to deep snow and snow crusting events is an ongoing threat to the Yellowstone population. Deep snow inhibits dispersal and increases the amount of energy bison must expend to find forage. In doing so, bison's fat reserves are depleted.

"[T]he criteria were designed to identify freeze/thaw/freeze events when at last 30 cm of snow was on the ground and precipitation fell as rain. We were unable to use other factors such as wind to predict crusting events because data were not available." Gates et al. 2005 at 48.

Number of years with ≥ 1 snow crusting event in bison winter ranges:

- 2 in Gardiner basin (1981–2004).
- 7 in West Yellowstone (1981–2004).
- 10 in Pelican valley (1981–2004).
- 10 in Mary Mountain (1981–2004).
- 9 in Tower Falls (1989–2004).

Gates et al. 2005 at 57 (Table 3.4).

The probability of snow crusting events is more frequent in Lamar valley. Gates et al. 2005 at 48.

> Winter severity is not the only climatic factor influencing bison populations, as suggested by Bamforth (1988), but decreases in forage availability and quality during periods of reduced precipitation can also have physiological effects on bison. In examining Early Holocene (8500-6300 BC) bison remains from the Lubbock Lake site in Texas, Johnson and Holliday (1986) found a high incidence of dental abnormalities that they attributed to poor range conditions and excess grit on the vegetation. It is also during this time period, and into the Middle Holocene, that environmental stress was being expressed phenotypically through the diminution of bison size (Holliday 1987).
>
> Historic, albeit anecdotal, references to bison having been severely impacted by severe winters is related by Roe (1970:181): "when, according to the reports of mountaineers and

> Indians, the snow fell to the depth of ten feet on a level. The few buffaloes that escaped starvation are said to have soon afterwards 'disappeared.'"
> What archeologists have demonstrated is that climate can have significant influences on bison population density, migration, and physiology.

Cannon 2008 at 79.

"Osborn (2003:210) has stated that "[s]evere winter conditions have adverse, limiting effects on ungulate distribution, abundance, body condition, reproduction, and mortality." Cannon 2008 at 78–79.

"[H]eavy mortality during exceptionally severe winters appeared most important in Yellowstone as a whole." Meagher 1973 at 111.

> The survival factor for bison in parts of Yellowstone may be the existence of thermal areas. As previously discussed, thermally active areas do not attract large numbers of bison for the winter, but the use of certain areas for brief periods—particularly at times of prolonged cold combined with deep snow as observed by Jim Stradley, or in late winter as seen during the study period—may determine the lower limits to which the population numbers drop.
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> . . .
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> Extensive sedge bottoms are a feature of the valleys used by bison; additionally, where winter conditions are consistently less severe, as in Lamar, there are extensive open side hills of sagebrush-grassland which allow both movement and feeding. Where winters are more severe, those valleys which have bison have either extensive thermal or warm areas, or else many small ones among which movement is possible. Some streams which remain unfrozen because of an influx of warm water are an additional feature of most wintering areas, as are some river benches or valley side slopes and small hills (sagebrush-bunchgrass upland sites) which aid both foraging and movement. Where too few of these factors occur together the valleys do not now, and probably never did, support mixed herd groups of bison.

Meagher 1973 at 113.

"Being able to survive the severe winters of interior Yellowstone may have to do with particular features of Pelican Valley, and elsewhere in the Park, such as thermal areas, open streams due to warm water, extensive sedge bottoms and open side hills for both forage and movement (Meagher 1973:113)." Cannon 2008 at 81.

> Climate as an environmental regulator of bison was an important aspect of early studies of the Yellowstone bison herd (e.g., McHugh 1958). McHugh observed that yearlings and 2-year-olds were particularly vulnerable to severe winter conditions, such as deep snow that would inhibit travel and effective foraging. Calves, on the other hand, may have been less vulnerable because of their close association with the cows. While deep snow and limited forage quantity did not appear to be directly related to winter mortality, the combination of severe winter weather effects (i.e., deep snow, cold temperatures, distribution of available

> forage) would impose incremental physical stresses on the bison, particularly subordinate individuals.

Cannon 2008 at 80.

> [T]he condition of the snow may be even more important in winter survival. Deep snow, hard crusts, cold air temperature, and limited access to forage may result in greater mortality. A simple correlation between snow depth and mortality may not be a robust index for understanding winter severity. For example, early snows followed by mid-season rain and freezing can create a hard crust on the surface of the snow, limiting herbivores ability to access forage. Prolonged exposure to cold air temperatures, strong winds, and deep snow will further deplete fat reserves of animals. While some herbivores, such as bison, are bigger and stronger and can travel and forage in deeper snows, their condition going into winter also has an influence on survival (Farnes 1997:10).
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> . . .
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> I calculated the snow severity index using the weighted measures as suggested by Cheville et al. (1998) and correlated it with bison populations for the northern and central herds as from 1970-1993 presented in Taper et al. (2000:Table A1).
>
> The population trend of the northern and central herds between 1970 and 1997 shows that the bison population had a strong growth rate. The only years in which the annual increment was below the regression line were severe winters (Figure 4.4). Cheville et al. (1998:64) illustrate a similar trend for the entire YNP population from 1970 to 1997.
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> . . .
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> Migration to more conducive winter range appears to be the preferred strategy of bison in order to maintain social bonds. However, while bison can survive by breaking social bonds by scattering into smaller groups to seek out areas of limited resources (e.g., geothermal areas), they preferentially move to maintain a higher level of aggregation (Meagher et al. 2002). If the area they are moving into is unoccupied, they will be able to survive largely intact. If the area is occupied, the migrating herd will either displace the resident herd or cause additional expansion of winter range. *Migrate or die seems to be a fairly accurate way to define bison behavior in relation to winter severity*.
>
> What is apparent from this short review of the effect of weather on bison is that it is a complicated issue based not only on the severity of winter, but also physiological conditions of the bison going into the winter, population size, and the ability of bison to migrate to more amenable habitats. Short-term severe weather conditions appear to play a role in bison population dynamics as illustrated in Figure 4.4 for the northern and central herds throughout the 1970s, when severe winters were common (Appendix A).

Cannon 2008 at 82–83, 85–86 (emphasis added).

> [T]he population growth rate of the central herd was negatively correlated with snow pack. . . similar to the findings of numerous studies of large ungulates in relation to winter severity (Gaillard et al. 2000, Clutton–Brock and Coulson 2002, Garrott et al. 2003, Jacobsen et al. 2004, Wang et al. 2006. We did not observe a negative effect of snow pack on the northern herd, possibly due to influx from central herd bison during or immediately after severe winters.
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> . . .
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> [C]limate-induced dispersal of bison from the central herd to the northern range during winter could create a source–sink dynamic that exacerbates the current controversy about management of bison . . . These movements will also complicate future analyses of bison time series because removals at the northwestern boundary can no longer be reliably assigned to the northern herd.

Fuller, Garrott & White 2007 at 1931.

"Winters are more severe in the central region of YNP, and the drier northern range would be a logical option for dispersing central-herd bison." Fuller, Garrott & White 2007 at 1930.

> Long distance migrations by ungulate species often surpass the boundaries of preservation areas where conflicts with various publics lead to management actions that can threaten populations. We chose the partially migratory bison (*Bison bison*) population in Yellowstone National Park as an example of integrating science into management policies to better conserve migratory ungulates. Approximately 60% of these bison have been exposed to bovine brucellosis and thousands of migrants exiting the park boundary have been culled during the past two decades to reduce the risk of disease transmission to cattle. Data were assimilated using models representing competing hypotheses of bison migration during 1990–2009 in a hierarchal Bayesian framework. Migration differed at the scale of herds, but a single unifying logistic model was useful for predicting migrations by both herds. Migration beyond the northern park boundary was affected by herd size, accumulated snow water equivalent, and aboveground dried biomass. Migration beyond the western park boundary was less influenced by these predictors and process model performance suggested an important control on recent migrations was excluded. Simulations of migrations over the next decade suggest that allowing increased numbers of bison beyond park boundaries during severe climate conditions may be the only means of avoiding episodic, large-scale reductions to the Yellowstone bison population in the foreseeable future. This research is an example of how long-distance migration dynamics can be incorporated into improved management policies.

Geremia et al. 2011 at 1.

Severe winters, deep snow, snow crusting events and government imposed boundaries resulting in large-scale slaughter of Yellowstone bison migrating to survive random and unpredictable environmental stressors are factors the U.S. Fish & Wildlife Service must examine and investigate in the agency's threats assessment and status review.

***State and federal management actions reducing Yellowstone bison's range and population, and climate-driven shifts in the range of bison outside "protected areas" is a threat to the migratory species.***

PHOTO: Kinley Bollinger

Bison's long distance migrations in their home ranges has been followed by a series of harmful management actions spanning decades inside the protected area of Yellowstone National Park and on contiguous National Forest habitat that cannot be sustained in a rapidly changing climate.

Instead of preserving habitat corridors to connect bison with reserves and designating refuges to cope with environmental conditions and adapt to climate change, State and federal managers are permitting barriers and traps to thwart migration and killing the migrants altogether.

As the climate rapidly changes and suitable habitats shift resulting in bison migrations beyond the fixed boundaries of protected areas and government imposed "tolerance" zones, without corridors and pathways for migration and dispersal to cope with environmental stress the risk of local and regional extinction for Yellowstone bison increases exponentially.

Clearly, the lack of corridors and reserves to withstand and recover from State and federal management actions confining bison's range and slaughtering migrants responding to rapid changes in the environment and climate are significant factors the U.S. Fish & Wildlife Service must examine and investigate in the agency's threats assessment and status review.

***Climate change was a factor in the extinction of Bison species in the Pleistocene.***

Climate change contributed to the extinction of *Bison* species in Europe during the Pleistocene/Holocene transition. Massilani 2016 at 1, 7.

Abrupt climate change may have also contributed to changing the diversity for the common ancestor that gave rise to the modern *Bison* species. Shapiro et al. 2004 at 1564 ("environmental changes . . . were the major cause of observed changes in genetic diversity" in Pleistocene bison populations in Beringia and North America).

> The paleogenetic analysis of bison remains from the last 50,000 years reveals the influence of climate changes on the dynamics of the various bison populations in Europe, only one of which survived into the Holocene, where it experienced severe reductions in its genetic diversity.
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> Climatic and environmental fluctuations as well as anthropogenic pressure have led to the extinction of much of Europe's megafauna. The European bison or wisent (*Bison bonasus*), one of the last wild European large mammals, narrowly escaped extinction at the onset of

> the 20th century owing to hunting and habitat fragmentation. Little is known, however, about its origin, evolutionary history and population dynamics during the Pleistocene.
>
> Through ancient DNA analysis we show that the emblematic European bison has experienced several waves of population expansion, contraction, and extinction during the last 50,000 years in Europe, culminating in a major reduction of genetic diversity during the Holocene. Fifty-seven complete and partial ancient mitogenomes from throughout Europe, the Caucasus, and Siberia reveal that three populations of wisent (*Bison bonasus*) and steppe bison (*B. priscus*) alternately occupied Western Europe, correlating with climate-induced environmental changes. The Late Pleistocene European steppe bison originated from northern Eurasia, whereas the modern wisent population emerged from a refuge in the southern Caucasus after the last glacial maximum.

Massilani et al. 2016 at 1.

Evidence of past climate change as a factor in driving *Bison* species to extinction must be examined in light of evidence of climate change driving the loss of bison range and genetic diversity for the foreseeable future.

> In bison, the pre-human decline in genetic diversity starting approximately 35 kyr BP and the strong correlation between range size and genetic diversity (Fig. 2) indicate climate as a main driver of demographic change. This conclusion is supported by the fivefold decline in effective population size (Fig. 3) and increased isolation-by-distance approximately 11 kyr BP in North America (Supplementary Fig. 3.1 and Supplementary Table 3.3). The timing of these demographic changes coincides with the pronounced climatic shifts associated with the Pleistocene/Holocene transition, although they also coincide with fossil evidence of growing populations of potential competitors such as *Alces* and *Cervus*. The accelerated rate of decline in genetic diversity after approximately 16 kyr BP (Fig. 2) is coincident with the earliest known human expansion in the Americas, and the significant presence of bison in 77% of the Siberian archaeological assemblages points to their popularity as a prey species (Fig. 4).
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> . . .
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> [A] combination of climatic and anthropogenic effects appears to be responsible for the demise of wild horse and steppe bison.

Lorenzen et al. 2011 at 363 (endnotes omitted).

> In recent simulation models, large-scale climatic shifts have been shown to result from changing atmospheric circulation patterns caused by changes in the orientation of the earth's axis (COHMAP 1988). At 18,000 BP, the Laurentide ice sheet caused a split in the jet stream, while cooling temperatures continent-wide. A deflection of the southern branch of the jet stream brought moister conditions to the southwest, while anticyclonic winds, generated by the ice sheet, brought prevailing easterlies and dry air to the northwest instead of the moisture-laden westerlies that are the common pattern today (Thompson et al. 1993). Cooler than present conditions existed in the region, depressing tree lines and vegetative communities hundreds of meters in comparison with modern distributions.

> Prior to about 18,000 BP, full-glacial conditions existed in the Intermountain West. The timing of the transition from full-glacial to late-glacial conditions in the region occurred between 15,000 and 12,000 BP. By about 12,000 BP, orbitally increased solar radiation enhanced the thermal contrast between land and sea, producing strong summer monsoons that raised lake levels in arid regions worldwide. With increased insolation and glacial retreat, readjustments in vegetation communities followed (COHMAP 1988).
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> . . .
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> Around 15,000 BP, changes in the geometry of the earth's orbit and axial tilt initiated a trend toward warming and an increase in seasonality (COHMAP Project Members 1988). The Pacific subtropical high was beginning to strengthen and to provide some moisture, but the area was generally arid (Whitlock and Bartlein 1993). Regional data are in close agreement with the model's retrodictions for this period (Thompson et al. 1993). Haynes (1990) suggests that this period ended with a millennium of severe drought (12-11 ka). This drought coincides with the earliest human presence in the region (Frison 1991; Gruhn 1961; Gruhn 1965) and also with the extinction of the Pleistocene megafauna (with the exception of the bison). Deglaciation progressed (Richmond 1986; Teller 1987), and vegetation zones shifted upwards in elevation (Barnosky et al. 1987). A wide variety of now-extinct Pleistocene megafauna was regionally present (Butler 1978; Walker 1987a), including bison (*Bison bison antiquus* and *Bison bison occidentalis*), musk ox (*Symbos* sp.), mammoth (*Mammuthus* sp.), horse (*Equus* sp.), and camel (*Camelops* sp.).

Cannon 2008 at 58–59, 59–60.

While rapid climate change is a key driver in previous *Bison* extinction events, humans also contributed to these terminal events.

"Rapid climate changes associated with interstadial warming events are strongly associated with the regional replacement/extinction of major genetic clades or species of megafauna," according to University of Adelaide Professor Alan Cooper, an evolutionary molecular biologist.

Cooper's investigation confirms "the importance of climate change in megafaunal population extinctions and suggests that metapopulation structures necessary to survive such repeated and rapid climatic shifts were susceptible to human impacts." Cooper et al. 2015 at 1.

PHOTO: Patricia Mitchell

The evidence supports Cooper's finding that a key driver of megafaunal extinction included the loss of population connectivity between resource rich habitats due to human presence, a condition Yellowstone bison have experienced for over 120 years, and a condition unlikely to change for the foreseeable future.

> Our results lend strong empirical support to the hypothesis that environmental changes associated with rapid climatic shifts were important factors in the extinction of many megafaunal lineages. Indeed, the rapid replacement of local genetic populations by congeners or conspecifics (e.g., cave bears, bison, mammoth) revealed by ancient DNA suggests that broader-scale metapopulation structures or processes (e.g., long-distance dispersal, refugia and rescue effects across spatially distributed subpopulations) were involved in maintaining ecosystem stability during the repeated phases of sudden climate change in the Pleistocene Holarctic. If so, human presence could have had a major and negative impact on megafaunal metapopulations by interrupting subpopulation connectivity, especially by concentrating on regular pathways between resource-rich zones, potentially leaving minimal signs of direct hunting. By interrupting metapopulation processes (e.g., dispersal, recolonization), humans could have both exacerbated regional extinctions brought on by climate changes and allowed them to coalesce, potentially leading to the eventual regime shifts and collapses observed in megafaunal ecosystems. The lack of evidence for larger-scale ecological regime shifts during earlier periods of the Glacial (i.e., >45 kyr) when inter-stadial events were common, but humans were not, supports a synergistic role for humans in exacerbating the impacts of climate change and extinction in the terminal events.

Cooper et al. 2015 at 3 (endnote omitted).

The loss of "widely interconnected" habitats enabling long distance dispersal from an inhospitable environment was a significant factor in the demise of *Bison* species, a condition similar to what Yellowstone bison are experiencing today and for the foreseeable future.

> Numerous mammal species became extinct in the Arctic at the end of the ice age, but it is unclear why. By comparing numbers of dated bones with climate records, we find that megafaunal species, like mammoth, horse, and bison, experienced boom and bust cycles during the ice age as they tracked rapid climate changes. For these species to persist, long-distance dispersal was necessary. Their extinction on the North Slope occurred as the ice age ended, because rising sea level severed dispersal routes and spreading peat simultaneously degraded range quality. This finding suggests that arctic mammals can be resilient to environmental changes but only if their habitats remain widely interconnected.

Mann et al. 2015 at 14301.

While present day bison survived these extinction events, the interconnected habitats enabling the migratory species' resiliency to withstand environmental changes has been fractured by the appropriation of bison range and habitat for human uses and livestock production, and exacerbated by government imposed boundaries.

If climate change and human actions contributed to the extinction of *Bison's* ancestors, the evidence presented herein indicates the same factors could do so again.

The U.S. Fish & Wildlife Service must examine and investigate the synergistic effects of fragmented habitat, degraded forage, and loss of dispersal and long distance migration pathways in an inhospitable environment imposed on Yellowstone bison by the government in the agency's threats assessment and status review.

The U.S. Fish & Wildlife Service must also examine and investigate the synergistic effects of rapid climate change and the role of humans in driving the risk of extinction for Yellowstone bison in the agency's threats assessment and status review.

***Few founders, hybridization, population bottleneck and isolation threaten or endanger Yellowstone bison in the wild.***

A number of human-made factors harm the continued existence, fitness, and natural adaptation of bison in the wild. These factors require bison to be managed as a conservation reliant species for the foreseeable future. If these factors cannot be avoided and continue unabated, the persistence of wild Yellowstone bison is in jeopardy.

> The likelihood of wild bison increasing over the next five years is entirely dependent upon conservation interventions. . . Without these large protected landscapes bison would not likely survive and the future survival of American bison would be in serious jeopardy. . . Hence, wild bison (wood or plains) are totally dependent upon conservation actions and protected lands. American Bison would not persist without those intensive conservation measures.

Aune, Jørgensen, & Gates 2018 at 2.

"During the late nineteenth century, North American bison underwent a significant population bottleneck resulting in a reduction in population size of over 99% and a species-level near-extinction event." Stroupe et al. 2022 at 1.

Bison need to be managed as a conservation species because of harmful effects from "low initial numbers of founders, past bottlenecks in various herds, cattle hybridization in a number of conservation herds, artificial selection for non-adaptive traits, isolation of most conservation herds, and the observation of severe inbreeding depression in 1 conservation herd." Hedrick 2009 at 412.

A small population is not defined, but relevant metrics to judge whether a bison population is too small to be viable and persist in the wild over centuries is provided by evidence and science presented herein. Consequently, a bison population is too small to contribute to the vitality and recovery of the wild species:

- If it is below a census of 2,000 to 3,000 conservation biologists recommend to avoid inbreeding and maintain genetic diversity for each individual herd or cluster. Hedrick 2009 at 419.

- If it is below 5,000 adult individuals to prevent extinction, and ensure long-term persistence and evolutionary potential. Traill et al. 2010 at 28, 30.

- If it is below an effective population size of 5,000 to maintain adequate evolutionary potential and long-term genetic viability in the wild. Lande 1995 at 782, 786, 789.

• If it is losing more than 5% of allelic diversity over a period of 200 years, and hence the ability to adapt to current and future alterations in habitats including climate change and exotic diseases. Freese et al. 2007 at 180.

• If it is below the ecological and evolutionary baseline of 2,000 for each herd where subpopulation substructure is evident, and ranging a minimum of 320,000 acres. Bailey 2013 at 190–191, 80 ("Computer modeling suggests that a herd of 2000–3000 bison will lose an estimated 5% of its allelic diversity" every 100 years.).

• If it is captive or domesticated, and home range is defined by artificial selection.

• If there is no potential for naturally dispersing to seasonal ranges and defining home range.

• If it is geographically isolated, natural interconnectivity between wild populations is lost or cannot be restored, or it is not self-sustaining for the foreseeable future.

• If long distance migration corridors and connectivity to habitat and range is lost or impaired or cannot be restored to withstand rapid changes in climate, extreme weather, and catastrophic events.

• If a preponderance of artificial human selection processes has usurped natural selection processes.

• If there is a lack of range and habitat to express the full extent of the wild species' keystone and ecological engineering roles and functions in a wild environment.

• If the wild genome in a wild population cannot be fully realized through natural selection.

The foregoing metrics are relevant in addressing the population bottlenecks, founder events, genetic and geographic isolation of the few bison populations functioning as wild or with the potential to function as wild, and the replacement of natural selection with artificial selection processes that has impaired the recovery of the wild species in North America.

> Just 200 years ago, plains bison *Bison bison bison* numbered 30–50 million in herds of up to 10000 animals (Redford & Fearn, 2007). By the late 1800s, massive overhunting and land use change reduced the population to roughly 1,000 individuals, <1% of the historical population size.
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> [A] number of obstacles remain to ensure genetic viability over the long term. First, conservation herds were established with small numbers of individuals that remained after the severe bottleneck (Halbert, 2003; Halbert & Derr, 2008). Surplus animals from these conservation herds were often used to establish new herds, potentially exacerbating the loss of genetic variation. Second, gene flow between herds has been sporadic during the

> past century, often limited by concerns about disease introduction (Williams & Barker, 2001). Third, conservation herds are typically maintained at small population sizes to avoid permanent habitat damage and accommodate multiple-use goals on small, isolated reserves (Boyd, 2003; Boyd *et al*., 2010). To maintain consistent population sizes, individuals are typically removed from populations each year. These obstacles make it critical that management of conservation herds focuses on retaining as much existing variation as possible. The annual removal of individuals is a key stage at which management actions could be designed to maximize the retention of genetic variation over time.

Giglio et al. 2016 at 381.

In comparison to robust herds of up to 10,000 or more bison, small population size is a threat to Yellowstone bison who have lived in genetic isolation from any other wild population for over 120 years. Natural gene flow resulting from competition between interconnected wild bison populations has been lost, a condition that will continue for the foreseeable future.

> Small, isolated populations are not only less demographically stable than large populations, but they are also more susceptible to erosion of genetic variation by genetic drift (Wright, 1931). In the absence of gene flow, the loss of genetic variation through drift is not mitigated. A lack of genetic variation not only makes a population more susceptible to inbreeding depression (Ralls, Brugger & Ballou, 1979; Crnokrak & Roff, 1999; Keller & Waller, 2002), but also less able to adapt to changing environmental conditions (Falconer, 1981; Keller *et al*., 1994; Willi, Van Buskirk & Hoffmann, 2006; Markert *et al*., 2010). Preserving genetic variation has become a priority for management, particularly for small and isolated populations, in order to maintain long term viability (McNeely *et al*., 1990; Lacy, 1997).

Giglio et al. 2016 at 380–381.

As a consequence of severe bottlenecks and few founders and the loss of genetic variation from these events, several scientists have warned inbreeding depression in all bison populations should be assumed.

"Genetic variation is the basis for evaluating biodiversity within and between populations; without genetic variation, populations could not evolve or adapt to changing environmental conditions." Forgacs et al. 2019 at 1.

> In addition to small herd size and a lack of gene flow among managed herds, historical events such as severe bottlenecks and cattle-gene introgression in both conservation and commercial herds threaten the integrity and diversity of the bison species genome (Halbert and Derr 2007; Freese et al 2007; Hedrick 2009). Reduced genetic variation limits the evolutionary potential of populations, but also can have direct and immediate effects on factors such as the response to diseases and new pathogens (O'Brien and Evermann 1988). As some of the remaining conservation herds of bison are infected with brucellosis (Meagher and [Meyer] 1994; Freese et al. 2007), maintaining genetic variation could be essential for the preservation of the species. Furthermore, since the entire bison species went through a severe bottleneck in the late 1800s, and then again as more conservation

herds were founded with few individuals, all bison populations can be assumed to have some level of inbreeding. For example, Hedrick (2009) estimated an approximate level of inbreeding of 0.367 (equal to 2 generations of full-sib mating) in the Texas State Bison Herd. Although the direct effects of inbreeding in bison are unclear, even small amounts of inbreeding have been correlated with the susceptibility to bacterial disease in other wildlife populations (Acevedo-Whitehouse et al. 2003). Overall, historical erosion of genetic variation due to severe bottlenecks, multiple founder events, and inbreeding make preservation of remaining genetic variation through effective management strategies even more imperative to the persistence of bison.

Toldness 2014 at 22.

Bison have experienced all of the interrelated mechanisms related to loss in genetic variation: bottlenecks, founder effects, genetic drift (from small, isolated populations and loss of natural gene flow between populations to mitigate drift), and inbreeding.

All of these interrelated mechanisms have reduced the "genetic toolkit" for Yellowstone bison to withstand catastrophic events and adapt to changing environmental conditions.

> Bison experienced a severe population decline in the 19th Century. Since then, they have undergone artificial hybridization, been subject to domestication, and been separated into isolated populations, all of which could have affected the integrity of the bison genome.
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> . . .
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> Genetic diversity within a species provides the mechanism for evolutionary change and adaptation (Mitton and Grant 1984; Allendorf and Leary 1986; Meffe and Carroll 1994; Chambers 1998). Reduction in genetic diversity can result in reduced fitness, diminished growth, increased mortality, and reduced evolutionary flexibility of individuals within a population (Ballou and Ralls 1982; Mitton and Grant 1984; Allendorf and Leary 1986; Berger and Cunningham 1994). There are four interrelated mechanisms that can reduce genetic diversity: demographic bottlenecks, founder effects, genetic drift, and inbreeding (Meffe and Carroll 1994). Over the last two centuries, bison in North America have to some degree experienced all of these mechanisms.
>
> North American bison approached extinction in the late 1800s and experienced a severe demographic bottleneck. . . The decline of bison was severe, with a reduction from millions to fewer than 1,000 individuals. . . Although the effects of the bottleneck on the genetic diversity of the species are not clear (Wilson 2001), there are several possible repercussions. After a severe reduction in population size, average heterozygosity is expected to decline (Nei *et al*. 1975; Nei *et al*. 1975; Allendorf 1986). . . Another considerable impact is the loss of alleles, which may inhibit natural selection and reduce the adaptive potential of a population (Robertson 1960; Nei *et al*. 1975; Allendorf 1986; Meffe and Carroll 1994).
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> . . .

> [S]ome herds have exhibited signs of inbreeding depression such as physical abnormalities and reduced growth (Berger and Cunningham 1994; Hebbring Wood 2000).
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> . . .
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> [T]here is no existing technology for recovering genetic material lost as a result of the bottleneck in the form of living animals. Therefore, it is imperative to maintain the existing genome, and minimize future losses in genetic diversity.

Boyd 2003 at 60, 61, 62.

Bison's "long-term viability as a species remains threatened due to restricted rangelands, artificial selection within confined herds, and a lack of gene flow between herds. Questions remain about the genetic diversity currently found in conservation herds and how the species will respond to environmental change within restricted areas." Davies et al. 2019 at 1.

A study of *Bison's* evolutionary responses to environmental change spanning the megafaunal extinctions of the Late Pleistocene to the present provides evidence of climate change and human pressure as drivers in the first of several population bottlenecks experienced by the wild species.

Davies study relies on an archaeological record of Northern Plains bison "representing post-glacial changes in bison diet and vegetation associated with changing climate during the recent natural history of the species" in environmental conditions "adverse enough to wipe out the majority of megafaunal species and facilitate bison's first recorded population bottleneck." Davies et al. 2019 at 3, 5 (endnotes omitted).

Evidence in the paleorecord indicates "a major bottleneck at the very end of the Pleistocene and/or around the beginning of the Holocene, at the same time as the Eurasion *B. priscus* went extinct. This corresponds to a period of generalized megafaunal extinctions in North Eurasia and America that have been attributed to a combination of climate–driven environmental changes and human–mediated pressures. It is thus likely that the extinction and severe bottlenecks experienced by *B. priscus* and its American descendant *B. Bison* were due to the same global causes." Grange et al. 2018 at 7 (endnotes omitted).

PHOTO: Theresa Bielawski

A significant and relevant finding from Davies study is the admission that it is unclear what is causing an observance of low variability in the diet of modern bison including Yellowstone bison "despite their ability to cover much larger areas and complete substantial elevational migrations." The factors could be related to restricted or limited ranges, management policies, or a "narrowing in plasticity" from the more recent 19th century genetic bottleneck. Davies et al. 2019 at 7 (endnotes omitted).

The paleoclimatic record during the Holocene provides evidence of "several periods of sudden climate change," wide variations and large fluctuations in temperature including three periods of a rapidly heating climate, and evidence of a steep drop in temperatures indicating bison "had to adapt to a wider range of climatic conditions than previously thought." Davies et al. 2019 at 2 (endnotes omitted).

"The abundance of C4 grasses increases as warm seasons get longer," and nitrogen values "provide insight into moisture level and nutritional stress due to an observed increase . . . in animal tissue from the recycling of urea under conditions of drought." Higher nitrogen consumption in bison's diet "can indicate warmer temperatures and a diet composed of more graminoids and herbs than trees and shrubs." Davies et al. 2019 at 2 (endnotes omitted).

"The shift from a $C_4$ dominant plant community to a $C_4$ dominant plant community is usually reflected by an increase of carbon within the soil (Coupland & Van Dyne, 1979, Frank et al. 1995)." Ecoffey 2009 at 17.

"Shifts from C3 to C4 grass dominance would have a substantial influence of altering critical features associated with forage quality and quantity." Fuhlendorf et al. 2018 at 5.

"The N [nitrogen] content of aboveground biomass is known to vary among species, functional groups (cool-season or $C_3$ plants are more nutritious than warm-season or $C_4$ plants), management (higher following burning of areas that have not recently burned), and season (Mattson, 1980; Hooper and Vitousek, 1997; Ranglack and du Toit, 2015)." Willand & Baer 2019 at 196.

The low variability in diet is concerning because bison's ability in the past to survive "changing composition of habitat" relied on "their ability to adapt and exploit a variety of resources" attributed to the species' long-term survival when other megafauna species were driven to extinction. Davies et al. 2019 at 6.

However, manager's actions imposing boundaries and limiting the natural range of Yellowstone bison regardless of climate variation, fire, extended drought, or ecosystem change driven by rapid climate change could render bison's confined range and habitat unfit for the survival of each distinct subpopulation, or the population as a whole.

> The North American landscape has been transformed dramatically during the last 250 years, and with few exceptions, bison are no longer allowed to migrate or range widely in localities where they currently exist. Further, the extreme population bottleneck experienced by bison at the end of the 19th century has left the species with only a microcosm of the genetic toolkit that it once wielded for adaptation. Thus, both the resiliency of the species and the landscape it once inhabited have been altered in a manner unprecedented since the last ice age. We may expect that genetically isolated and spatially confined herds will be the most challenged by environmental fluctuations. Range expansion efforts . . . are already underway . . . but only at incrementally small amounts in comparison to the native range of the species.

Davies et al. 2019 at 7 (endnote omitted).

As a result of Davies findings, scientists are advocating for managers to "pursue opportunities to expand bison range to maximize forage opportunities for the species in the face of future environmental change." Davies et al. 2019 at 1.

Plains bison were extirpated from the wild in the United States except in Yellowstone National Park (<25 bison), while the remainder of the wild species was reduced to five captive herds on private ranches, and one captive herd at the New York Zoological Park. Hedrick 2009 at 411; Dratch & Gogan 2010 at 3.

Plains bison were extirpated from the wild in Canada around 1890. Hedrick 2009 at 411 (citing Roe 1970).

> Two biological scientists at the University of Alberta say that "genetic variation within and between populations can be affected by population bottlenecks, founder effect, genetic drift and the amount of gene flow between populations" (Wilson and Strobeck 1998: 180). A population bottleneck occurred when bison were nearly exterminated. A founder effect, created when a small group of animals are removed from a larger herd to start a new one, bears directly on both private and public herds. Two founder effects have been experienced. The first one occurred when a small number of wild bison were captured to begin private herds (Wilson and Strobeck 1998), and the second founder effect occurred when a small number of animals were taken from private herds to start public herds (Wilson and Strobeck 1998). Genetic drift involves random changes in alleles and occurs when gene flow via the exchange of animals between populations is restricted. Alleles, according to veterinarian C.W. Seeman (2000, personal communication), are genes that occupy a specific place on a chromosome and determine inheritance.

McDonald 2001 at 108.

Driving bison in the wild to near extinction in the 19th century created another bottleneck resulting in the entire present-day plains bison population in North America being descended from less than 100 founders. Hedrick 2009 at 411, *see also* Table 5 at 418.

This near extinction event and subsequent genetic isolation reduced bison's fitness and increased inbreeding depression in the remaining populations.

"Shaw (1993) estimates that there were only 74 to 79 animals that provided the genetic foundation for all future tribal, federal and private herds in North America." Ecoffey 2009 at 9.

> Before the identification of cattle ancestry in bison, the major conservation genetic concern in bison was the potentially low genetic variation, mainly because of low initial founder numbers but also because of subsequent bottlenecks and genetic isolation. For example, the 5 original ranch herds were each founded by a very small number of individuals. From the historical literature (Dary 1974; Wilson and Strobeck 1999; Halbert, Ward, et al. 2005), it appears that the Goodnight herd (Texas) was descended from 5 founders, the Alloway–McKay herd (Canada) from 5 founders, the Dupree–Philip herd (South Dakota) from 6 or 7 founders, and the Pablo–Allard herd (Montana) from 6 founders. Although the Jones herd (Kansas and Oklahoma) appears to have had a number of founders, it is known to have contributed only 1 animal to the New York Zoological Gardens population and a small number of founders to other private herds. In other words, the total number of independent

> founders that these 5 herds contributed to the present population appears to be less than 50 and may have been only 30.

Hedrick 2009 at 416–417.

> The formerly large population size, and presumably large ancestral effective population size for bison, suggests that there was substantial detrimental genetic variation segregating in bison, assuming equilibrium. Further, the rapid reduction in population size from many millions to an effective founder number of less than 100 in plains bison suggests that some of these detrimental variants became fixed or increased in frequency by chance, resulting in a lowered population fitness (genetic load) and/or increased inbreeding depression (Hedrick 2005). . . . At this point, inbreeding depression has only been documented in the Goodnight herd (discussed below) and suggested for the population in Badlands NP (Berger and Cunningham 1994). However, this does not mean that it has not been present in other herds, only that it has not been demonstrated.

Hedrick 2009 at 415.

Because of manager's concern over the "low numbers in the wild Yellowstone herd, 18 cows from the Pablo–Allard herd and 3 bulls from the Goodnight herd were introduced into a fenced area in Yellowstone NP in 1902 (Meagher 1973)." Hedrick 2009 at 417.

Elder historian Mose Chouteh recorded one of the more remarkable oral stories relating how the tribal Chiefs allowed Ɬatatí (Little Peregrine Falcon Robe), the son of a Pend d'Oreille named Aticeʔ (who originally proposed the idea), to bring orphaned bison calves found east of the Rocky Mountains in Montana to begin a herd on the Flathead Reservation. Six calves survived the journey. Ɬatatí raised them and the bison grew to thirteen. Years later, Ɬatatí's stepfather, Samwel, sold the bison to Michel Pablo and Charles Allard. Smith, Salish-Pend d'Oreille Culture Committee 2011 at 15–16.

> [I]t appears that a majority of the Yellowstone ancestry may be descended from a small effective founder number of [7] animals from the Pablo–Allard and Goodnight herds, which may have reduced overall genetic variation in the Yellowstone herd.

Hedrick 2009 at 417.

> Although some population sizes of the conservation bison herds are not small, these numbers should be compared with the very high numbers present 150 years ago. When the total number for plains bison was in the many millions and there was generally gene flow throughout the subspecies, there presumably was high variation for genes having detrimental, neutral, and advantageous effects. It is not known whether the variation today reflects this historic variation. . . . if the variation at neutral loci or sites is lower today than historically, this may indicate significant bottleneck effects and a consequent potential for increase in some detrimental variants.

Hedrick 2009 at 419.

Given bison's history of population bottlenecks, few founders, large ancestral population size and substantial gene flow compared to today's isolated herds managed in small numbers with cattle ancestry, "[i]ndividual herds or clusters should have an effective population size of 1,000 (census number of 2,000–3,000) to avoid inbreeding depression and maintain genetic variation." Hedrick 2009 at 419.

Based on Halbert's (2012) evidence of subpopulation division in Yellowstone bison and assuming Hedrick's baseline, an effective population size of 1,000 for each cluster or herd would require a census of 2,000–3,000 for each genetically distinct subpopulation or breeding herd.

While Halbert's study relied on 46 nuclear microsatellites to identify genetically distinct subpopulations, Forgacs's study of mitochondrial haplotypes "identified two independent and historically important lineages in Yellowstone bison . . ." Halbert et al. 2012 at 362; Forgacs et al. 2016 at 1.

If "Yellowstone bison represent nearly half —10 of 22 modern plains bison haplotypes — of all the known haplotypes in plains bison" (Forgacs et al. 2016 at 6), State and federal managers must adopt new standards and policies to prevent the loss of genetically distinct subpopulations, and the most genetically significant population of American bison in North America.

Few founders, population isolation (>120 years), artificial selection pressures, the potential loss of intact bison in Yellowstone (and elsewhere throughout North America, examined herein), exacerbates any further loss of genetic diversity and natural variation, and increases the risk of extinction for Yellowstone bison in the wild.

Vast population loss, few founders, isolation, and inadequate population sizes to prevent inbreeding for each genetically distinct herd in Yellowstone bison are harmful factors undermining the migratory species' condition and resiliency to ongoing and future management actions in a rapidly changing ecosystem.

These factors also reduce the representation — genetic and environmental diversity — of wild migratory bison in the Yellowstone ecosystem for the foreseeable future.

Because the aforementioned factors affect the health of the wild subspecies and the ability for Yellowstone bison to persist in the wild, the U.S. Fish & Wildlife Service must examine and investigate the additive, synergistic, and cumulative effects in the agency's threats assessment and status review.

***State and federal manager's use of artificial selection and domestication processes infringe on natural selection, and threaten or endanger the persistence of wild Yellowstone bison.***

> Many scientists have cautioned that low genetic variability, to the extent that it appears, would limit the potential of bison for future evolutionary change (Lacy 1987; Lewin et al. 1993).
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> . . .
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> Isolating bison on small landscapes, where gene flow between isolated groups can occur only through artificial migration and human intervention, further erodes genetic diversity (Berger and Cunningham 1994). Bottlenecks and chance events not only lower genetic variability but also limit the evolutionary potential of bison to adapt to changing conditions

> because natural selection is inhibited by the loss of rare alleles (Berger and Cunningham 1994).

McDonald 2001 at 108, 109.

Management of the distinct population segment of Yellowstone bison is undermining natural selection amidst a rapidly changing climate threatening migratory bison's persistence in the wild.

Human selection is systematically removing bison before the values of the fittest individuals are fully realized by natural selection.

State and federal manager's use of livestock management and veterinary practices are artificial selection pressures jeopardizing natural selection, genetic variation, and evolutionary adaptation of wild Yellowstone bison.

Domestication, the preponderance of human selection pressures reflected in current management, jeopardizes natural selection and representation of wild Yellowstone bison.

Artificial selection and domestication pressures operating on Yellowstone bison and exerted by State and federal managers include but are not limited to:

1) Managing the bison population through a preponderance of human selection processes.
2) Managing the bison population without regard for population subdivision, genetic distinction, and variation.
3) Confining, limiting and reducing bison's natural migrations and dispersal to range for forage, water, and shelter.
4) Confining and limiting bison's access to territorial range, including spring calving grounds, and obstructing connectivity to habitats and exploratory movements.
5) Altering sex ratios, skewing age structures, and killing entire family groups (generational parent-offspring) in large-scale, nonrandom government trapping for slaughter operations.
6) Disease management actions selecting against brucellosis and bison's natural or acquired immunity and resistance to disease.
7) Domesticating bison by taking them from the wild for quarantine.
8) Vaccinating and conducting population control experiments which undermines natural selection of disease resistant bison and natural selection of mates.

State and federal management is exacerbating loss of wild variation and increasing the risk of extinction for the distinct population segment of Yellowstone bison that has been living in isolation for over 120 years.

Natural migration between bison populations is a rare occurrence, and dispersal of bison among populations has been lost to human developments, loss of range and habitat to cattle, loss of migration corridors, and other factors detailed herein.

The loss of natural connectivity between wild self-sustaining bison populations also undermines the migratory species' resiliency and redundancy in the Yellowstone ecosystem.

Furthermore, there is no known source population of intact bison in the wild of large enough size that is not subject to inbreeding depression to restore connectivity with the Yellowstone bison population. *See* Stroupe et al. 2022 at 7 (finding introgression of cattle genes in all seven founding bison lineages); Aune, Jørgensen & Gates 2018 at 5 (of the 4 bison populations functioning as wild only 2 meet the large population criteria (> 1,000) defined by the International Union for the Conservation of Nature).

Threats from current management actions also include the decline and loss of ecological diversity wild bison provide the Yellowstone ecosystem:

> Ecological status within this survey refers to the state of the relationship between a herd and the processes of natural regulation and selection. The natural state of a herd is assumed to be on a continuum with the degree of human intervention. Therefore, ecological status worsens as the degree of human management imposed on the herd increases.

Boyd 2003 at 54.

Managing bison using a preponderance of human selection processes is a direct threat to wild Yellowstone bison for the foreseeable future.

Because artificial selection and domestication harm the migratory species' condition and resiliency to ongoing management actions and rapidly changing environmental conditions, the U.S. Fish & Wildlife Service must examine and investigate these factors in the agency's threats assessment and status review.

***Current management threatens or endangers retention of the wild genome and the persistence of Yellowstone bison as a wild population.***

> On May 9, 2018, the Superintendent was informed that the Secretary of the Interior wanted (1) Yellowstone bison managed more actively like cattle on a ranch, and (2) the Bureau of Land Management to conduct an assessment of the number of bison the park could support using the animal unit month (AUM) concept. This approach is traditionally used to manage forage use by grazing livestock.

Yellowstone National Park, *USDI Guidance to Manage Bison and Grazing More Actively Like Livestock on a Ranch*, 2018 at 1.

> The current management approach for Yellowstone bison is not serving the broader common good, but rather specific livestock interests based on perpetuated myths and misperceptions. The lack of tolerance for wild bison on more suitable public lands in the Greater Yellowstone Area is no longer justified based on the comparative risks of brucellosis transmission to cattle, human injury, and property damage; all of which are much higher for wild elk that are tolerated without substantive management.

White et al. 2018 at 13 (unpublished manuscript).

Current management is jeopardizing the wild genome: the ability of Yellowstone bison to persist as a wild population in a wild environment.

Current management also threatens to overwhelm natural selection of Yellowstone bison best suited to survive and reproduce in the wild and leave descendants capable of persisting as a wild population in a dynamic ecosystem undergoing environmental disturbances and evolving natural selection pressures.

Above all factors, it is the wildness of Yellowstone bison that is at greatest risk of extinction.

Wildness in the few bison populations "functioning as wild" in North America will become irretrievable without a paradigm shift in management practices conserving Yellowstone bison's ability to bequeath a wild genome to a population adapting in the wild.

> The goal of retaining wild characteristics recognizes value in a wild population genome. But what is a wild genome? Most animal characteristics are **polygenic**, that is, determined by interactions of several genes at several gene-loci. For these characteristics, each gene, and whatever **allele** (type of gene) happens to occur at each gene-locus, has a small to moderate effect upon the animal's characteristics (Hendry 2013), and it is the combination of alleles that occur at a set of gene-loci that determine each animal characteristic. For each characteristic, there are many different combinations of alleles occurring across all the individual animals in a population. And this pattern is repeated for very many different characteristics of the animals.
>
> A wild population, having suffered a preponderance of natural selection during its recent evolution, should contain a preponderance of animals having a preponderance of allele combinations that enhance **fitness** (survival and reproduction) in a wild environment.
>
> Fitness to the wild environment ("**wildness**") may be diminished by (1) loss of valuable alleles from the population genome due to random drift, (2) accumulation of mildly deleterious alleles as drift replaces selection that normally would remove such alleles, and by (3) rearrangement of alleles throughout the genome due to drift and artificial selection, such that combinations of alleles that are best for wildness become rarer. In the short term (a few to several generations), rearrangement of allele patterns and accumulation of deleterious alleles are likely to be more involved in diminishing wildness than is allele loss (Hendry 2013). However, loss of alleles has a permanent effect on diminished wildness.
>
> Genetic drift and artificial selection weaken or replace natural selection in determining the future composition of a population genome. For many populations of large mammals, the predominant artificial selection is a removal of animals by hunting or other management actions to limit population size and/or distribution. Effects of such artificial selection upon evolution of adult animal characteristics are numerous (Allendorf and Hard, 2009).

Bailey 2017, *Endangered Genes of the Yellowstone Ecosystem*, at 3 (emphasis in the original).

According to Bailey, a wildlife population must be large enough to avoid inbreeding and conserve the genetic diversity necessary for "retaining wild characteristics bequeathed from past evolution" and the "evolutionary potential for responding to changing environments of the future," primarily influenced by a "preponderance of natural selection" processes, and avoiding the "weakening of natural selection with human interventions and impacts." Bailey 2017, *Endangered Genes of the Yellowstone Ecosystem,* at 3, 4 (the "sum of effects of natural selection upon a wild population genome should exceed the sum of effects of random factors (drift) and artificial selection.").

It is the forces of natural selection experienced over millennia of evolution under which wild bison originate and persist as a wild population in Yellowstone.

The wild traits and characteristics Yellowstone bison evolved over millennia have been usurped by more than a century of artificial selection and domestic processes.

> Consequently, natural selection is easily weakened or replaced by (1) inbreeding that causes deleterious recessive alleles to outweigh the values of beneficial alleles in some animals, such that inbreeding, not natural selection determines their survival; (2) genetic drift that replaces selection with random factors affecting some animals; (3) artificial selection by harvest or other human-caused mortality or by selective breeding; (4) human interventions such as winter feeding or vaccinations that avoid natural selection; (5) restricting population size such that limitations of the environment are avoided in most years; and (6) a monotonous environment, lacking a diversity of natural-selective factors, including effective predators and a diversity of habitat resources.

Bailey 2016 at 6.

Subjecting bison to a preponderance of human selection processes, as is the case in Yellowstone detailed herein, is diminishing natural selection of wild bison, and harming the ability of genetically wild bison to pass their adaptive traits and characteristics to a wild population living in a wild environment.

> Without effective natural selection, we expect a redistribution of alleles across the population genome, gradual accumulation of slightly deleterious alleles, and loss of some "wild-type" alleles – the gradual and insidious process of domestication.
>
> . . .
>
> A genetically healthy population must be large enough to avoid significant inbreeding and also to maintain sufficient genetic diversity and evolutionary potential for adapting to future environmental conditions. This, alone, is sufficient for domesticated populations, but inadequate to maintain wild populations. Wildlife should be genetically healthy and also genetically wild.

Bailey 2016 at 6, 7.

Because current management is a major driver jeopardizing retention of the wild genome in Yellowstone bison and the migratory species' ability to bequeath a wild genome to future generations in a wild population, the U.S. Fish & Wildlife Service must examine and investigate these insidious factors in the agency's threats assessment and status review.

***Population viability for Yellowstone bison is unknown.***

A population viability analysis has not been conducted for Yellowstone bison to determine subpopulation representation, resiliency to random stochastic events, and long-term viability of the population as a whole. Halbert et al. 2012 at 368.

For detailed evidence and analysis on the regulatory mechanisms threatening or endangering Yellowstone bison's population viability, *see* factor 8.D.

Studying population viability was identified as a high priority in the State of Montana's and Yellowstone National Park's bison management plan in 2000. U.S. Dept. of the Interior & U.S. Dept. of Agriculture 2000 FEIS Vol. 1 at 731.

Over two decades later, this high priority scientific study to ensure the Yellowstone bison population persists in the wild remains unfulfilled.

One measure of long-term viability is retaining bison genetic diversity and variation to avoid the "negative impacts of inbreeding," retain the "wild characteristics from past evolution," and the "evolutionary potential for adapting to a changing future." Bailey 2017, *Endangered Genes of the Yellowstone Ecosystem*, at 3.

Because of the loss of genetic variation suffered in population bottlenecks, few founders, and population isolation, further loss or erosion of wild Yellowstone bison genetic diversity resulting from management actions must be examined in time frames of 100, 200, and 500 years. *See* the modeling studies of Giglio et al. 2016; Giglio et al. 2018; Toldness 2014; Gross & Wang 2005; Pérez-Figueroa et al. 2012.

"Differences among herds and among culling strategies in the amount of genetic variation retained and extent of inbreeding became more pronounced over time and were most evident at the 500-year mark." Giglio et al. 2018 at 769.

As examined herein, however modeled, Giglio, Toldness, Gross & Wang, and Pérez-Figueroa all found loss of bison genetic diversity under any management scenario.

The metric to express rate of loss (percent of alleles over certain time periods), and managers adopting or assuming an acceptable rate of loss has no biological basis because what is being lost and the functions performed by what is lost is unknown. *See* Bailey 2016, *Population Genetics and Wildlife Management*, at 1–2.

The U.S. Fish & Wildlife Service must examine and investigate factors jeopardizing the long-term viability of wild Yellowstone bison and each genetically distinct subpopulation in the agency's threats assessment and status review.

***State and federal managers are jeopardizing genetic variation in wild Yellowstone bison.***

> Genetic variation is the basis for evaluating biodiversity within and between populations; without genetic variation, populations could not evolve or adapt to changing environmental conditions.

Forgacs et al. 2019 at 1 (endnote omitted).

The best available science provides strong evidence of subpopulation structure and unique herd lineages in the distinct population segment of Yellowstone bison.

However, managers do not recognize Halbert's findings — findings not refuted by peer-reviewed data — and management has not changed to consider conserving subpopulation distinction or establishing herd sizes that preserve distinctiveness and avoid inbreeding depression.

In refusing to accept and adopt the best available science, State and federal managers are jeopardizing subpopulation distinction, genetic variation, and viability of Yellowstone bison in the wild.

> Population subdivision theoretically leads to decreased genetic variation within individual subpopulations due to genetic drift, although overall variation is expected to increase due to differential drift of alleles and the establishment of new mutations within subpopulations (Lande and Barrowclough 1987). Therefore, the high levels of genetic variation observed among Yellowstone bison compared with other populations (Wilson and Strobeck 1999; Halbert and Derr 2008) may be explained by the maintenance of subpopulations and comparatively large effective size of the Yellowstone National Park population. Nonetheless, the identification of genetic subpopulations in this study raises serious concerns for the management and long-term conservation of Yellowstone bison.
>
> Yellowstone bison have long been treated as a single metapopulation whereby the total number of bison is assumed to be the most important factor in determining appropriate winter cull levels (US Department of Interior and US Department of Agriculture 2000; Plumb et al. 2009). However, the unequal census sizes of the 2 subpopulations call this strategy into question: The Northern subpopulation ranges from 16% to 31% of the total population (US Department of Interior and US Department of Agriculture 2000; Gates et al. 2005). It is highly likely, therefore, that the 2 subpopulations have been disproportionately culled in some years. For example, approximately 735 bison were culled near Gardiner at the park's northern boundary during the 1996–1997 winter. Applying our estimate that around 68% of the bison culled near Gardiner that year originated from the Northern subpopulation (Figure 3A), we calculate that approximately 500 of the bison culled during the 1996–1997 winter were from the Northern subpopulation. Given the prewinter estimate for the Northern subpopulation of 877 bison (US Department of Interior and US Department of Agriculture 2000; Gates et al. 2005), the 500 culled bison represent approximately 57% of the entire subpopulation.
>
> In contrast, combining the remaining 235 bison culled at the park's northern boundary with the 363 culled at the western boundary during the winter of 1996–1997 results in an estimated 600 bison culled from the Central subpopulation. These bison represent approximately 20% of the prewinter estimate of 2928 bison in the Central subpopulation (US Department of Interior and US Department of Agriculture 2000; Gates et al. 2005). Therefore, the rate of loss of genetic diversity may be quite different between the 2 subpopulations.

. . .

> It is not clear at this point how the subpopulations may be changing over time or how the current bison management plan (US Department of Interior and US Department of Agriculture 2000) might influence the genetic integrity of the subpopulations. For example, when the total census size is less than 3000 bison, the current plan calls for holding 125 bison that test negative for brucellosis at a facility near Gardiner throughout the winter and then releasing the bison into the park in the spring. Such seronegative bison are most commonly calves (Rhyan et al. 2009). Being young, these bison may join the Northern subpopulation rather than return to the central range, which would erode the genetic distinctiveness between the 2 groups. Additional sampling and genetic analyses are needed to assess changes in genetic composition between the 2 subpopulations.
>
> In conclusion, we have presented strong evidence for the existence of 2 genetically distinct subpopulations of bison within Yellowstone National Park. Our study has also revealed longitudinal differences in migration patterns among Yellowstone bison, as it appears that bison moving to the park boundary in the vicinity of West Yellowstone are consistently from the Central subpopulation, whereas those moving to the park boundary in the vicinity of Gardiner may originate from either the Central or Northern subpopulation. These observations warrant serious reconsideration of current management practices. The continued practice of culling bison without regard to possible subpopulation structure has the potentially negative long-term consequences of reducing genetic diversity and permanently changing the genetic constitution within subpopulations and across the Yellowstone metapopulation. Population subdivision is a critically important force for maintaining genetic diversity and yet has been assessed in only a handful of species to date. The identification of cryptic population subdivision of the magnitude identified in this study exemplifies the importance of genetic studies in the management of wildlife species.

Halbert et al. 2012 at 368.

Management actions changing or altering the divergence of bison subpopulations jeopardizes unique herd distinctions and the adaptation of each unique herd to different ecological settings in the Yellowstone ecosystem.

> The level of differentiation between the 2 subpopulations is only slightly lower than between some of the other federal herds that have been completely isolated for over 40 years and have smaller population sizes. Given these estimates, the level of divergence is expected to continue to increase, and there is a potential for adaptive differentiation in the different environments inhabited by the Yellowstone subpopulations.

Halbert et al. 2012 at 367.

In 2016, Forgacs and colleagues assessed mitochondrial haplotypes and "identified two independent and historically important lineages in Yellowstone bison . . ." representing descendants of the indigenous bison in the Central herd, and descendants of the reintroduced bison in the Northern herd. Forgacs et al. 2016 at 1 (finding ten unique haplotypes from 25 Yellowstone bison).

Significantly, Forgacs found "Yellowstone bison represent nearly half — 10 of 22 modern plains bison haplotypes — of all the known haplotypes in plains bison . . ." Forgacs et al. 2016 at 6.

> Before new management standards and policies are defined for the Yellowstone bison population, additional studies involving population structure and genetic diversity based on both mtDNA and nuclear genetic diversity assessments need to be conducted.

Forgacs 2016 et al. at 7.

Yet, State and federal managers have not adopted standards or policies for conserving subpopulation distinction and no additional studies have been conducted examining how management is transforming Yellowstone bison's evolving subpopulation structure and genetic distinction.

> Wildlife management strategies are often designed to control a population's size and demography, but such strategies also can inadvertently impact a population's genetic variation. For species like bison, where management includes the regular removal of individuals to maintain small population sizes on restricted landscapes . . . the information used to select individuals for removal notably influence the rate at which a population loses various measures of genetic variation (Fig. 2).

Giglio et al. 2016 at 385.

"Management of particular species should incorporate details of the species ecology, especially its life history and demography, which may require larger populations than has been suggested on genetic grounds alone." Lande 1988 at 1459.

"An effective population size of 500 has been suggested as sufficient to maintain genetic variation for adaptation to a changing environment, but . . . this number is of dubious validity as a general rule for managing wild populations." Lande 1988 at 1458 (endnotes omitted).

> Historically large, outcrossing populations that suddenly decline to a few individuals usually experience reduced viability and fecundity, known as inbreeding depression. In many species, lines propagated by continued brother-sister mating or self-fertilization tend to become sterile or inviable after several generations. Rapid inbreeding in small populations produces increased homozygosity of (partially) recessive deleterious mutants that are kept rare by selection in large populations, and by chance such mutations may become fixed in a small population despite counteracting selection.
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> . . .
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> In small populations, random fluctuation in gene frequencies (random genetic drift) tends to reduce genetic variation, leading eventually to homozygosity and the loss of evolutionary adaptability to environmental changes. The maintenance of genetic variability in a finite population can be understood through Wright's concept of effective population size. This refers to an ideal population of $N$ individuals with discrete generations reproducing by random union of gametes. The effective size of a population, $N_e$, is the number of individuals in an ideal population that would give the same rate of random genetic drift as in the actual

> population. Unequal numbers of males and females, increased variance in family size (greater than the mean), and temporal fluctuations in population size are the main factors causing the effective sizes of natural populations to be substantially less than their actual sizes. In the absence of factors acting to maintain genetic variation, such as mutation, immigration, or selection favoring heterozygotes, the expected rate of loss of heterozygosity, or purely additive genetic variance in quantitative characters, is $1/(2N_e)$ per generation.

Lande 1988 at 1456 (endnotes omitted).

The U.S. Fish & Wildlife Service must examine and investigate how the lack of science-based management is jeopardizing genetic variation, the distinctiveness of each herd, and Yellowstone bison's population structure in the agency's threats assessment and status review.

***Yellowstone bison are unlikely to persist in the wild without a minimum of 5,000 or more adults.***

> Many biologists (including geneticists) agree that bison herds should be large (thousands of individuals), allowed to move more than thousands of square kilometers, and be exposed to natural predators such as wolves, in order to serve their ecological role on the landscape. However, only a small fraction of the bison alive today reside in these ecologically relevant herds (Sanderson and others, 2008).

Kauffman et al. 2020 at 106.

Traill (2010) and colleagues found populations of endangered species are unlikely to persist in the face of global climate change and habitat loss unless they number around 5,000 adult individuals or more.

"Conservation biologists routinely underestimate or ignore the number of animals or plants required to prevent extinction," according to Dr. Lochran Traill from the University of Adelaide's Environment Institute. "Often, they aim to maintain tens or hundreds of individuals, when thousands are actually needed. Our review found that populations smaller than about 5000 had unacceptably high extinction rates. This suggests that many targets for conservation recovery are simply too small to do much good in the long run." University of Adelaide 2009.

> To ensure both long-term persistence and evolutionary potential, the required number of individuals in a population often greatly exceeds the targets proposed by conservation management.
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> . . .
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> Genetically viable populations are those large enough to avoid inbreeding depression, prevent the accumulation of deleterious mutations, and maintain evolutionary potential. Small populations can persist in the wild for some time, but the reproductive fitness of these, and especially the ability to adapt to change (evolutionary potential) is compromised and extirpation is likely (Spielman et al., 2004; Kristensen et al., 2008).
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> . . .

> The bottom line is that both the evolutionary and demographic constraints on populations require sizes to be at least 5000 adult individuals. These seem to be large requirements, but a number of studies across taxonomic groups have made similar findings: the median MVP derived from PVA of 102 vertebrate species was 5816 individuals (Reed et al., 2003), and 4169 individuals from a meta-analysis of 212 species (Traill et al., 2007). The census-based MVP of 5500 reported by Thomas (1990) is also remarkably congruent; all similar to the recommended census *N* of 5000 individuals (Frankham, 1995). We note though that similarities are not strictly equivalent, and are a result of evaluation of some non-overlapping factors, meaning minimum viable population size in many circumstances will be larger still.

Traill et al. 2010 at 28, 30, *see also* Genetically effective population sizes and the factors that influence and describe the evolutionary Minimum Viable Population at 30 (Box 1).

A study of the Sturgeon River plains bison in Saskatchewan, Canada on the interface of a protected national park and private agricultural lands found genetic transfer of new animals would be required to retain ≥90% of genetic variability over 200 years with a minimum population of 420 bison. Cherry et al. 2019 at 553, 557, 559.

The Sturgeon River plains bison "is one of only a few unfenced plains bison populations in North America." Created in 1969 from ~10 to 22 founders from a fenced herd in Elk Island National Park Alberta, Canada, the Sturgeon River plains bison inhabit approximately 1,000 square kilometers of deciduous and coniferous forest, shrublands, and meadows. "Range expansion of plains bison outside of Prince Albert National Park is largely restricted by agricultural practices and other human developments." Cherry et al. 2019 at 554, 555.

The study's objective was to examine the likelihood of population persistence/extinction and conservation of genetic diversity given the "proposed maximum social carrying capacity threshold" of 430 Sturgeon River plains bison. Cherry et al. 2019 at 553, 557.

The population has declined by more than 50% since 2005 to 222 bison in 2013. Cherry et al. 2019 at 554 (citing Merkle et al. 2015).

A population viability analysis indicated "undesirable levels of population extinction risk and further declines in genetic variability" from current hunting practices. Cherry et al. 2019 at 553.

Probability of population persistence was based on population size and demographic structure, "social carrying capacity, and other limiting factors, such as unrestricted hunting, predators and anthrax outbreaks to determine long-term extinction risk." Cherry et al. 2019 at 555.

> When we applied the 2013 harvest data for the SRPB [Sturgeon River plains bison] annually to population simulations, the probability of population extinction was 14% by 2040, 37% by 2060, and levelled off near 45–50% by the year 2100 (Fig. 3). When we modeled anthrax with a 10% mortality with annual harvest rates equivalent to those observed in 2013, the probabilities of population extinctions after 200 years ranged between 72% (for a 5% annual probability of an outbreak) and 100% (for a 25% annual probability of an

> outbreak—Fig. 3). When we considered the effects of hunting in combination with the rare anthrax scenario (50% mortality and 2% frequency), assuming annual harvest rates equal to those in 2013, the probability of extinction was >97% after 200 years (Fig. 3 ). In the absence of unrestricted harvest, none of the anthrax outbreak simulations resulted in probabilities of extinction above zero over a 200 year period. However, the 20 and 25% annual probabilities of an outbreak with a 10% population mortality and the rare anthrax scenario resulted in mean population sizes (range = 393 to 411) below the minimum abundance predicted to meet the long-term genetic maintenance goals (*N* = 420). The mean simulated population size reached social carrying capacity after 10 years in the absence of harvest and anthrax. Once social carrying capacity was reached, the average number of individuals randomly selected and removed per year to maintain social carrying capacity ranged from 25.6 to 31.1 (SD range: 28.7– 32.9). Updated population estimates from aerial surveys indicated the population has been below our predicted minimums to maintain genetic diversity since 2007 (Fig. 4 ).
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> . . .
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> There is ample evidence to suggest that low levels of genetic variability and inbreeding depression in mammals affect birth weight, survival, reproduction, and susceptibility to disease (Keller and Waller 2002). Our results indicate the SRPB population has less genetic diversity than its founding population, which could reduce its relative resilience to inbreeding or environmental change.
>
> . . .
>
> [B]oth our current population estimate and population viability simulations indicate that population targets deemed sufficient to attain genetic maintenance goals may not be achievable under current management conditions.

Cherry et al. 2019 at 557–558, 558, 559.

Another study found the extinction risk for the Sturgeon River plains bison was driven by a minute proportion (<1%) of the population's range outside the protected area of the park. "Under current conditions, continued bison use of this area over just a few months a year is likely to result in the disappearance of the population over the next 50 years." Simon & Fortin 2019 at 371.

Several lessons from the Sturgeon River plains bison population can be inferred here.

First, protected areas do not in and of themselves ensure long-term bison population viability.

Second, conversion of bison range to agricultural and other human land uses remains a threat to recovering the migratory species in the wild.

Third, movements in the bison's range beyond protected areas result in conflicts which are driving the loss of genetic diversity and threatening population persistence in the wild.

Fourth, small population sizes and limited ranges determined by “social carrying capacity” are far below the threshold necessary to maintain a viable population in the wild for the long-term (centuries).

In Yellowstone, bison are threatened by similar factors threatening Sturgeon River bison but on a much larger scale.

Because Yellowstone bison are unlikely to persist in the wild under current management population targets, the U.S. Fish & Wildlife Service must examine and investigate inadequate population and subpopulation sizes in the agency’s threats assessment and status review.

***Current management is undermining natural selection of Yellowstone bison. Evidence of effects from the loss in ecological choice (natural selection) for Yellowstone bison is not being systematically examined for publication.***

> Short-term economic and political interests often dominate scientific considerations in the development and implementation of management plans for threatened or endangered species. Whether economics and politics continue to produce scientifically deficient conservation plans will be decided in many cases only by extended litigation.

Lande 1988 at 1459.

PHOTO: BFC Archives

State and federal managers are jeopardizing natural selection in bison, and the full extent of loss of ecological choice is unknown because evidence is not being systematically examined for publication.

For example, current management repeatedly kills migratory bison in a systemic process selecting against disease that has operated on Yellowstone bison for decades.

“Under natural selection, bison with the least disease resistance, or bison carrying the most virulent, debilitating strains of a pathogen, will experience relatively low rates of reproduction and/or survival. In this coevolving system, natural selection favors persistence of disease resistant bison and of less virulent strains of pathogens.” Bailey 2013 at 145.

If natural selection favors bison’s ability to migrate long distances in response to climate variation or a deteriorating environment, and the government systemically kills migrants, over time the inheritance bequeathed to future generations is impoverished because the fittest individuals are being removed before the values of their fitness is fully realized in natural selection.

Bison are more than their genes; without habitat to evolve and adapt amidst predators and a preponderance of natural selection processes, genetic diversity alone will not save bison from extinction in the wild. *See e.g.*, Roffe 2007 at 2 (reducing bison to "seed stock" as National Wildlife Refuges do not provide the land base to sustain or maintain a bison population functioning as wild in a wild environment).

> Attempts to establish the minimum size for a viable population on genetic grounds alone are highly questionable for several reasons. The management goal of preserving maximum genetic variability within populations is based on the assumption that the rate of evolution in a changing environment is limited by the amount of genetic variation. This assumption has been previously rejected, in favor of ecological opportunity (natural selection), as the primary rate-controlling factor, at least in morphological evolution. Recent writings on genetics and conservation also espouse the view that genetic variation is adaptive in and of itself. However, there is little direct evidence that heterozygosity per se increases fitness (that is, that heterozygote advantage at single loci is common), beyond simply avoiding inbreeding depression and allowing adaptation to environmental change.
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> . . .
>
> Extinction is fundamentally a demographic process, influenced by genetic and environmental factors. If a population becomes extinct for demographic reasons, such as habitat destruction, the amount of genetic variation it has is irrelevant. . . . For wild populations in natural or semi-natural environments, demography is likely to be of more immediate importance than genetics in determining population viability.

Lande 1988 at 1457 (endnotes omitted).

As Bailey observed, saving genetic diversity is not enough; allowing natural selection of the wild Yellowstone bison genome is what is being lost and at risk under current management.

The U.S. Fish & Wildlife Service must examine and investigate management policies, processes, and practices undermining natural selection and the outcomes for Yellowstone bison in the agency's threats assessment and status review.

***In restricting the range and habitat for Yellowstone bison to naturally evolve and adapt to rapid climate and environmental change, State and federal managers are placing the distinct population segment at increased risk of extinction in the wild.***

Demographic and environmental threats, habitat loss and fragmentation, any of these factors alone or together with rapid climate change could render protected areas unsuitable for Yellowstone bison, a migratory species that has lost all 14 long distance migration corridors in the Greater Yellowstone bioregion. Berger 2004 at 322 (Table 1) (estimating lost routes based "on point counts of discrete winter and summer ranges.").

Together with loss of connectivity to habitat and connectivity to any other self-sustaining population of wild bison, managers have created no margin of safety for Yellowstone bison to withstand random demographic, environmental, or human-made catastrophe.

These interacting factors could also drive and or precipitate changes in migrations to habitat presently off-limits thereby increasing the risk of local extinction or loss of subpopulation, e.g., Yellowstone bison kill zones delineated in the State of Montana's and Yellowstone National Park's bison management plan, and enforcement of regulatory mechanisms in Montana, Idaho, and Wyoming that eliminate migratory bison.

> *Edge effects*. Of course, if an area with fixed boundaries has been established as a natural preserve containing suitable habitat for some species, long-term climatic trends may induce major evolutionary changes in the population, or render the entire preserve unsuitable. This problem is compounded for species that undergo long-distance seasonal migrations and require two or more widely separated patches of suitable habitat.
>
> *Local extinction and colonization*. Many species exist in subdivided populations for social reasons or because suitable habitat has a patchy spatial distribution. Fluctuating environments may make some habitat patches temporarily unsuitable, so that a widely distributed population persists through a balance between local extinction and colonization. . . Critical factors affecting the persistence of a subdivided population include the number, size, and spatial distribution of patches of suitable habitat and dispersal rates between them.
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> . . .
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> Increasing either the number of territories a dispersing individual can search, or the expected number of off-spring produced, increases both the demographic potential of the population and the equilibrium occupancy of suitable habitat.
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> . . .
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> This model demonstrates two important features of populations maintained by local extinction and colonization. First, as the amount of suitable habitat (randomly or evenly distributed) in a region decreases, so does the proportion of the suitable habitat that is occupied. Second, there is an extinction threshold, or minimum proportion of suitable habitat in a region necessary for a population to persist. If the proportion of suitable habitat falls below $1 — k$, the population will become extinct. Extensions of this model show that an Allee effect caused by difficulty in finding a mate, an edge effect due to the finite extent of the region containing suitable habitat, or a fluctuating environment all increase the extinction threshold.

Lande 1988 at 1458 (endnotes omitted).

Fixing boundaries to a protected area that may be rendered unsuitable for migratory Yellowstone bison, in the short or long term, increases the risk of loss of important geographic, genetic, and life history variation in the distinct population segment.

Hence, the U.S. Fish & Wildlife Service must examine and investigate Yellowstone bison's ability to withstand the sum of management actions acting together with rapid climate change and catastrophic environmental conditions in the agency's threats assessment and status review.

***State and federal managers are increasing the risk of inbreeding by confining and limiting migratory range and managing bison in small populations in isolated ranges. Evidence of the risk of inbreeding in Yellowstone bison is not being systematically examined for publication.***

Managers do not systematically retain usable quantitative information or "scientifically defensible" evidence of inbreeding or malformities in bison conservation herds. Licht 2017 at 91.

Without accurate and valid data on bison, researchers' simulations and models may not reflect how management actions are retaining or reducing genetic diversity and variation year to year, decade to decade, and over the next century.

Well tested, grounded, and robust evidence must be comprehensively, systematically, and non-intrusively gathered and examined over time and acted upon by managers to be relevant for Yellowstone bison.

Models and simulations are subject to the assumptions used to make predictions and the actual state or condition of the population, monitoring data error and incompleteness, and the inability to distinguish unique individuals from similar groups in Yellowstone's bison population. Hobbs et al. 2009 at 1.

In addition, instruments used to gather data on bison such as GPS collars are also subject to collection error and biases. Jung et al. 2018 at 1.

According to Hobbs et al. (2009 at 30), even the most superbly accurate data, model, and range of actions presented to prevent undesirable outcomes for bison can be undercut by:

- unforeseen variables,
- managers not making informed decisions or disregarding scientific evidence in making decisions, and
- not properly observing and recording undesirable management outcomes through monitoring to inform managers, who may or may not adopt the new information into management decisions and actions.

Furthermore, the validity of selecting for a set of values to retain (or not) in bison is arbitrary because, for example, standards for allowable inbreeding and genetic drift "rarely have a strong biological basis in any understood population genetics of the local population. . . . Since we don't know what alleles are being lost, nor how they function, there is no biological basis for accepting and promoting this rate as an acceptable management goal." Bailey 2016, *Population Genetics and Wildlife Management*, at 1, 2 (describing how managers adopted a metric expressing the loss of alleles over a set time period "as an acceptable rate of loss" in management, i.e., 5% of alleles each 100 years).

*See e.g.*, Giglio, Toldness, Gross & Wang, and Pérez-Figueroa on the various models used to estimate retention (and loss) of a selected set of values in bison.

How scientists measure allelic diversity is one thing, but understanding the effects of what is lost is an unknown in the absence of evidence showing how the lost cooperating alleles influences "anatomy, physiology and behavior and ultimately, the success of populations. Too often, this immense variation among individuals and among subsets of animals, and this uncertainty, are ignored in wildlife management." Bailey

2016, *Population Genetics and Wildlife Management*, at 7–8.

Some observations can be inferred from Licht's study of inbreeding in four National Park Service bison populations.

> I reviewed the available information for other evidence of inbreeding, such as tallies of malformed bison, but was unable to find usable quantitative information.

Licht 2017 at 90.

While Licht "found no evidence of inbreeding depression as measured by lambda and percentage of calves" among bison herds in Badlands, Wind Cave, and Theodore Roosevelt National Parks, simulations of culling scenarios of yearlings only indicated the bison herd in the North Unit of Theodore Roosevelt had the highest risk of inbreeding depression. Licht 2017 at 89 (culling yearlings only every three years could result in heterozygosity approaching that of the inbreeding depressed Texas State bison herd at Caprock Canyons State Park).

> Why is there no compelling evidence of inbreeding depression in the four bison herds in the National Park Service units in the northern Great Plains? One possible explanation is that the herds grew quickly and have generally been near or above the lower range recommended for the conservation of genetic diversity in wildlife populations (Franklin 1980). Furthermore, the herds are not exposed to stressors that can exacerbate inbreeding depression, such as predators and food shortages (O'Grady et al. 2006). As a result, the herd's demographic response to inbreeding is more comparable to a captive population than a wild population (Crnokrak and Roff 1999). Another possibility is that bison might be predisposed to avoid breeding with closely related animals, as is apparently the case in some species (Archie et al. 2007; Hoffman et al. 2007; Dunn et al. 2012). Yet another possibility is that heterozygous animals could be more successful breeders (Bensch et al. 2006). Although I found no persuasive evidence of inbreeding depression, inbreeding effects could be occurring that are not so severe as to manifest themselves in demographic analyses. For example, Wołk and Krasińska (2004) suggested that pathomorphological changes in European bison over a 20-year period were due to a decline in immunity as a result of inbreeding. Berger and Cunningham (1994) noted hoof malformations in Badlands bison and such malformations were also observed by park staff at Wind Cave (internal park files). Regrettably, disfigurement data were not collected in a manner conducive to trend analyses
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> . . .
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> The analysis conducted here underscores the importance of collecting accurate bison demographic data. Regrettably, there are large information gaps regarding the park bison herds. Even the most basic of data, such as how many bison are in the park, is not collected in a systematic manner. Informed management requires robust information. To better manage bison in National Park Service units more emphasis needs to be placed on collecting usable and scientifically defensible demographic data.

Licht 2017 at 90, 90–91.

Inbreeding effects in bison "may include physiological or behavioral issues including poor biochemical balance, improper organ function, altered social behavior and susceptibility to disease. These symptoms are not easily recognized in wild populations." Bailey 2016, *Population Genetics and Wildlife Management*, at 2.

Inbreeding in bison can also "contribute to a weakening and replacement of natural selection, dismantling wild genomes and discarding valuable characteristics of wild populations." Bailey 2016, *Population Genetics and Wildlife Management*, at 3.

In addition to a number of human-made factors threatening the persistence of bison in the wild, Lande (1995) found mutation "can critically affect the viability of small populations by causing inbreeding depression, by maintaining potentially adaptive genetic variation in quantitative characters, and through the erosion of fitness by accumulation of mildly detrimental mutations."

In managing for population sizes without regard for subpopulation division or genetically distinct herds, and below the threshold conservation biologists recommend to avoid inbreeding, State and federal managers are undermining genetic diversity and increasing the risk of inbreeding in Yellowstone bison.

> Recent experiments indicate that the rate of production of quasineutral, potentially adaptive genetic variance in quantitative characters is an order of magnitude smaller than the total mutational variance because mutations with large phenotypic effects tend to be strongly detrimental. This implies that, to maintain normal adaptive potential in quantitative characters under a balance between mutation and random genetic drift (or among mutation, drift, and stabilizing natural selection), the effective population size should be about 5000 rather than 500 (the Franklin- Soulé number). Recent theoretical results suggest that the risk of extinction due to the fixation of mildly detrimental mutations may be comparable in importance to environmental stochasticity and could substantially decrease the long-term viability of populations with effective sizes as large as a few thousand. These findings suggest that current recovery goals for many threatened and endangered species are inadequate to ensure long-term population viability.

Lande 1995 at 782.

> Mutation is the ultimate source of all genetic variation (Dobzhansky 1970). Different kinds of genetic variation can critically affect population viability, especially in small populations. Deleterious (partially) recessive mutations, such as recessive lethal alleles, contribute to inbreeding depression in fitness, which increases the risk of extinction. Mildly detrimental mutations accumulate and can become fixed by random genetic drift, gradually eroding fitness and increasing extinction risk. Quasineutral, potentially adaptive genetic variance in quantitative characters maintained by mutation becomes diminished by inbreeding and random genetic drift, reducing the ability of a population to adapt and persist in a changing environment.
>
> Measurements of the rates at which different types of mutations arise spontaneously have been used in conjunction with population genetic theories to suggest minimum population sizes for different goals in species conservation, such as avoiding inbreeding depression, maintaining potential for adaptive evolution, and avoiding genetic erosion of fitness from

> the accumulation of detrimental mutations (Franklin 1980; Soulé 1980; Lynch & Gabriel 1990; Lynch et al. 1993).
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> . . .
>
> Genetic and statistical analysis shows that about half of the inbreeding depression in viability is caused by rare, nearly recessive lethal and sublethal point mutations, with the remainder attributable to numerous mildly detrimental mutations of small, more nearly additive effect (Simmons & Crow 1977). There is little evidence that overdominance (heterozygote advantage) contributes substantially to inbreeding depression (Charlesworth & Charlesworth 1987, 1990; Crow 1993).
>
> The amount of inbreeding depression manifested by a population depends on the rate of inbreeding and the opportunity for selection to purge recessive lethal and semi lethal mutations; this important point is neglected in some recent models that therefore overestimate the impact of inbreeding depression on population viability (Senner 1980; Halley & Manasse 1993; Mills & Smouse 1994). Gradual inbreeding by incremental reductions in population size over several or many generations allows selection to eliminate at least the lethal and sublethal mutations when they become homozygous (Falconer 1989). In contrast, the component of inbreeding depression from more nearly additive mutations of small effect may be difficult or impossible to purge by inbreeding, and even habitually self-fertilizing plants show considerable inbreeding depression manifested as heterosis (increased fitness) upon crossing different lines (Lande & Schemske 1985; Charlesworth & Charlesworth 1987; Charlesworth et al. 1990; Hedrick 1994).

Lande 1995 at 783.

Managing for effective population sizes to avoid inbreeding in bison is arbitrary if it's not based on biological evidence examined over meaningful time scales to judge whether inbreeding or genetic loss is evident or not.

For example, inbreeding in a population of 1,200 bison from 53 introduced bison (another 20 were added in 1984) ranging across 19,500 hectares (48,185 acres) in Badlands National Park is evidence that population size alone does not prevent against harmful genetic decline. Licht 2017 at 90 (bison hoof malformations were also observed in Wind Cave National Park); Licht & Johnson 2018 at 116; National Park Service 2020 (Badlands bison are subject to roundups with new calves fitted with tags). In its entirety, Badlands National Park spans 244,000 acres.

A complex variable influencing Yellowstone bison's adaptation in the wild is genetic drift.

> Genetic drift refers to among-generation changes in a population genome that occur due to randomness, not due to any selection for or against any alleles. In all populations, random factors determine which alleles occur in successful ova and sperm. Random factors of the environment also influence survival and reproduction of many animals.
>
> In the transfer of alleles from parent to offspring, half the parent's alleles are discarded

> essentially at random as pairs of chromosomes are reduced to single chromosomes in ova or sperm (the process of meiosis).
>
> . . .
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> Due to random effects, some alleles will happen to increase, while other alleles happen to decrease between generations of animals. (Allele frequencies are "drifting". The frequency of an allele is the percent of animals that carry the allele.) Over long time periods, some alleles will decrease, by chance, over some number of successive generations and thus, may decline to zero and be lost from the population. The probability of losing alleles increases with time and is greater in smaller populations. Rare alleles are most at risk. With drift, loss of alleles will decrease a population's ability to adapt to future changes in its environment.

Bailey 2016, *Population Genetics and Wildlife Management*, at 3, 4.

In sum, "genetic drift diminishes the population's evolutionary potential for adapting to future environments; and also diminishes the population's adaptedness to the current environment by dismantling the effects of past evolution. While relatively long-term losses of genetic diversity and evolutionary potential due to genetic drift are uncommonly recognized in wildlife management, short-term dismantling of current genome quality due to drift is recognized even less." Bailey 2016, *Population Genetics and Wildlife Management*, at 5.

> Clearly, individually FWS [Fish & Wildlife Service] herds are at risk for significant genetic drift and loss of diversity.
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> . . .
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> FWS Refuges are individually relatively small tracts of land. Combined with the need to manage for other wildlife species, prevent habitat degradation and keep bison populations well within long term carrying capacities, bison populations on individual refuges are limited. Annual culling is necessary to stay within these parameters, yet can lead to rapid loss of genetic diversity.

Roffe 2007 at 2, 3.

> Mostly, wildlife managers address inbreeding by maintaining a population size that is believed sufficient to avoid an arbitrarily chosen level of inbreeding. If there is also concern for genetic drift, a still larger population is maintained to avoid exceeding an arbitrarily chosen rate of loss of **alleles** (kinds of genes) due to drift.
>
> I contend our standards for allowable inbreeding and genetic drift, if addressed at all, are often "arbitrarily chosen" because these standards rarely have a strong biological basis in any understood population genetics of the local population. Standards are influenced by (1) theoretical calculations based on similar, often hypothetical populations; (2) comparing limited samples of genetic diversity between the local population and a larger population that is only assumed to be "genetically healthy"; and (3) social and environmental constraints upon the local population, when these constraints bias managers' interpretations of the genetics evidence toward conclusions that best fit the political

environment and/or commonly accepted management paradigms from the past.

> Note: the negative consequences of poor genetic health may accumulate slowly, often over timescales exceeding professional careers; whereas avoiding disputes with dominant constituents or accepted management paradigms can produce immediately convenient management solutions. Recommendations of wildlife managers may be constrained by agency policies that arise from a lack of understanding and leadership at higher levels of government. Consequently, there is little ability or incentive to explain the consequences of complex genetic issues to the public owners of wildlife. Management of a public trust resource fails due to a breakdown in the quality of trustee-public communication.
>
> A metric for genetic drift, loss of 5% of alleles each 100 years, was first used only as a way to express this rate of loss. However, management agencies have adopted it as an acceptable rate of loss. Since we don't know what alleles are being lost, nor how they function, there is no biological basis for accepting and promoting this rate as an acceptable management goal.

Bailey 2016, *Population Genetics and Wildlife Management*, at 1–2 (emphasis in the original).

Malformed tails and horns have been observed in Yellowstone bison. Geist & Mease pers. observations.

The lack of a systematic effort to examine and publish data of observed malformations complicates the ability to forecast how inbreeding may manifest or is manifesting in the Yellowstone bison population.

The U.S. Fish & Wildlife Service must examine and investigate the risk of inbreeding in the agency's threats assessment and status review because Yellowstone bison are being managed below thresholds conservation biologists recommend to avoid inbreeding and maintain genetic diversity.

***In managing Yellowstone bison for a limited population size in a restricted and isolated range, it is unknown how management is transforming mutation rates and maintenance of adaptive genetic variance.***

> Quantitative characters of morphology, physiology, and behavior are of great importance in adaptation to natural environments. The rate of evolution of the mean phenotype in response to directional natural selection is proportional to the additive genetic variance (the heritable portion of the genetic variance responsible for the resemblance between relatives) when selection acts on a single character (Falconer 1989), or to the additive genetic variance-covariance matrix when selection acts on a set of correlated characters (Lande & Arnold 1983).
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> . . .
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> Natural selection on quantitative characters (other than major components of fitness) generally favors an intermediate optimum phenotype that may fluctuate with time.

Lande 1995 at 784, 785.

The multi-edged effect of mutation has implications for determining an effective population size of

Yellowstone bison with a genetically distinct subpopulation structure that can persist in the wild for centuries.

The population target State and federal manager's select for in Yellowstone bison is far below the number of mature individuals necessary to retain adaptive genetic variance and genetically distinct herds. This is especially true for the evolution of genetic variation in single locus traits in resisting disease.

> For example, under the house-of-cards approximation, including all mutations (ignoring recessive lethal effects), a population with $N_e = 1000$ is expected to maintain 67% of the additive genetic variance maintained in an infinite population; under the Gaussian allelic approximation, a population with $N_e = 707$ is expected to maintain 67% of the additive genetic variance maintained in an infinite population. Including only quasineutral mutations $N_e$ would have to be five times larger (5000) in the house-of-cards approximation and 3.15 times larger in the Gaussian allelic approximation (2236) to maintain 67% of the additive genetic variance in an infinite population.
>
> The house-of-cards approximation is most accurate for loci with relatively large effects and low mutation rates, and the Gaussian allelic approximation is most accurate for loci with relatively small effects and high mutation rates. Because both types of loci probably contribute to variance of quantitative characters, the actual amounts of additive genetic variance maintained by mutation are likely to be between these two approximations. Excluding recessive lethal mutations, and whether or not we include stabilizing selection, it therefore appears that the effective population size necessary to maintain a high proportion of the potentially adaptive, additive genetic variance that would occur in a large population requires effective population sizes an order of magnitude larger than the original Franklin-Soulé number, increasing the management goal from $N_e = 500$ to $N_e = 5000$.
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> . . .
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> Of course, $N_e = 5000$ should not be regarded as a magic number sufficient to ensure the viability of all species, because of differences among characters and among species in genetic mutability and differences in environmental fluctuations and selective pressures to which populations are exposed. Maintenance of potentially adaptive genetic variation in single-locus traits (such as major disease resistance factors), which have mutation rates on the order of $10^{-6}$ per allele per generation, may require much larger effective population sizes, on the order of $10^4$ or $10^5$ (Lande & Barrowclough 1987; Lande 1988).

Lande 1995 at 786, 789.

In assessing factors threatening bison with extinction, population bottleneck (from millions to < 1,000 in North America; <25 in Yellowstone), few founders ("substantially less than 100" in North America; "unlikely to be more than" 7 in Yellowstone), and present population isolation (> 120 years) must be examined in relationship to multi-decade management actions selecting against brucellosis (natural or acquired immunity and disease resistance), nonrandom, differential government slaughter of subpopulations, skewing sex ratios, altering age structures, and loss of entire family groups (generational parent-offspring). (Quoting Hedrick 2009 at 411, 417).

Avoiding inbreeding, preventing the erosion of fitness, and preserving the evolutionary adaptive potential in genetic variance are impaired by State and federal management policies confining and restricting Yellowstone bison's natural migrations, thwarting connectivity to habitat in response to stresses (natural and human-made), and establishing a "target" population without regard for genetically distinct subpopulations.

> The above results cast doubt on whether populations of many threatened and endangered species will maintain adequate evolutionary potential and long-term genetic viability unless they recover to much large sizes. Effective population sizes generally are substantially lower than actual population sizes because of fluctuations in population size, high variance in reproductive success, and unequal sex ratios (Wright 1969; Crow & Kimura 1970; Lande & Barrowclough 1987); maintaining effective population sizes of several thousand in the wild therefore will usually require average actual population sizes on the order of $10^4$ or more. Synergistic interactions among different genetic and demographic factors contributing to the risk of population extinction (Gilpin & Soulé 1986) are likely to cause the minimum population sizes for long-term viability of many wild species to be much larger than $10^4$.

Lande 1995 at 789.

The U.S. Fish & Wildlife Service must examine and investigate how managing for limited population sizes in an isolated and restricted range is transforming mutation rates and maintenance of adaptive genetic variance in Yellowstone bison in the agency's threats assessment and status review.

***State and federal management actions are driving the loss or extinction of Yellowstone bison family groups (generational parent-offspring). Evidence of the extent and rate of loss in Yellowstone bison family groups is not being systematically examined for publication.***

The loss or extinction of Yellowstone bison family groups is largely unknown because only one published study is available examining how State and federal management actions are killing entire parent-offspring generations.

PHOTO: BFC Archives

The loss of extended matrilineal groups of Yellowstone bison in management actions "increases jeopardy to retention of genetic diversity." Bailey 2008 at 2.

"Since bison are known to naturally assemble in matriarchal groups including several generations of related females and the most recent calf crop (Seton 1937; Haines 1995), it is possible that the culling of bison at the YNP boundaries is non-random with respect to family groups, a practice that over sufficient time may lead to systematic loss of genetic variation." Halbert 2003 at 133.

> [T]he total parent-offspring matches made in each group are considered underestimates of the true number of parent-offspring pairs that likely existed in each location-year group. Attempts were made to

> detect "cohorts," in this case referring to any related group, and are reported below with maximum inclusion such that the same individual is not represented in more than one group. A summary of the number of parent-offspring matches and cohorts detected in each group is shown in Table 23. From the 166 bison sampled from Gardiner in the 1996 – 97 winter, 29 total parent-offspring matches were confirmed.

Halbert 2003 at 141 (acknowledging the study's underestimates of the extent and number of Yellowstone bison family groups killed in ongoing government actions).

"The only multi-generational female cohort detected in this study was led by a 7 year-old female killed 01/24, who was the dam of a 4 year-old female killed 01/16, who was the dam of a 3 year-old female killed 01/17, who was the dam of a male calf killed 01/22" in Gardiner basin during the winter of 1996–1997. Halbert 2003 at 142.

"Three parent-offspring matches were made within the West Yellowstone 1996 – 97 group. The 2 involving calves matched an 11 year-old dam and a 4 year-old dam. The other match was a 15 year-old male with his 6 year-old female offspring killed one month apart (01/27 and 02/27)." Halbert 2003 at 142.

"From the West Yellowstone 2001 – 02 group, 12 parent-offspring pairs were matched. Of these, 8 were calf-dam pairs. One cohort was detected, involving a 5 year-old dam killed 04/25 and 2 of her offspring: a male calf killed 04/25 and a 4 year-old female killed 04/10." Halbert 2003 at 144.

> Bison calves generally remain with their mothers throughout the first year of life (Berger and Cunningham 1994), so it is not very surprising to find cow-calf pairs within the sampled groups. The long-term genetic and ecological effects of killing off cow-calf pairs in this manner are unknown.
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> . . .
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> The parent-offspring matches were not limited to calf-cow pairs. Both male and female 1, 2, and 3 year-old offspring were matched to dams. Several cases of dams with multiple offspring of different ages were found, indicating the presence of family units within the groups analyzed. In one case, a multigenerational matriarchal group was found which spanned 4 generations ranging from a 7 year-old female to a male calf. All of the animals from this group were killed within 8 days of each other from the same location. These analyses indicate [it] is much more likely for sisters or mother-daughter pairs to be sampled from the same location within days of each other, providing evidence of matriarchal groups and corroborating observational data (Seton 1937; Haines 1995).

Halbert 2003 at 150 (acknowledging the long-term ecological and genetic effects of killing Yellowstone bison females and their offspring is unknown).

> Although a disconcerting number of parent-offspring pairs and family groups were found in this study, providing evidence of nonrandom culling within the YNP bison population, the magnitude and long-term genetic and demographic effects of this type of nonrandom culling are unknown. For instance, inadequate sampling and difficulties in establishing

groups based on capture dates prohibited testing of average relatedness within cohorts from a single location on a single date against a random sample of bison from the associated subpopulation. The resolution of these issues, including potential long-term genetic impact, will require a complete sampling of bison as they migrate off park boundaries regardless of their eventual status. In this manner, cohorts can be fully investigated, levels of relatedness established, and culled versus non-culled groups compared. The potential impact of these issues on the long-term preservation of YNP bison warrants consideration in the future management of this historically and genetically important bison resource.

Halbert 2003 at 151–152.

Halbert's dissertation is the only known study to assign parentage estimating — and underestimating — the loss of entire generational family groups in Yellowstone bison.

PHOTO: BFC Archives

In not systematically examining crucial data for publication, the extent and rate of loss or extinction of Yellowstone bison family group lineages under current State and federal management is unknown.

Because the long-term ecological, genetic, and demographic effects of killing generational parent-offspring is unknown, the U.S. Fish & Wildlife Service must examine and investigate loss or extinction of Yellowstone bison family groups in the agency's threats assessment and status review.

***The unknown extent and rate of loss or extinction of family groups (generational parent-offspring) is a threat to Yellowstone bison's adaptive potential and resilience to adverse events in a rapidly changing climate and environment.***

Because the loss of entire family groups in management actions has long-term implications on the effective population size needed for Yellowstone bison herds to retain their adaptive potential, government management must be examined and investigated as a threat to the wild species' resiliency to adverse events in a rapidly changing climate and environment.

"[W]ithout further information on the extent of allelic or genetic lineage change in populations free from human disturbance, it will remain difficult to develop a rational approach to the long-term conservation of populations and their genetic population structure." Gompper et al. 1997 at 858.

*Because populations in zoological parks and nature reserves often are derived from only a few individuals, conservationists have attempted to minimize founder effects by equalizing family group sizes and increasing the reproductive contributions of all individuals. Although such programs reduce potential losses of genetic diversity, information is rarely available about the actual persistence of family groups or genetic lineages in natural populations. In the absence of such data, it can be difficult to weigh the importance of human intervention in the conservation of small populations. Separate long-term studies of two mammals, the North American bison (*Bison bison*) and the white-nosed coati (*Nasua narica*), and a bird, the Acorn*

*Woodpecker (*Melanerpes formicivorus*), demonstrate differential extinction of genetic lineages. Irrespective of the mechanisms affecting population structure, which may range from stochastic environmental events to such behavioral phenomena as poor intrasexual competitive abilities, our results show that lineages can be lost at rapid rates from natural populations. A survey of comparable studies from the literature indicates that the loss of matrilines over the course of the study varies from 3% to 87% in wild mammals and from 30% to 80% in birds, with several small mammals losing approximately 20% of matrilines per year of study. These lineage extinctions were not an artifact of the length of the study or the generation time of the species. Such rapid losses of lineages in less than 20-year periods in natural populations suggest that efforts to maintain maximal genetic diversity within populations may not always reflect processes that occur in the wild. Conservation biologists need to give further thought to the extent to which parity among genetic lines should be a primary goal of management of captive and small wild populations.*

Gompper et al. 1997 at 857 (emphasis in the original).

"[E]fforts to minimize immediate genetic losses may be insufficient to assure the long-term maintenance of uncommon alleles (Crow & Kimura 1970; Wright 1978; Fuerst & Maruyama 1986; Ballou 1991), and only rarely has information been available about the actual persistence of family groups or genetic lineages in natural populations (Simberloff 1988). Such information is critical to gain a fuller understanding of genetic population structure and the extent to which unforeseen and unpredictable events may shape that structure." Gompper et al. 1997 at 858.

Loss of entire generational family groups in government management actions is concerning because such losses decrease the effective population size of Yellowstone bison.

> Lineage loss necessarily decreases the genetic effective size of the population ($N_e$) through time. Lande (1995) has shown that for quantitative characters to maintain adaptive potential in the face of environmental and demographic stochasticity, $N_e$ should be about 5,000. Unlike some processes that effect $N_e$ (Crow & Kimura 1970; Harris & Allendorf 1989; Hartl & Clark 1989), however, lineage loss may not be a random process but can result from specific ecological or behavioral processes such as mating ability in bison . . . To the extent that these processes result in directional selection in free-living populations, the $N_e$ needed to maintain adaptive potential will be even greater than that estimated by Lande (1995). The practicality of attaining these $N_e$ sizes are interesting problems for which few data on vertebrates are yet available.
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> [G]iven the frequent loss of lineages among even the established breeders as indicated by these results, it is unclear whether or not most immigrants will actually have an impact on the genetic population structure. And, as the habitats of most species become increasingly fragmented and immigration between populations more difficult, such genetic rescue may become even less common.

Gompper et al. 1997 at 865.

While bison herd size may increase in time in response to management actions killing a substantial portion of the Yellowstone population, an increase in census does not measure the loss of generational family groups, and the genetic contributions those family groups could have made to each distinct herd and the population.

The extent and rate of loss of lineages destroyed in ongoing management actions is unknown but must be examined and investigated as a strike against Yellowstone bison's adaptive potential and resiliency to human-made stressors and natural disturbances.

The U.S. Fish & Wildlife Service must examine and investigate the loss or extinction of generational family groups in management actions and the effects on Yellowstone bison's adaptation and resiliency to adverse events in a rapidly changing climate in the agency's threats assessment and status review.

***The long-term viability, fitness, and evolutionary potential of wild Yellowstone bison is not secure and at risk of extinction. Under current State and federal management, inbreeding in the Yellowstone bison population may not be evident for a century.***

> As predicted for any population of finite size, we observed a reduction in allelic richness and GD [gene diversity], and an increase in inbreeding, for all strategies. Heterozygosity increased or decreased depending on the strategy employed. All strategies succeeded in maintaining the target population size and a balanced sex ratio. Differences among strategies in the amount of genetic variation retained and the extent of inbreeding were evident at the 100-year time step and became more pronounced over time. Differences in the pattern of genetic variation loss were also detected between the target and non-target microsatellite loci for some culling strategies.

Giglio et al. 2016 at 384.

While Giglio's study is informative, it must be contrasted with the nonrandom and intensive human selection pressures evident in management practices used over decades, e.g., State and federal managers do not preferentially kill yearlings, and as Halbert's (2003) dissertation found, entire bison family lineages are being lost, the extent and rate of loss of generational parent-offspring is unknown, and managers do not recognize Halbert's (2012) finding of genetically distinct subpopulations.

> Loss of alleles and a reduction in genome-wide heterozygosity in small populations result in loss of overall genetic variation. Since loss of genetic variation can be partially mitigated by increasing population size (e.g. Supporting Information Table S1a), wildlife managers often attempt to maximize the population size to minimize the effects of genetic drift (Epps *et al*., 2005; Dixo *et al*., 2009) and the related accumulation of inbreeding (Soulé & Mills, 1998). As population size decreases, maintaining stable demography and retaining genetic variation become increasingly important to prevent local extinction (Lande, 1988). In our study, the differences in genetic variation became more profound as population size decreased, demonstrating that the choice of management strategy becomes increasingly important as population size decreases (Supporting Information Table S1a). For range-restricted species such as bison, where habitat is limited and populations must be maintained at particular target sizes, management has historically focused on removal strategies based on demographic parameters to select individuals for cull. The advantage of such strategies is

> that they require only limited data and resources to implement. Our RANDOM culling strategy relied solely on demographic data (an individual's age and sex) to inform culls. At the end of 500 years, the RANDOM strategy yielded the lowest allelic richness, observed heterozygosity and *GD* [gene diversity], as well as the highest average inbreeding of the three tested culling strategies (Table 2). Further, the RANDOM, as well as the MAF [Mean Allele Frequency], culling strategies exhibited high variance in measures of genetic variation across iterations, indicating less predictability in the outcome of these strategies and potentially important impacts on population persistence. These results indicate that although demographically based removal strategies can be easy to implement and effective at maintaining sex and age ratios, incorporating genetic data into culling decisions improves a population's long-term retention of genetic variation and thus, its adaptive potential.

Giglio et al. 2016 at 386.

> Our results suggest wildlife management strategies that incorporate goals for retaining genetic variation are better suited to preserving the evolutionary potential of wildlife populations than those that focus solely on a target size and demographic stability. Declines in genetic variation not only limit the evolutionary potential of a population, but can also have direct and immediate effects on factors such as the response to diseases and new pathogens (O'Brien & Evermann, 1988). For these reasons, bison are an exemplary example of a species in need of genetic management. Bison, as a species, underwent a severe bottleneck in the late 1800s, and were further bottlenecked as conservation herds were founded with few individuals. Thus, all contemporary bison populations can be assumed to have accumulated some level of inbreeding, with Hedrick (2009) estimating 0.367 inbreeding (equal to two generations of full sibling matings) in the Texas State Bison Herd. Although the direct effects of inbreeding in bison are unclear, even small amounts of inbreeding have been correlated with the susceptibility to bacterial disease in other wildlife populations (Acevedo-Whitehouse *et al*., 2003). Historical erosion of genetic variation due to severe bottlenecks, serial founding events, and current levels of inbreeding make the preservation of remaining genetic variation through effective management strategies even more imperative to the persistence of bison.

Giglio et al. 2016 at 387–388.

While not recommended here, pedigree based management would have to overcome the logistical difficulties of non-intrusively acquiring genetic data from all individuals regularly, and consistently taking each individual based on kinship, making it an unlikely strategy for a wild bison population. Nonetheless, it is informative in comparison to other management strategies attempting to retain genetic variation in bison conservation herds including Yellowstone bison.

For example, the U.S. Fish & Wildlife Service is using an allele frequency strategy for managing six bison conservation herds on National Wildlife Refuges "with the goal of keeping at least a few individuals that represent each element of genetic variation. Other bison management entities such as the National Park Service often use random culling or slight variations thereof." Toldness 2014 at ii.

Toldness developed an "individual-based model" to compare management strategies using mean allele frequency (MAF) by removing bison with more common alleles and retaining bison with more rare alleles, random removal of young based on sex and age classes, and the zoo-biology developed strategy of removing bison based on kinship or pedigree with highly related bison removed and bison with low relatedness retained. Toldness 2014 at ii, 7–11.

> The model was parameterized using existing long-term demographic and genetic data from the herd located in the Fort Niobrara NWR, Nebraska. Models were run at 100, 200, and 500 year marks. Variation among iterations was greatest within the 'random removal of young' culling strategy. This model was outperformed by the 'pedigree-based' and 'MAF' culling strategy across summary statistics (allelic richness, gene diversity, inbreeding, and heterozygosity). A trade off was observed between the 'pedigree-based' strategy and the 'MAF' culling strategies in that the MAF culling strategy performed the best in regards to retaining the highest allelic richness . . . and observed heterozygosity . . . and the pedigree-based culling strategy retained the most gene diversity . . . and maintained the lowest amount of inbreeding . . .

Toldness 2014 at ii–iii.

> As habitats are increasingly altered and wildlife populations impacted by human activities, more species are being actively managed to assure their persistence (Baker et al. 2011). These increased threats to wildlife populations also are changing the intensity at which we manage wildlife. Many wildlife species are no longer self-sustaining, and require regular, intensive management at the individual or population level to prevent extinction (e.g, strict harvest regulations or moratoria, anti-poaching efforts, predator removal, culling, routine demographic monitoring, individual-based health care or disease management).
>
> One consequence of intensive management is that populations are often managed in small, isolated populations, due to factors such as limited availability of habitat or resources. This, in turn, makes them more susceptible to evolutionary processes, such as genetic drift, that erode genetic variation over time (Wright 1931, Allendorf and Luikart 2007). . . Preserving genetic variation is a main priority for conservation to maintain long-term population viability (McNeely et al. 1990; Lacy 1997) by providing the raw material for a population to adapt and survive in changing conditions (Allendorf & Luikart 2007; Markert et al. 2010). This correlation between genetic variation and adaptability of a population has been demonstrated in populations exposed to selective pressures such as environmental stress (Frankham et al. 1999), parasite communities (Paterson et al. 1998), as well as artificial selection (Robertson 1960; James 1971).

Toldness 2014 at 1–2.

> Of the three culling strategies, the random removal of young strategy preserved the fewest alleles, as measured by allelic richness (Table 2). This difference was already evident after the 100-year time step. This strategy also ended with the lowest heterozygosity, lowest gene diversity, and highest inbreeding coefficient across all time steps (Table 2). After 500 years, the random removal of young culling strategy resulted in an average decrease of 34.3% in allelic richness, 7.4% in heterozygosity, 18.7% in gene diversity, and an increase of

inbreeding to 0.184 (Table 4, Figure 5).

> The MAF culling strategy retained more genetic variation than the random removal of young strategy at all genetic variation measures. Allelic richness decreased by 4.5% and gene diversity decreased by 16.3% over 500 years (Table 4, Figure 5). The MAF strategy resulted in an increase in heterozygosity relative to the founding population; over 500 years heterozygosity increased by 32.3% (Table 4, Figure 5). Inbreeding increased over time in the MAF strategy, rising to 0.160 over 500 years (Table 4, Figure 5).
>
> The pedigree-based strategy retained the most genetic variation in terms of gene diversity retention (10.2% decrease) and accumulated the least inbreeding (0.099) over 500 years (Table 2). It performed second to the MAF strategy in retention of allelic richness (decrease of 22.5%) and heterozygosity (increase of 2.5%) (Table 4, Figure 5).

Toldness 2014 at 18–19.

Significantly, "a reduction in allelic richness and gene diversity was observed for all culling strategies from the founding population" and "an increase in inbreeding from the founding population from each time step with varying rates of accumulation . . ." Toldness 2014 at 17–18.

Management actions resulting in increased inbreeding "not only reduces genome-wide variation but also could lead to detrimental fitness effects (Charlesworth and Charlesworth 1999). Although Hedrick and Miller (1994) characterized reductions in genetic variation and fitness associated with selection for variation at a functional locus, similar patterns might be expected when selecting for variation at neutral loci, particularly if the effects of genetic drift are strong (Charlesworth and Guttman 1996; Hey 1999; Otto 2000)." Toldness 2014 at 24.

PHOTO: BFC Archives

In addition, selection for variation only reflects retention of a subset of bison genes, the fate of the other genes "across the genome is unknown." Toldness 2014 at 24.

All of the developed models to retain genetic variation have drawbacks and deficiencies, namely, as is the case in Yellowstone, they do not mirror real management actions year-to-year, decade-to-decade, or generation-to-generation for long periods of time, and vary in the degree to which they measure actual effects from management actions.

The assumptions incorporated into models may or may not mirror actual demographic and population structures of bison herds, fitness in females and males, and actual variation data of each contributing female and male to reproduction of offspring. Each model, the assumptions, data, and value set, must therefore be critically examined using precautionary principles grounded in conservation biology.

The near extermination of bison from millions of individuals to less than 1,000 "represents a genetic bottleneck of epic proportions." Gross & Wang 2005 at 4.

Gross & Wang developed an individual-based model "of bison herds inhabiting National Park Service (NPS) units to evaluate the consequences of management actions on retention of genetic diversity." Gross & Wang 2005 at 3 (Gross & Wang's 2005 final report is used here as the 2006 revised final report with several new authors is a carbon copy save the deleted Figures 1–10 found at 19–25).

> We examined the effects of removal of bison that were young, old, or a random selection of ages, and removals that contained a high proportion of cow-calf groups (24% or 50% of animals removed). We also evaluated the effects of using contraceptives applied to young, old, or a random selection of breeding-age cows. Over the 200-year period of the simulations, herd size accounted for more variation in retention of $H_0$ [heterozygosity] and loss of alleles than any other factor. Based on Monte Carlo analysis of 500 replicate simulations, bison herds with more than 400 animals generally met the objective of achieving a 90% probability of retaining 90% of the herd's $H_0$ for 200 years. Differences in generation time accounted for about 75% of the variation in retention of $H_0$ in herds of 200–800 bison. When allelic diversity was used as the key criterion for evaluating management alternatives, a population size of about 1000 animals was needed to achieve a 90% probability of retaining 90% of alleles. . . . Population control strategies had huge effects on the age and sex composition of bison herds.

Gross & Wang 2005 at 3.

"Data on breeding rates by bulls are extremely limited and we thus developed parameter estimates from available literature and interviews with bison herd managers. . . . Data on other factors that may influence lifetime breeding success of bison bulls, such as size, social status, mating group size, etc., are poorly documented and were not included in the model." Gross & Wang 2005 at 5.

"Because there was considerable uncertainty in estimates of bison vital rates, we conducted a sensitivity analysis to evaluate the potential influence of variation in vital rates on simulation results." Gross & Wang 2005 at 6.

> There are currently no quantitative NPS or US Fish and Wildlife Service management objectives for conserving genetic diversity. Gross (2000) used a goal to achieve a 90% probability of maintaining 90% of the selectively neutral genetic variation for 200 years, following recommendations by Soule *et al*. (1986). This goal is consistent with U.S. Bureau of Land Management operational guidelines for wild horse management (Coates-Markle 2000) and we used it as the default evaluation criterion.
>
> . . .
>
> Eight population size objectives were examined: 200, 300, 400, 500, 600, 700, 1000, and 2000 bison. These population objective treatments were crossed with population control treatments (removal or contraceptive) and with age-specific treatments.

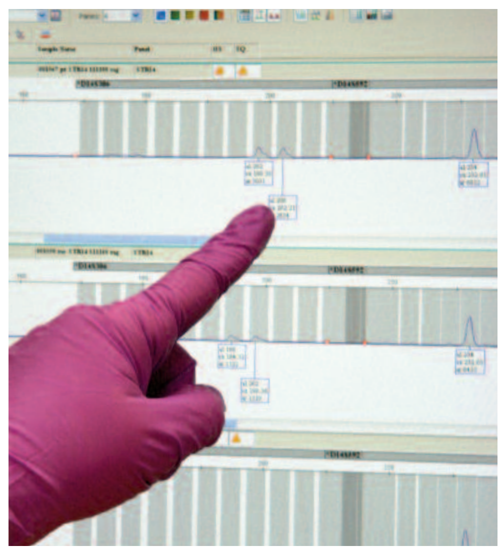
. . .

> We used data from Halbert (2003) for initial allele frequencies at the 51 autosomal loci simulated in these model experiments. Halbert (2003: 38) reported two to 11 microsatellite alleles per locus, with a total of 350 alleles. . . . We created initial populations that matched population size targets (200-2000 individuals). Observed heterozygosities in these initial populations were mostly within 1% of the values reported by Halbert and all were within 2%.
>
> . . .
>
> Of all National Park bison herds (Halbert 2003: 40), the YELL herd had the highest proportion of all alleles, the second highest $H_0$, and the most severe environmental conditions.

Gross & Wang 2005 at 7, 8.

Microsatellites are segments of DNA distributed throughout the genome in repeated sequences. DNA is the hereditary material found primarily in nuclear but also mitochondrial cells. Microsatellites are used as a marker in determining genetic diversity and identifying important genetic traits. By looking at microsatellite variation, inferences can be made about population structures and differences, genetic drift, genetic bottlenecks, and even the date of a last common ancestor.

PHOTO: Roger Parchen



Microsatellites in Yellowstone bison average approximately 5 alleles per locus. "Immune system genes (e.g., MHC) often have 20 or more alleles per locus in many species." Pérez-Figueroa et al. 2012 at 164 (a key region of the genome, MHC, the major histocompatibility complex, plays a crucial role in immune system function).

Heterozygosity is having different alleles at one or more corresponding chromosomal loci. *The Free Dictionary* (Farlex, Inc. 2022) (heterozygous: having two different alleles of the same gene).

Alleles are two or more genes occupying a given site (locus) on a chromosome which affect or determine a specific trait. *Britannica* (Encyclopaedia Britannica, Inc. 2021).

> [A] much larger population objective – on the order of 1000 bison (Figure 8) – is required to achieve a reasonable assurance of retaining 90% of currently existing alleles.
>
> . . .
>
> [W]e did not explicitly model non-random removal of extended matrilineal groups.
>
> Bison have been reported to naturally assemble into matriarchal groups including several

> generations of related females and calves (Seton 1937; Haines 1995). In YELL, where culling is primarily through opportunistic selection of bison groups as they exit park boundaries, Halbert (2003) estimated that 24% of the removals were cow-calf pairs, about 50% more cow-calf pairs than we estimated would be removed through a random selection of bison ($p < 0.05$). The extent of matrilineal group removal from YELL cannot be accurately determined given current limitations in bison sampling as they exit the park. The genetic consequences of non-random removal of matrilineal groups (3 or more generations) was not explicitly considered in this study and it merits further study, although results from simulations with very high levels of cow-calf removals suggest that the effects of matrilineal removals in YELL may be small. While the effect of removal of matrilineal groups from YELL has been most actively discussed, this may be a more important issue in parks where a significant proportion of the herd was traditionally harvested at the same location year after year.

Gross & Wang 2005 at 11–12 (acknowledging Halbert's (2003) estimate of female-calf loss is 50% more than their study's random selection of bison).

Recognition of subpopulation substructure is essential for conserving genetic variation because it reduces the effective population size of Yellowstone bison. Another way of expressing this risk is subpopulation structure requires larger census sizes for each herd to avoid inbreeding and maintain genetic diversity for the Yellowstone bison population to persist in the wild.

> The genetic subpopulation structure of the YELL bison population complicates accurate simulation modeling and the interpretation of the existing simulations. Meagher (1973) reported geographically distinct bison herds within YELL, but as the number of bison in YELL increased some of the herds merged (Taper et al. 2000). Recent radiotelemetry data indicated little interchange of bison between the northern and central herds (Edward Olexa, personal communication) and historical sightings indicated high densities of bison in several distinct areas of activity (Taper et al. 2000). Recent work revealed genetically distinguishable subpopulations in YELL (Halbert 2003) and cluster analysis of this data (Pritchard et al. 2000) revealed at least 2, and most likely 3, genetically distinguishable subpopulations among those YELL bison sampled (Halbert 2003). Furthermore, statistically significant genetic differentiation between bison collected in different locals (West Yellowstone vs. Gardiner) were observed for between 65 and 78% of the markers analyzed, a result also indicative of subpopulation structure (Halbert 2003). Subpopulation structure serves to reduce $N_e$ from that estimated by the overall population size, and the rate of interchange will need to be considered in the long-term genetic management of YELL bison.
>
> At present, data from YELL are inadequate to accurately estimate rates of genetic interchange between herds, particularly as the total number of bison in YELL varies from 2500 to more than 4000. However, it appears that animal movements between herds are relatively rare (E. Olexa, personal communication), and thus model results should be interpreted as representing a single herd unit (e.g., the northern range herd unit or West Yellowstone). A more complex simulation analysis will be necessary to fully assess the long-

> term genetic consequences of subpopulation structure and interchange, and non-random removal of matrilineal groups.

Gross & Wang 2005 at 12 (acknowledging their model results should be interpreted for each distinct herd in the Yellowstone bison population).

The unknown rate of actual variance in male reproductive success over meaningful time scales confounds any forecast for retaining subpopulation structure and genetic diversity in the Yellowstone bison population.

> Any interpretation of simulation model results must consider the quality of the data used to drive the model, the assumptions on which the model is founded, and the sensitivity of model results to uncertainty in model inputs and assumptions. Sensitivity analyses showed that our model results were relatively insensitive to realistic variation in vital rates, initial population structure, and initial genetic composition of herds. In this model, sensitivity analysis showed that a potentially realistic variation in male breeding success could significantly affect results, primarily in populations with fewer than about 600 animals. We identified complicated interactions between variation in male breeding success, population control strategy, and target population size. In general, greater levels of variation in male breeding success affected treatments that removed old animals to a greater extent than those that removed young. There are extremely few reliable data available to estimate variation in lifetime breeding success of bison, or for that matter, any other large ungulate (Wilson et al. 2002; McEligott and Hayden 2000; Roed et al. 2002; Coltman et al. 1999). The reliability of simulation model predictions for some treatments could be significantly increased by incorporating data on paternity analysis based on genetic samples from herds of interest. At present, there are no data from bison herds that can be used to estimate how herd size, sex ratio, habitat characteristics (e.g., open vs closed), age structure, or other factors influence variation in male success. The absence of this information constrains our ability to realistically forecast the effect of population control measures on retention of genetic diversity.
>
> . . .
>
> Because there are inherent uncertainties in model assumptions, input data, and our ability to properly interpret model results, the most appropriate use of these results is to support general recommendations on management of NPS bison units. Management actions can be simulated with a much higher degree of precision than they can be implemented under field conditions.

Gross & Wang 2005 at 14 (acknowledging significant gaps in data constrains a "realistic forecast" of how actual management action affects retention or loss of bison genetic diversity).

> Given these caveats, there are several clear conclusions:
> 1. For small bison herds (say, fewer than 500 animals), removal or contraception of young animals can significantly enhance retention of genetic variation. Other treatments that significantly increase generation time will yield similar results.
> 2. Bison herds with fewer than about 400 animals are unlikely to meet a long-term goal of achieving a 90% probability of retaining 90% of genetic heterozygosity for 200 years.

3. A moderate bison population size – about 1000 animals – is necessary to meet a long-term goal of achieving a 90% probability of retaining 90% of allelic diversity for 200 years.
4. Goals described in 2 & 3 can be achieved with much smaller herd sizes if animals can be moved between herds. Development and evaluation of a set of realistic management strategies that involves transferring animals between herds requires knowledge of individual herd characteristics, including genetic composition and disease status, and a clear statement of management objectives. A similar result might be obtained by other treatments not identified or evaluated by this study (e.g., preserving and reintroducing sperm or eggs).
5. In particular, the absence of reliable data on and understanding of variation in male lifetime reproductive success is a constraint to developing more specific management recommendations.

Gross & Wang 2005 at 14–15.

> Our simulations assumed that individual bison in herds mixed randomly and that herds were relatively homogeneous. Population substructures can result in reduced rates of genetic recombination and in non-random harvest of animals. Results in this report are thus more appropriately applied, for example, to the YELL northern range herd or the YELL central herd, rather than to the entire YELL bison population. Similarly, spatial structuring in a park like BADL may lead to highly non-random removals, thereby increasing the loss of genetic diversity relative to these simulations.

Gross & Wang 2005 at 34.

Yellowstone bison's vital rates for reproductive success is unknown.

A more recent model of Yellowstone bison genetic diversity is not based on known vital rates, and Pérez-Figueroa's (2012) study contains several limitations and qualifications including the lack of actual empirical data to determine retention of genetic diversity, and thus ensure bison population viability under current management regimes.

Among the assumptions, limits, and qualifications the authors identified include:

- Yellowstone bison is one deme (an interbreeding group within a larger population).
- Actual male reproductive success in bison is unknown (four scenarios were used).
- DNA-based paternity analysis was not used (the data is not being collected).
- Selection and mutation were not included.
- Actual levels of allelic diversity could be even higher than those obtained in the model's simulations (mutation was not considered; selection could enhance genetic diversity in isolated ungulate populations).
- Culling was random among all age classes or random within age groups.
- Culling was conducted whenever population size exceeded a threshold value of 4500 or 3500 depending on the scenario.
- Individuals were culled until the target population size (2500 or 3000) was reached (loss of family group lineages was not considered).

Pérez-Figueroa et al. 2012 at 165, 161, 164.

Furthermore, the authors "did not consider high variance in female reproductive success or heritability of fitness, both of which could increase the rate of loss of variation (heterozygosity) by perhaps 10-20% (Ryman et al., 1981)." Pérez-Figueroa et al. 2012 at 165.

PHOTO: Gail Tucker

Allelic diversity influences Yellowstone bison's long-term adaptive potential and resistance to disease, among other fitness traits and characteristics. From an adaptive perspective, the limit to natural selection "is determined by the initial number of alleles (Hill and Rasbash, 1986)." Pérez-Figueroa et al. 2012 at 164.

Prudence and precaution must be exercised in conserving bison for future generations because geneticists "know very, very little about which alleles are associated with what traits of bison, or about how alleles interact to determine bison characteristics." Bailey 2013 at 81.

Heterozygosity ($H_e$) is a measure of Yellowstone bison's genetic variation. Heterozygosity influences the effective population size, and adaptability of Yellowstone bison to environmental change.

The lack of empirical data from immune system genes complicated the model's estimation and understanding of the loss of allelic diversity and the adaptive genes found at such loci in Yellowstone bison. Pérez-Figueroa et al. 2012 at 165.

The DNA that influences bison's "ability to detect and resist disease organisms is exceptionally diverse but contains very many rare alleles that are most susceptible to loss." Bailey 2013 at 80.

> Loss of genetic variation through genetic drift can reduce population viability. However, relatively little is known about loss of variation caused by the combination of fluctuating population size and variance in reproductive success in age structured populations.
>
> . . .
>
> Relatively little is known about $N_e$ [effective population size] and rates of loss of allelic diversity (*AD*) resulting from the combined effects of age structure, mating system variation (e.g., high variance in male reproductive success resulting from a dominance hierarchy), and fluctuations in population census size ($N_c$) caused by culling or hunting (Ryman et al., 1981; Harris and Allendorf, 1989; Frankham, 1995; Jorde and Ryman, 1995; Waples and Yokota, 2007).

Pérez-Figueroa et al. 2012 at 159.

> However, the population is geographically isolated and likely has moderate or high variance in reproductive success, as in many ungulates (Hogg et al., 2006; Ortego et al., 2011) due to a polygamous mating system and a dominance hierarchy in which a limited proportion of males breed most of the females and which could lead to relatively rapid loss of genetic variation.
>
> . . .
>
> We used computer simulations of an individual-based model of age structured bison populations to assess the potential effects of variance in male reproductive success (VMRS), amount of initial genetic variation, and fluctuating population size on $N_e$, loss of $H_e$, and loss of *AD* over a 100–200 year period.
>
> . . .
>
> Little is known about male reproductive success in bison. Lott (1979) suggested that 33% of males produce 66% of offspring. Berger and Cunningham (1994) reported that 10% of males produce 50% of offspring. Halbert et al. (2004) reported that 10% of males produce 40% of offspring. However, these studies were largely based on behavioural observations rather than DNA-base paternity analysis which gives the true paternity and variance in male reproductive success.
>
> . . .
>
> A polygamous mating system can reduce or eliminate the genetic contribution of many males and thereby increase VMRS which in turn can rapidly reduce genetic variation in a population (e.g., Kaeuffer et al., 2004). Due to the uncertainty of VMRS in a large population of wild bison, we tested a broad range of VMRS values. The most likely male mating scenario for Yellowstone bison is the moderate or high VMRS that we used for simulations.
>
> . . .
>
> In our simulations, VMRS was the factor with the strongest influence on $N_e$ and the loss of variation, when VMRS was high to extreme. Thus, future research could improve understanding of loss of variation by providing estimates of VMRS through paternity analyses in bison populations. We did not consider high variance in female reproductive success or heritability of fitness, both of which could increase the rate of loss of variation (heterozygosity) by perhaps 10–20% (Ryman et al., 1981).

Pérez-Figueroa et al. 2012 at 160, 161, 164.

Even with all of the model's assumptions and lack of empirical data, conserving more than 95% of loci with more than 5 alleles requires the maintenance of a population size greater than 3,250 bison and the killing of mainly or only juveniles. Pérez-Figueroa et al. 2012 at 159.

Managing Yellowstone bison for a loss in allelic diversity is managing for the wild population's extinction.

The genetic wellspring for bison was damaged from the bottlenecks and few founders left after the wild species was driven to near extinction. It ignores 120 years of isolation and the foreseeable loss of natural interchange with any other wild self-sustaining bison population, if any remain. It ignores the consequences of scientists discovering cattle genes — including near bison's major histocompatibility complex — in all seven founding bison lineages. There is no genetic rescue coming from other bison populations hovering far below conservation biology thresholds to avoid inbreeding. Conserving and safeguarding the evolutionary legacy of wild Yellowstone bison cannot happen through a pinhole of natural selection in a fragment of their indigenous range.

The point of diving into the details in each of the aforementioned studies is to draw attention to the insecurity and risk of extinction Yellowstone bison are facing under current management which is driven by too many unknown variables, unproven assumptions, and the lack of empirical data monitoring management's effects on each distinct subpopulation and the population as a whole.

Crucial biological evidence about Yellowstone bison is not being examined for publication.

Population modeling studies appear biased to meet State and federal manager's expectations and assumptions.

Important scientific findings on the structure and genetic constitution of Yellowstone bison are ignored altogether.

The U.S. Fish & Wildlife Service must be cognizant of, examine, and investigate these factors in the agency's threats assessment and status review.

Without a significant course correction, current management is risking extinction for the country's only wild bison roaming their indigenous range in the 48 contiguous States: the distinct population segment of Yellowstone bison.

The United States and the respective States of Montana, Idaho, and Wyoming are duty bound to honor, protect, and restore the remnant population of wild Yellowstone bison remaining in their indigenous range.

## 9. Actions needed for protecting and restoring Yellowstone bison in the wild.

***Protections and provisions for restoring wild Yellowstone bison in the ecosystem and bioregion.***

Protections and provisions for restoring wild Yellowstone bison must incorporate the biological principles of resiliency, representation, and redundancy in the ecosystem the migratory species is an integral part of.

The inclusion of Indigenous leadership and inter-governmental cooperation with Indigenous tribes in developing and implementing habitat recovery plans is an indispensable part to naturally restoring wild Yellowstone bison in the bioregion.

Procuring the services of Indigenous scientists, wildlife biologists, traditionalists with ecological knowledge and insight from tribes with treaty rights and ancestral ties to Yellowstone bison is fundamental to the success of protecting and restoring the migratory species in the wild.

Tribes with treaty rights and ancestral ties to Yellowstone bison can and should have a federally funded role in:

1) developing site-specific actions for recovering wild Yellowstone bison herds;
2) establishing measurable criteria for recovering wild Yellowstone bison herds;
3) carrying out conservation measures and taking those steps necessary in achieving recovery of wild Yellowstone bison herds; and
4) effectively monitoring the recovery of wild Yellowstone bison herds in the bioregion.

***Honoring and recognizing the implied right of habitat for Yellowstone bison under Treaty right can and could restore Yellowstone bison where the wild species is now extinct due to State and federal government actions.***

In effectively addressing the inadequacy of existing regulatory mechanisms, honoring and recognizing the implied right of habitat protection for Yellowstone bison under Treaty right can and could help bring about the natural recovery of the migratory species in the ecosystem and bioregion where they are now extinct due to State and federal government actions and inadequate regulatory mechanisms.

PHOTO: BFC Archives

In doing so, an historical wrong could also begin to be mended for the numerous tribes who negotiated treaties with the U.S. government to fulfill rights providing sustenance for tribal families, for maintaining ancestral life ways, and preserving the cultural and religious relationships connected with the persistence of Yellowstone bison as a wild species.

For example, the treaty between the United States and the Nez Perce reserved to that tribe

> “the privilege of hunting, gathering roots and berries, and pasturing their horses and cattle upon open and unclaimed land.” *Id.* at 703. The treaty with the Nisqually and Puyallup reserved to those tribes “the privilege of hunting, gathering roots and berries, and pasturing their horses on open and unclaimed lands.” *Id.* at 662. Treaties with the Crow, *id*. at 1009, and Eastern Shoshone and Bannock Tribes, *id*. at 1021, reserved to those tribes “the right to hunt on the unoccupied lands of the United States so long as game may be found thereon.”

Nye 1992 at 175–176 n.4 (citing C. Kappler ed. 1972).

The U.S. Supreme Court found President Cleveland’s proclamation creating the Bighorn National Forest “reserved” the lands “from entry or settlement” making the Apsáalooke Nation’s (the Crow Tribe’s) exercise of the 1868 Treaty right to hunt on unoccupied lands “more hospitable, not less.” *Herrera v. Wyoming,* 139 S. Ct. 1686, 203 L. Ed. 2d 846, 2019 U.S. LEXIS 3538.

Treaty rights could provide a way for the States and federal government to affirm an implied right for protecting and expanding habitat for wild bison to freely roam the Greater Yellowstone bioregion.

> In a context where wild bison sorely need more habitat in order to thrive, tribes may have an opportunity to work toward this goal by asserting an affirmative right to habitat protection encompassed within their treaty hunting right. . . [A] negative right is essentially useless if a species’ habitat has already been largely destroyed, as in the case of wild bison.

Leonard 2014 at 18–19.

Leonard’s statement is true across bison’s North American range where the migratory species has been reduced to less than 1% of their habitat with few populations functioning as wild. Sanderson et al. 2008 at 252–253; Aune, Jørgensen, & Gates 2018 at 1.

However, 8,103,157 acres of National Forest habitat contiguous to Yellowstone National Park is found in every direction Yellowstone bison currently roam.

> Acres of National Forest on the Shoshone: 2,439,093
> Acres of National Forest on the Caribou-Targhee: 2,624,739
> Acres of National Forest on the Custer Gallatin: 3,039,325

Yellowstone National Park is 2,301,786 acres with approximately 784,560 acres of bison habitat, almost all of which is within the park. U.S. Forest Service 2015 (Table 3); Custer Gallatin National Forest Final Terrestrial Wildlife Report 2017 at 133.

While no self-sustaining wild bison herds exist on more than 145 million acres of National Forest habitat in the Western United States (U.S. Forest Service Warren 2011), vast public trust lands on National Forests and other unoccupied lands in the Greater Yellowstone bioregion present an opportunity for mitigating the inadequacy of regulatory mechanisms threatening or endangering Yellowstone bison in the wild.

Whether grounded in law or treaty, the government has a duty to restore the abundance and diversity of Yellowstone’s bison herds in the wild commensurate with its’ agency and culpability in destroying bison inside Yellowstone National Park, and excluding the migratory species from substantial portions of their

National Forest range and habitat, and other National public trust lands.

> To hold now that "the game may no longer be found" where the buffalo have been intentionally exterminated would absolve the government of fault while allowing roundabout abrogation by extracongressional action.

Cole 2021 at 1089 (inferring a similar situation for buffalo and salmon exists where the courts found the government culpable for infringing on tribes' treaty-protected fishing rights for blocking salmon from their spawning grounds).

> United States v. Washington (*Culverts Case*), 853 F.3d 946, 954 (9th Cir. 2017) (affirming the district court's holding "that in building and maintaining these culverts Washington had caused the size of salmon runs in the Case Area to diminish and that Washington thereby violated its obligation under the Treaties"), *aff'd mem. by an equally divided court*, 138 S. Ct. 1832 (2018).

Cole 2021 at 1088 n.234.

Currently, State and federal law and policy stands in the way of recovering Yellowstone bison and in restoring the wild species' abundance and distribution on National Forest habitat contiguous with Yellowstone National Park.

> Together the agencies tightly manage the Yellowstone bison herd and its access to potential habitat outside the park.
>
> In practice, for the most part, this has meant that Yellowstone bison have extremely limited access to habitat outside the park. The current implementation protocols for the IBMP [Interagency Bison Management Plan] require bison to be removed from their winter habitat in Montana each year in mid-spring, before they would naturally migrate back into the park. This removal is accomplished by hazing the bison herds with helicopters, ATVs, riders on horseback, and sometimes snowmobiles. The result is that bison have no year-round habitat, or even habitat that they can use on a cycle consistent with their natural migration patterns, outside Yellowstone National Park. And in years when the numbers of bison that leave the park are too great to manage, state and federal agencies routinely capture bison and often ship them to slaughter facilities, sending the meat to Native tribes and food banks. Not only does this management scheme deprive the Yellowstone bison herd of access to habitat; keeping the herd geographically and numerically confined also limits tribes' access to culturally important and treaty-guaranteed hunting opportunities. It also costs taxpayers $2 million annually in bison capture, hazing, and other management costs.

Leonard 2014 at 20–21.

A similar framework for intergovernmental collaboration already exists in the National Park Service recognizing the Nez Perce Tribe and Confederated Salish & Kootenai Tribes as cooperators in the development of a bison management plan for Yellowstone National Park. Stark et al. 2022 at 439.
In addition, while underfunded and often overlooked, tribal wildlife biologists, wildlife and game officials, in

tandem with tribal councils, currently regulate treaty hunts of Yellowstone bison on National Forest lands within the confines of State and federal imposed boundaries.

In order to avoid conflict and effectively address local concerns, such an endeavor would require substantive input from local communities, ample opportunity for public meetings and comments in a transparent and collaborative process, and involvement of tribal, federal, and State wildlife biologists, scientists, and people with traditional knowledge of bison.

If the States are unwilling or uncooperative in restoring wild Yellowstone bison on National Forest lands, "Indian treaty provisions supersede conflicting state laws or state constitutional provisions," under the U.S. Constitution's Supremacy Clause. Nye 1992 at 178 (footnote omitted).

Furthermore, the National Park System, National Forest System, along with other federal land management agencies with wildlife-specific powers "have an obligation, and not just the discretion, to manage and conserve fish and wildlife on federal lands," and can and must "stop the practice of reflexively acquiescing to state claims of wildlife authority." Nie et al. 2017 at 798, 905.

Designating Yellowstone bison as a federally protected threatened or endangered species could bypass the stranglehold the States have asserted over the migratory species.

The Montana Wyoming Tribal Leaders Council (2012) have unequivocally asked managing authorities to recognize "the trust responsibility and Treaty obligations to American Indian Nations in providing for viable populations of migratory buffalo in their native habitat."

The Shoshone-Bannock Tribes have also articulated their concern "to protect, preserve, and enhance populations of wild bison" amidst the "geo-political boundaries preventing them from occupying much of their historic range throughout the Greater Yellowstone Ecosystem." Fort Hall Business Council 2012.

PHOTO: The Great Omaha pow-wow dance of the Cheyennes in Montana / Wiley Bros., photographers, successors to L.A. Huffman, Miles City, Montana, circa 1891.

As it stands, the U.S. government owes a duty to uphold its' trust responsibility and treaty relationship with Indigenous tribes and must fulfill its' public trust duty to the American people in protecting and recovering threatened and endangered species.

Ideally, cooperation from the States would speed recovery of Yellowstone bison in the wild but it is not a prerequisite according to several courts including the U.S. Supreme Court.

"In our view, the 'complete power' that Congress has over public lands necessarily includes the power to regulate and protect the wildlife living there." *Kleppe v. New Mexico*, 426 U.S. 529, 541 (1976).

Within their jurisdictions, the States are entrusted to care for and protect wild animals but the States' police powers exist only "in so far as (their) exercise may be not incompatible with, or restrained by, the rights conveyed to the federal government by the constitution." *Kleppe* at 545 (quoting *Geer v. Connecticut*, 161 U.S. 519, 528 (1896)).

In addition to the U.S. Supreme Court, other federal courts have affirmed federal wildlife management authority for National public trust land management agencies.

> [T]he Tenth Amendment does not reserve to the State of Wyoming the right to manage wildlife . . . regardless of the circumstances.

*Wyoming v. United States*, 279 F.3d 1214, 1227 (10th Cir. 2002).

> Under the public trust doctrine, the State of Virginia and the United States have the right and the duty to protect and preserve the public's interest in natural wildlife resources. Such right does not derive from ownership of the resources but from a duty owing to the people.

*In re Steuart Transp. Co.*, 495 F. Supp. 38, 40 (E.D. Va. 1980) (citation omitted).

***Creating refuges, safe harbors, and reintroducing fire can help build resiliency, expand representation, and provide redundancy for Yellowstone bison to adapt in the ecosystem the migratory species is an integral part of.***

The keystone grassland and climate species known as the Yellowstone bison have much and more to offer in restoring native species diversity in the ecosystem they are an integral part of.

In accord with Tribes, creating refuges and safe harbors — where none currently exist — on National Forest lands could allow Yellowstone bison to retain and transmit the culture and knowledge learned in their natural migrations to future generations.

PHOTO: Darrell Geist

Reintroducing fire in Yellowstone bison's migration corridors and pathways could lead them to available habitats and thereby avoid conflicts while restoring bison's keystone ecological roles in the ecosystem.

According to a U.S. Forest Service Fire Effects Information System study, "[f]ire is important in creating and maintaining American bison habitat. Fire regenerates grasslands and enhances production, availability and palatability of many American bison forage species." Tesky 1995 at 7 (endnotes omitted).

Because Yellowstone bison are attracted to burned sites, reintroducing fire can facilitate seed dispersal, maintain sedge-grasslands (an important winter habitat), reduce forest fuel loads and generate firebreaks. Tesky 1995 at 6, 9, 7.

Together, creating safe places for Yellowstone bison to freely roam and reintroducing fire are sound provisions for restoring the migratory species and their keystone ecological roles in the native ecosystem they are an integral part of.

***Creating wildlife safe passage infrastructure would increase habitat connectivity, prevent and reduce wildlife-vehicle collisions, and help local communities working to improve road safety and preserve native wildlife.***

As Yellowstone bison naturally recover in the ecosystem, creating infrastructure for the safe passage of wildlife across highways would increase habitat connectivity to seasonal ranges, help prevent and reduce wildlife-vehicle collisions, and provide assistance to local communities working to address these issues. Huijser et al. 2021.

Based on the frequency and number of ongoing accidents involving vehicles colliding with bison crossing roads (Dupree & DiMambro 2023), there is a need for designing, demonstrating, and constructing wildlife safe passage infrastructure on highways 191, 287, 20, and 89 in Montana.

The Western Transportation Institute (Ament 2022) is recording data of wildlife killed or crossing roads for geo-spatial analysis, and identifying hazardous locations. The data provides a basis for prioritizing, developing, and implementing solutions addressing vehicular safety and promoting safe passages for wildlife across highways.

Leadership action, and the acquisition of funding is necessary for implementing cost-effective solutions to increase habitat connectivity for wildlife species like Yellowstone bison, and prevent and reduce wildlife vehicle collisions in the region while providing assistance to local communities working to improve road safety and preserve native wildlife.

PHOTO: BFC Archives

**10. Independent scientific research needed to honor, protect, and restore wild Yellowstone bison in the ecosystem on which they depend for survival.**

Gardipee (2007) and Gardipee et al. (2008) developed feasible field sampling methods, and Forgacs et al. (2019) refined the ability to non-intrusively collect and analyze fecal DNA in Yellowstone bison yielding consistent and reliable results.

Because of observed and recorded harmful effects, handling and drugging of wild bison can and should be avoided.

There is a scientific need for funding non-intrusive, non-invasive independent research, collection of empirical data, and biological studies to support the conservation and recovery of Yellowstone bison in the wild including:

- Researching bison genetic diversity.
- Examining genetic diversity through long-term, random sampling and monitoring of bison subpopulations and the population as a whole.
- Examining the extent of introgression of cattle DNA in bison, in particular the major histocompatibility complex, and effects on bison's fitness.
- Conducting population viability analyses to determine long-term (centuries) persistence and diversity of bison in the wild.
- Investigating eliminating barriers to bison migrations and facilitating connectivity to habitats.

PHOTO: Joanne Murray

• Studying how bison migrations developed and are maintained for the foreseeable future.
• Piloting projects reintroducing fire in fire-adapted habitats to regenerate bison range and forage throughout the Yellowstone ecosystem and bioregion.
• Researching the ecological keystone roles bison fulfill in the ecosystem.
• Examining the effects, extent and rate of nonnative and invasive plant species on the quality and quantity of native forage available in the Yellowstone ecosystem.
• Examining the harmful effects of displacing bison from their range and habitat and the ecological benefits lost in the Yellowstone ecosystem.
• Studying long-term effects of frequent, recurrent, large-scale, non-random slaughter of bison.
• Examining the effects and consequences of artificially selecting against disease resistance and nonrandom slaughter of bison.
• Investigating the extent and rate of loss of genetic variation under current management practices; comparing variation in the bison fossil record with current variation.
• Investigating the extent and rate of loss in bison family groups (generational parent-offspring) and genetic lineages for each subpopulation under current management practices.
• Examining the extent and rate of loss in natural selection for disease resistant bison under current management practices.
• Studying DNA based paternity analysis in a migratory bison population with a genetically distinct subpopulation substructure.
• Investigating behavioral and genetic data on the actual variance in male reproductive success and female selection of mates.
• Studying the ecological and biological impact of hazing (harassing) and excluding bison from their migratory range, the relationships between bison and the quality, quantity, and nutritional value of forage.
• Studying how management actions such as vaccination and selection against disease, influence and modify the evolution of disease organisms and resistance in bison.

**11. The movement for restoring bison to their indigenous range on tribal homelands.**

This section is presented in brief to draw attention to one of many Indigenous-led movements underway to restore buffalo to their indigenous range on tribal homelands.

The signing of The Buffalo: A Treaty of Cooperation, Renewal, and Restoration in 2014 embodies the profound resolve and self-determination of Indigenous tribes and peoples in cooperating to restore buffalo, a relative, to their ancestral range, and renew and revitalize a cultural and spiritual relationship held since time immemorial.

THE BUFFALO: A TREATY OF COOPERATION, RENEWAL AND RESTORATION

2014

RELATIONSHIP TO BUFFALO

Since time immemorial, hundreds of generations of the first peoples of the FIRST NATIONS of North America have come and gone since before and after the melting of the glaciers that covered North America. For all those generations BUFFALO has been our relative. BUFFALO is part of us and WE are part of BUFFALO culturally, materially, and spiritually. Our on-going relationship is so close and so embodied in us that BUFFALO is the essence of our holistic eco-cultural life-ways.

PURPOSE AND OBJECTIVE OF THE TREATY

To honor, recognize, and revitalize the time immemorial relationship we have with BUFFALO, it is the collective intention of WE, the undersigned NATIONS, to welcome BUFFALO to once again live among us as CREATOR intended by doing everything within our means so WE and BUFFALO will once again live together to nurture each other culturally and spiritually. It is our collective intention to recognize BUFFALO as a wild free-ranging animal and as an important part of the ecological system; to provide a safe space and environment across our historic homelands, on both sides of the United States and the Canadian border, so together WE can have our brother, the BUFFALO, lead us in nurturing our land, plants and other animals to once again realize THE BUFFALO WAYS for our future generations.

PARTIES TO THE TREATY

WE, the undersigned, include but not limited to BLACKFEET NATION, BLOOD TRIBE, SIKSIKA NATION, PIIKANI NATION, THE ASSINIBOINE AND GROS VENTRE TRIBES OF FORT BELNAP INDIAN RESERVATION, THE ASSINIBOINE AND SIOUX TRIBES OF FORT PECK INDIAN RESERVATION, THE SALISH AND KOOTENAI TRIBES OF THE CONFEDERATED SALISH AND KOOTENAI INDIAN RESERVATION, TSUU T'INA NATION along with other nations.

ARTICLE I - CONSERVATION

Recognizing BUFFALO as a practitioner of conservation, We, collectively, agree to: perpetuate conservation by respecting the interrelationships between us and 'all our relations' including animals, plants, and mother earth; to perpetuate and continue our spiritual ceremonies, sacred societies, sacred languages, and sacred bundles to perpetuate and practice as a means to embody the thoughts and beliefs of ecological balance.

ARTICLE II - CULTURE

Realizing BUFFALO Ways as a foundation of our ways of life, We, collectively, agree to perpetuate all aspects of our respective cultures related to BUFFALO including customs, practices, harvesting, beliefs, songs, and ceremonies.

ARTICLE III - ECONOMICS

Recognizing BUFFALO as the centerpiece of our traditional and modern economies, We, collectively, agree to perpetuate economic development revolving around BUFFALO in an environmentally responsible manner including food, crafts, eco-tourism, and other beneficial by-products arising out of BUFFALO's gifts to us.

ARTICLE IV - HEALTH

Taking into consideration all the social and health benefits of BUFFALO ecology, We, collectively, agree to perpetuate the health benefits of BUFFALO.

ARTICLE V - EDUCATION

Recognizing and continuing to embody all the teachings we have received from Buffalo, We, collectively, agree to develop programs revolving around BUFFALO as a means of transferring intergenerational knowledge to the younger and future generations and sharing knowledge amongst our respective NATIONS.

ARTICLE VI - RESEARCH

Realizing that learning is a life-long process, We, collectively, agree to perpetuate knowledge-gathering and knowledge-sharing according to our customs and inherent authorities revolving around BUFFALO that do not violate our traditional ethical standards as a means to expand our knowledge base regarding the environment, wildlife, plant life, water, and the role BUFFALO played in the history, spiritual, economic, and social life of our NATIONS.

ARTICLE VII - ADHESIONS

North American Tribes and First Nations, and NATIONS, STATES, AND PROVINCES may become signatories to this treaty providing they agree to the terms of this treaty.

ARTICLE VIII – PARTNERSHIPS AND SUPPORTERS

WE, collectively, invited Non-Governmental organizations, Corporations and others of the business and commercial community, to form partnerships with the signatories to bring about the manifestation of the intent of this treaty. Organizations and Individuals may become signatories to this treaty as partners and supporters providing they perpetuate the spirit and intent of this treaty.

ARTICLE VIII - AMENDMENTS

This treaty may be amended from time-to-time by a simple majority of the signatories.

The Signatories (2020) expressly recognize the vital role of buffalo in the perpetuation of "spiritual ceremonies, sacred societies, sacred languages, and sacred bundles" and the ecological balance buffalo provide in restoring the foundation of Indigenous "customs, practices, harvesting, beliefs, songs, and ceremonies."

Reintroducing buffalo "to tribal lands is a fundamentally different process from cattle ranching or conservation of endangered species. The unique relationship between Native people and buffalo imbue this process with unique issues and concerns." Ecoffey 2009 at 125.

Ecoffey studied four buffalo herds run by an individual tribal member (1,000 hectares or 2,471 acres), a tribal family cooperative (700 hectares or 1,729 acres), a Tribal University (on several range units), and a Tribal Fish and Wildlife agency (530 hectares or 1,309 acres). Ecoffey 2009 at 34, 35.

The holistic Lakota worldview and understanding that buffalo are a relative connected with all aspects of life, *Mitakuye Oyasin,* "all my relatives," provides a framework for interpreting the interviewees efforts to restore buffalo to tribal lands. Ecoffey 2009 at 124.

PHOTO: BFC Archives

among the herd managers interviewed, the common theme Ecoffey found include taking a natural "hands-off" approach and respecting buffalo as a sacred species, a profound concern for the health and interactions of the land, animals, and people, a de-emphasis on the importance of economics and elevation of the importance of culture and life ways. Ecoffey 2009 at 117–124.

Ecoffey's four case studies of tribal-led reintroductions of buffalo to their ancestral homelands on reservations in South Dakota provide insight into the "deeper awareness and appreciation of the intersections between economics and community, science and culture, management, spirituality and the environment" and the "challenges, successes and unique perspectives of a diverse group of herd managers and contemporary Native leaders of tribal bison reintroduction." Ecoffey 2009 at 125–126.

The case studies offer a glimpse into numerous obstructions Indigenous peoples face and must overcome in successfully restoring buffalo: the affordability of land and access to leasing land, and imposing of stocking rates "dictated" by the Bureau of Indian Affairs. Ecoffey 2009 at 119, 122.

Indigenous communities must also overcome the privatization, loss, enclosure, and fragmentation of the tribal commons on reservation lands, among other obstacles to restoring buffalo to their indigenous range on tribal homelands.

> Communities with persistent poverty are less likely to possess the resources needed to prepare for the future and, therefore, are considered more vulnerable to climate change (Lal et al., 2011). This is true of rural Native American communities, where poverty is two to three times higher than in white rural communities (Harvey, 2017). Land dispossession and forced migrations of indigenous peoples have culminated in scattered tribal governed lands having increased climate vulnerability and offering diminished economic opportunities (Figure 1; Farrell et al., 2021).
>
> As of 2014, less than 50% of Native Americans from federally recognized Tribes were employed, and approximately 25% of Native American families earned incomes below the poverty line (U.S. Department of the Interior, 2014). Income disparities are particularly pronounced in Northern Great Plains tribal communities, where income is 20–40% less per capita than the national average for Native Americans (Feir et al., 2018; Johns, 2020).

Shamon et al. 2022 at 2.

**12. Current State and federal bison laws and regulations.**

**MONTANA**

**Montana Code Annotated 2021**
**TITLE 81. LIVESTOCK**
**CHAPTER 1. DEPARTMENT OF LIVESTOCK**
**Part 1. General Provisions**
**Definitions**

81-1-101. Definitions. Unless the context requires otherwise, in Title 81, the following definitions apply:

(1) (a) “Bison” means domestic bison or feral bison.

(b) The term does not include:

(i) wild buffalo or wild bison; or

(ii) for the purposes of chapter 9, buffalo.

(2) “Board” means the board of livestock provided for in 2-15-3102, except as provided in Title 81, chapter 23.

(3) “Department” means the department of livestock provided for in Title 2, chapter 15, part 31.

(4) “Domestic bison” means a bison that is not a wild buffalo or wild bison.

(5) “Feral bison” means a domestic bison or progeny of a domestic bison that has escaped or been released from captivity and is running at large and unrestrained on public or private land.

(6) “Wild buffalo” or “wild bison” means a bison that:

(a) has not been reduced to captivity;

(b) has never been subject to the per capita fee under 15-24-921;

(c) has never been owned by a person; and

(d) is not the offspring of a bison that has been subject to the per capita fee under 15-24-921.

History: En. 46-103.1 by Sec. 48, Ch. 310, L. 1974; R.C.M. 1947, 46-103.1; amd. Sec. 1, Ch. 361, L. 2009; amd. Sec. 2, Ch. 403, L. 2011; amd. Sec. 2, Ch. 507, L. 2021.

**Montana Code Annotated 2021**
**TITLE 81. LIVESTOCK**
**CHAPTER 2. DISEASE CONTROL**
**Part 1. General Administration**
**Management Of Wild Buffalo Or Wild Bison For Disease Control**

81-2-120. Management of wild buffalo or wild bison for disease control. (1) Whenever a publicly owned wild buffalo or wild bison from a herd that is infected with a dangerous disease enters the state of Montana on public or private land and the disease may spread to persons or livestock or whenever the presence of wild buffalo or wild bison may jeopardize Montana's compliance with other state-administered or federally administered livestock disease control programs, the department may, under a plan approved by the governor, use any feasible method in taking one or more of the following actions:

(a) The live wild buffalo or wild bison may be captured, tested, quarantined, and vaccinated. Wild buffalo or wild bison that are certified by the state veterinarian as brucellosis-free may be:

(i) sold to help defray the costs that the department incurs in building, maintaining, and operating necessary facilities related to the capture, testing, quarantine, or vaccination of the wild buffalo or wild bison. Proceeds from the sale of live, brucellosis-free, vaccinated wild buffalo or wild bison must be deposited in the state special revenue fund to the credit of the department. Any revenue generated in excess of the costs referred to in this subsection (1)(a)(i) must be deposited in the state special revenue fund provided for in 87-1-513(2).

(ii) transferred to a qualified tribal entity that participates in the disease control program provided for in this subsection (1)(a). Acquisition of wild buffalo or wild bison by a qualified tribal entity must be done in a manner that does not jeopardize compliance with a state-administered or federally administered livestock disease control program. The department may adopt rules consistent with this section governing tribal participation in the program or enter into cooperative agreements with tribal organizations for the purposes of carrying out the disease control program.

(b) The live wild buffalo or wild bison may be physically removed by the safest and most expeditious means from within the state boundaries, including but not limited to hazing and aversion tactics or capture, transportation, quarantine, or delivery to a department-approved slaughterhouse.

(c) The live wild buffalo or wild bison may be destroyed by the use of firearms. If a firearm cannot be used for reasons of public safety or regard for public or private property, the animal may be relocated to a place that is free from public or private hazards and destroyed by firearms or by a humane means of euthanasia.

(d) The live wild buffalo or wild bison may be taken through limited public hunts pursuant to 87-2-730 when authorized by the state veterinarian and the department.

(2) Whenever the department is responsible for the death of a wild buffalo or wild bison, either purposefully or unintentionally, the carcass of the animal must be disposed of by the most economical means, including but not limited to burying, incineration, rendering, or field dressing for donation or delivery to a department-approved slaughterhouse or slaughter destination.

(3) In disposing of the carcass, the department:

(a) as first priority, may donate a wild buffalo or wild bison carcass to a charity or to an Indian tribal organization; or

(b) may sell a wild buffalo or wild bison carcass to help defray expenses of the department. If the carcass is sold in this manner, the department shall deposit any revenue derived from the sale of the wild buffalo or wild bison carcass to the state special revenue fund to the credit of the department.

(4) The department may adopt rules with regard to management of publicly owned wild buffalo or wild bison that enter Montana on private or public land and that are from a herd that is infected with a contagious disease that may spread to persons or livestock and may jeopardize compliance with other state-administered or federally administered livestock disease control programs.

(5) Except for a transfer to a qualified tribal entity pursuant to subsection (1)(a)(ii), after a wild buffalo or wild bison is certified brucellosis-free by the state veterinarian, the department may authorize its transplantation or relocation into any county in the state pursuant to this section after the department receives the authorization of the board of county commissioners of the affected county or counties pursuant to 7-21-3214.

History: En. Sec. 1, Ch. 346, L. 1995; amd. Sec. 2, Ch. 523, L. 1997; amd. Sec. 2, Ch. 604, L. 2003; amd. Sec. 3, Ch. 403, L. 2011; amd. Sec. 3, Ch. 354, L. 2021.

**Montana Code Annotated 2021**
**TITLE 87. FISH AND WILDLIFE**
**CHAPTER 1. ORGANIZATION AND OPERATION**
**Part 2. Department of Fish, Wildlife, and Parks**
**Wild Buffalo Or Bison As Species In Need Of Management — Policy — Department Duties**

87-1-216. Wild buffalo or bison as species in need of management — policy — department duties. (1) The legislature finds that significant potential exists for the spread of contagious disease to persons or livestock in Montana and for damage to persons and property by wild buffalo or bison. It is the purpose of this section:

(a) to designate publicly owned wild buffalo or bison originating from Yellowstone national park as a species requiring disease control;

(b) to designate other wild buffalo or bison as a species in need of management; and

(c) to set out specific duties for the department for management of the species.

(2) The department:

(a) is responsible for the management, including but not limited to public hunting, of wild buffalo or bison in this state that have not been exposed to or infected with a dangerous or contagious disease but may threaten persons or property;

(b) shall consult and coordinate with the department of livestock on implementation of the provisions of subsection (2)(a) to the extent necessary to ensure that wild buffalo or bison remain disease-free; and

(c) shall cooperate with the department of livestock in managing publicly owned wild buffalo or bison that enter the state on public or private land from a herd that is infected with a dangerous disease, as provided in 81-2-120, under a plan approved by the governor. The department of livestock is authorized under the provisions of 81-2-120 to regulate publicly owned wild buffalo or bison in this state that pose a threat to persons or livestock in Montana through the transmission of contagious disease. The department may, after agreement and authorization by the department of livestock, authorize the public hunting of wild buffalo or bison that have been exposed to or infected with a contagious disease, pursuant to 87-2-730. The department may, following consultation with the department of livestock, adopt rules to authorize the taking of bison where and when necessary to prevent the transmission of a contagious disease.

(3) The department may adopt rules with regard to wild buffalo or bison that have not been exposed to or infected with a contagious disease but are in need of management because of potential damage to persons or property.

(4) The department may not:

(a) release, transplant, relocate, or allow wild buffalo or bison on any private or public land in Montana that has not been authorized for that use by the private or public owner; or

(b) except for a transfer to a qualified tribal entity pursuant to 81-2-120(1)(a)(ii), release, transplant, or relocate any wild buffalo or bison into any county in the state without authorization of the board of county commissioners of the affected county or counties pursuant to 7-21-3214.

(5) Subject to subsection (4), the department shall develop and adopt a management plan before any wild

buffalo or bison under the department's jurisdiction may be released, transplanted, or relocated onto private or public land in Montana. A plan must include but is not limited to:

(a) measures to comply with any applicable animal health protocol required under Title 81, under subsection (2)(b), or by the state veterinarian;

(b) any animal identification and tracking protocol required by the department of livestock to identify the origin and track the movement of wild buffalo or bison for the purposes of subsections (2)(b) and (5)(c);

(c) animal containment measures that ensure that any animal released, transplanted, or relocated on private or public land will be contained in designated areas. Containment measures must include but are not limited to:

(i) any fencing required;

(ii) contingency plans to expeditiously relocate wild buffalo or bison that enter private or public property where the presence of the animals is not authorized by the private or public owner;

(iii) contingency plans to expeditiously fund and construct more effective containment measures in the event of an escape; and

(iv) contingency plans to eliminate or decrease the size of designated areas, including the expeditious relocation of wild buffalo or bison if the department is unable to effectively manage or contain the wild buffalo or bison.

(d) a reasonable means of protecting public safety and emergency measures to be implemented if public safety may be threatened;

(e) a reasonable maximum carrying capacity for any proposed designated area using sound management principles, including but not limited to forage-based carrying capacity, and methods for not exceeding that carrying capacity, including in years of drought or severe winters. The carrying capacity must be based on a forage analysis conducted in accordance with standards contained in the most recent natural resources conservation service field office technical guide by a range scientist who is on the staff of:

(i) the Montana state university-Bozeman college of agriculture;

(ii) the United States natural resources conservation service; or

(iii) a technical service provider certified by either the natural resources conservation service or the society for range management.

(f) identification of long-term, stable funding sources that would be dedicated to implementing the provisions of the management plan for each designated area.

(6) When developing a management plan in accordance with subsection (5), the department shall provide the opportunity for public comment and hold a public hearing in the affected county or counties. Prior to making a decision to release, transplant, or relocate wild buffalo or bison onto private or public land in Montana, the department shall respond to all public comment received and publish a full record of the proceedings at any public hearing.

(7) The department is liable for all costs incurred, including costs arising from protecting public safety, and any damage to private property that occurs as a result of the department's failure to meet the requirements of subsection (5).

(8) When adopting and implementing rules regarding the special wild buffalo or bison license issued pursuant to [87-2-730](), the department shall consult and cooperate with the department of livestock regarding when and where public hunting may be allowed and the safe handling of wild buffalo or bison parts in order to minimize the potential for spreading any contagious disease to persons or to livestock.

History: En. Sec. 2, Ch. 346, L. 1995; amd. Sec. 3, Ch. 604, L. 2003; amd. Sec. 1, Ch. 383, L. 2011; amd. Sec. 9, Ch. 403, L. 2011; amd. Sec. 1, Ch. 172, L. 2015; amd. Sec. 4, Ch. 354, L. 2021.


**MONTANA Federal Lands & Indian Reservations**
Some small sites not shown, especially in urban areas.

**Montana Code Annotated 2021**
**TITLE 7. LOCAL GOVERNMENT**
**CHAPTER 21. BUSINESS, AGRICULTURE, AND LIVESTOCK SERVICES AND REGULATION**
**Part 32. County Agricultural and Livestock Services**
**Transplantation Or Relocation Of Wild Buffalo Or Wild Bison Into County — Authorization**

7-21-3214. Transplantation or relocation of wild buffalo or wild bison into county — authorization. (1) A board of county commissioners shall review any proposal made by the department of livestock or the department of fish, wildlife, and parks under 81-2-120 or 87-1-216 to authorize the transplantation or relocation of any wild buffalo or wild bison certified by the state veterinarian as brucellosis-free into that county.

(2) A board of county commissioners may not authorize a wild buffalo or wild bison to be transplanted or relocated into a county unless:

(a) the animal is certified as brucellosis-free; and

(b) the board finds the transplantation or relocation does not threaten the public health, safety, and welfare of the citizens of the county.

(3) The provisions of this section do not apply to proposals made by the department of livestock or the department of fish, wildlife, and parks under 81-2-120 or 87-1-216 to transplant or relocate wild buffalo or wild bison certified by the state veterinarian as brucellosis-free to a qualified tribal entity pursuant to 81-2-120(1)(a)(ii).

History: En. Sec. 1, Ch. 354, L. 2021.

**Montana Code Annotated 2021**
**TITLE 87. FISH AND WILDLIFE**
**CHAPTER 2. FISHING, HUNTING, AND TRAPPING LICENSES**
**Part 7. Special and Combination Licenses and Nongame Certificate**
**Special Wild Buffalo License — Regulation**

87-2-730. Special wild buffalo license — regulation. (1) The public hunting of wild buffalo or bison that have been designated as a species in need of disease control under 81-2-120 is permitted only when authorized by the department of livestock under the provisions set forth in 81-2-120.

(2) The department may issue special licenses to hunt wild buffalo or bison designated as a species in need of disease control when authorized by the department of livestock.

(3) The department shall adopt rules in cooperation with the department of livestock. The rules must provide for:

(a) license drawing procedures;

(b) application fees consistent with 87-2-113;

(c) notification of license recipients as to when and where they may hunt;

(d) fair chase hunting of wild buffalo or bison, including requirements that hunting be conducted on foot and away from public roads and that there be no designation of specific wild buffalo or bison to be hunted;

(e) means of taking and handling of carcasses in the field, which must include provisions for public safety because of the potential for the spread of infectious disease;

(f) the use of bows and arrows and other hunting arms;

(g) tagging requirements for carcasses, skulls, and hides;

(h) possession limits;

(i) requirements for transportation and exportation; and

(j) requirements and criteria for authorization by the state veterinarian and the department of livestock of any public hunting.

History: En. Sec. 1, Ch. 604, L. 2003; amd. Sec. 2, Ch. 221, L. 2011; amd. Sec. 1, Ch. 181, L. 2013; amd. Sec. 2, Ch. 298, L. 2013.

## IDAHO

## TITLE 25
## ANIMALS

## CHAPTER 6
## BANG'S DISEASE

25–618. BISON — MANAGEMENT OF DISEASED ANIMALS. (1) The legislature finds that significant potential exists for the spread of contagious disease to persons, livestock and other animals in Idaho, and in particular, the spread of brucellosis to livestock, elk, moose and other susceptible animals from bison emigrating into Idaho from Yellowstone national park and its environs. It is the purpose of the provisions of this section to provide for the management or eradication of bison which have not been reduced to captivity and which pose a threat to persons, livestock or other animals through the transmission of contagious disease, and to prescribe the duties of the department of agriculture with respect thereto.

(2) When estrayed or migratory bison exposed to or affected with brucellosis or other communicable disease determined by the department to pose a significant threat to persons, livestock or other animals, enter into or are otherwise present within the state of Idaho, one (1) of the following actions will be taken by the department:

(a) The live bison may be physically removed by the safest and most expeditious means from within the state boundaries. This means may include, but is not limited to, capture, trucking, hazing/aversion or delivery to a slaughterhouse approved by the department. This shall constitute the action of choice if at all feasible.

(b) If live bison cannot safely or by reasonable and permanent means be removed from the state as provided in paragraph (a) of this subsection, they may be destroyed where they stand by the use of firearms. If firearms cannot be used with due regard for human safety and public and private property, the bison shall be relocated to a danger free area and destroyed by any practicable means of euthanasia, including the use of firearms.

(c) When bison of necessity or unintentionally are killed through actions of the department, the carcass remains will be disposed of by the most economical means possible. This may include but is not limited to burying, incineration, rendering or field dressing for delivery to a departmentally approved slaughterhouse or slaughter destination.

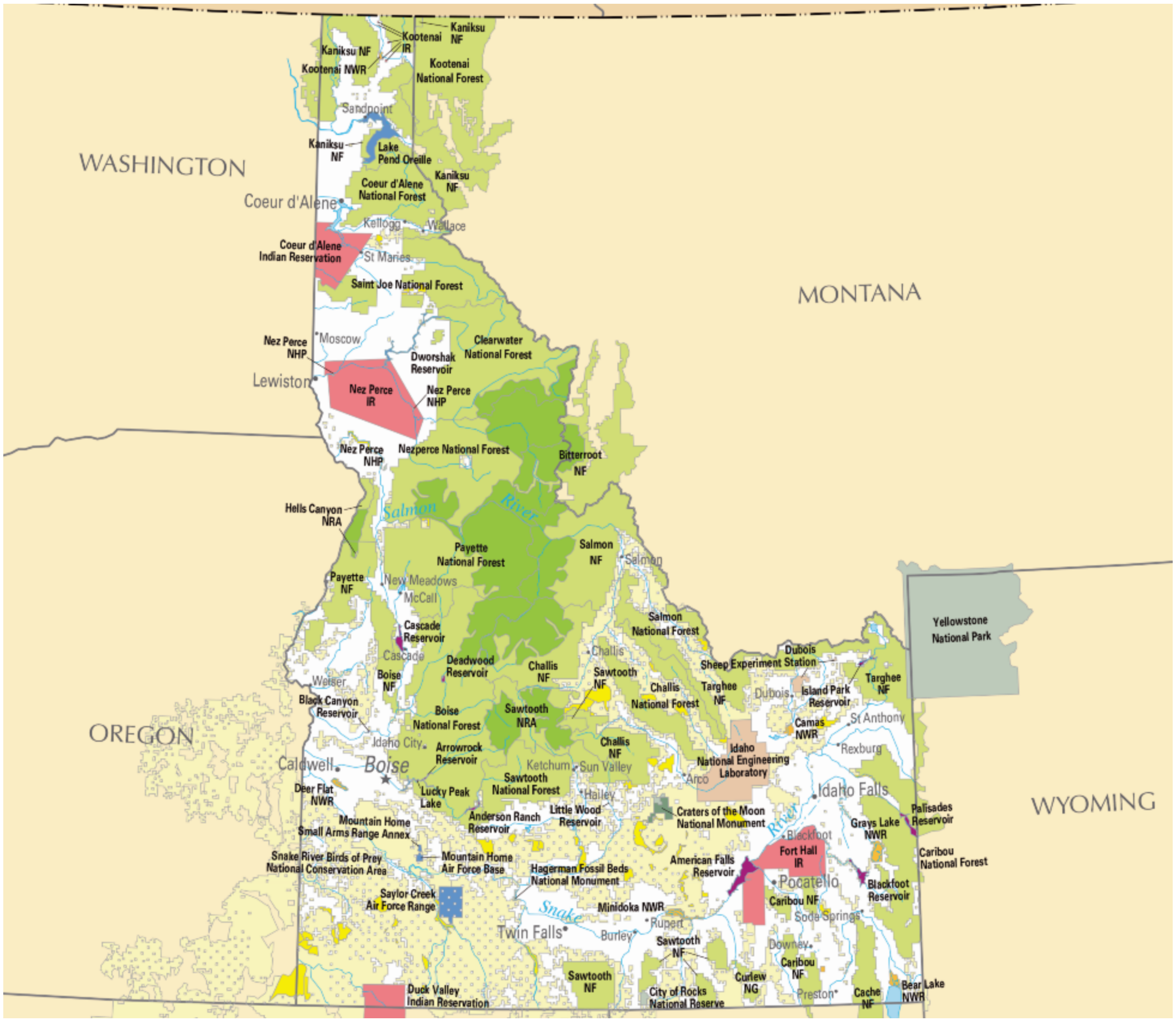
(3) The department shall promulgate such rules and regulations pursuant to chapter 52, title 67, Idaho Code, as it deems necessary to implement the provisions of this section.

(4) Upon the request of the department of agriculture, the department of fish and game shall cooperate with and assist the department of agriculture in accomplishing the requirements of this section.

History:

[25-618, added 1992, ch. 271, sec. 1, p. 842.]

Current through the 2021 Legislative session.




**IDAHO Federal Lands & Indian Reservations**
Some small sites not shown, especially in urban areas.

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Albers equal area projection

NationalAtlas.gov/US Department of the Interior/US Geological Survey

- Bureau of Indian Affairs
- Bureau of Land Management / Wilderness
- Bureau of Reclamation
- Department of Agriculture
- Department of Defense (includes Army Corps of Engineers lakes)
- Fish and Wildlife Service / Wilderness
- Forest Service / Wilderness
- National Park Service / Wilderness

| | |
|---|---|
| IR | Indian Reservation |
| NB | National Battlefield |
| NF | National Forest |
| NHS | National Historic Site |
| NM | National Monument |
| NRA | National Recreation Area |
| NWR | National Wildlife Refuge |

## WYOMING

### Title 23 Game and Fish
### Chapter 1 Administration
### Article 1. General Provisions

**§ 23-1-101. Definitions of wildlife.**

(a) As used in this act:

(xiii) "Wildlife" means all wild mammals, birds, fish, amphibians, reptiles, crustaceans and mollusks, and wild bison designated by the Wyoming game and fish commission and the Wyoming livestock board within Wyoming.

**§ 23-1-102. General definitions.**

(a) As used in this act:

(xvi) "Livestock" means horses, mules and asses, rabbits, llamas, cattle, swine, sheep, goats, poultry, or other animal generally used for food or in the production of food or fiber, and guard animals actively engaged in the protection of livestock. Bison are considered livestock unless otherwise designated by the Wyoming livestock board and the commission;

## WYOMING

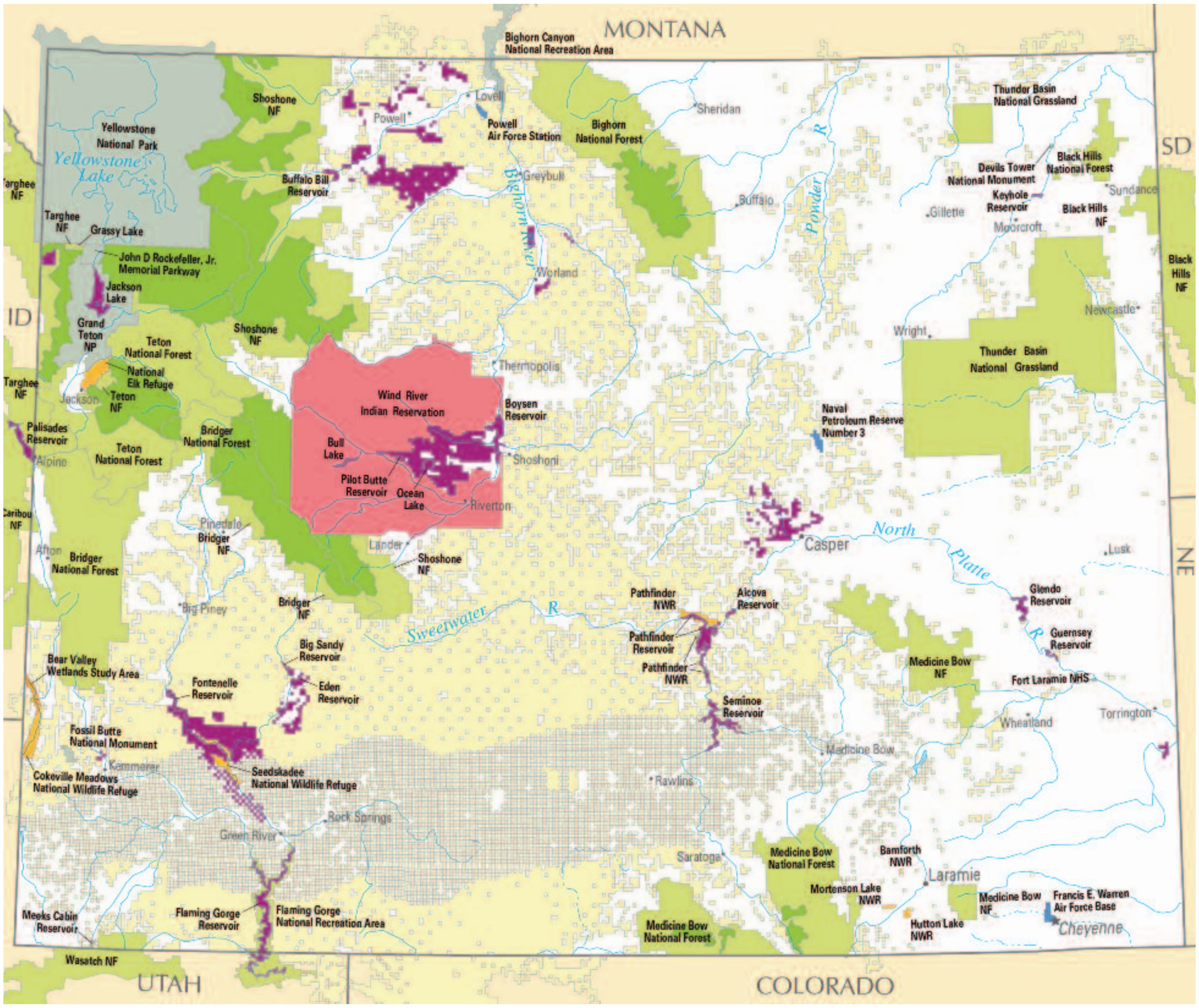
### Title 23 Game and Fish
### Chapter 1 Administration
### Article 3. General Powers and Duties of the Commission

**§ 23-1-302. Powers and duties.**

(a) The commission is directed and empowered:

> (xxvii) To designate individual bison or identifiable herds of bison as wildlife when the action is subsequently approved by the Wyoming livestock board;

(p) The commission may, by rule and regulation, establish a process by which big game licenses, trophy game licenses and wild bison licenses may be issued by a competitive raffle and prescribe the manner of payment for which raffle chances are sold and the amount of payment for each raffle chance. No more than two (2) licenses for each big game species and trophy game species and no more than two (2) wild bison licenses shall be issued under this subsection. Each license issued for bighorn sheep, moose, mountain goat, grizzly bear or wild bison through a competitive raffle shall, when applicable, be counted against any nonresident quota. The five (5) year restriction imposed on the receipt of a moose or bighorn sheep license by W.S. 23-1-703(b) or the lifetime restriction imposed on the receipt of a grizzly bear, mountain goat, bighorn sheep, wild bison or moose license by W.S. 23-1-703(c), and any restriction imposed on the receipt of a wild bison license by W.S. 23-2-107 shall not be applicable in any manner to a license issued pursuant to this subsection. The commission shall issue licenses upon receipt of the proper license fee by the successful competitive raffle winner. Nothing in this subsection shall authorize the issuance of a license to any person whose privilege to procure, purchase or possess a license has been suspended pursuant to this act or by operation of law.




**WYOMING Federal Lands & Indian Reservations**

Some small sites not shown, especially in urban areas.

MILES 0 25 50 75 100

Albers equal area projection

NationalAtlas.gov/US Department of the Interior/US Geological Survey

- Bureau of Indian Affairs
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- Department of Agriculture
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- Forest Service / Wilderness
- National Park Service / Wilderness

| | |
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| IR | Indian Reservation |
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**National Bison Legacy Act**
**Public Law 114–152, 130 Stat. 373, (36 U.S.C. note prep. 301) H.R. 2908 (Jan. 4, 2016).**

**One Hundred Fourteenth Congress**
**of the**
**United States of America**
**AT THE SECOND SESSION**
***Begun and held at the City of Washington on Monday,***
***the fourth day of January, two thousand and sixteen***

**An Act**

To adopt the bison as the national mammal of the United States.

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled*,

**SECTION 1. SHORT TITLE.**

This Act may be cited as the "National Bison Legacy Act".

**SEC. 2. FINDINGS.**

Congress finds that—

(1) bison are considered a historical symbol of the United States;

(2) bison were integrally linked with the economic and spiritual lives of many Indian tribes through trade and sacred ceremonies;

(3) there are more than 60 Indian tribes participating in the Intertribal Buffalo Council;

(4) numerous members of Indian tribes are involved in bison restoration on tribal land;

(5) members of Indian tribes have a combined herd of more than 1,000,000 acres of tribal land;

(6) the Intertribal Buffalo Council is a tribal organization incorporated pursuant to section 17 of the Act of June 18, 1934 (commonly known as the "Indian Reorganization Act")(25 U.S.C. 477);

(7) bison can play an important role in improving the types of grasses found in landscapes to the benefit of grasslands;

(8) a small group of ranchers helped save bison from extinction in the late 1800s by gathering the remnants of the decimated herds;

(9) bison hold significant economic value for private producers and rural communities;

(10) according to the 2012 Census of Agriculture of the Department of Agriculture, as of 2012, 162,110 head of bison were under the stewardship of private producers, creating jobs and providing a sustainable and healthy meat source contributing to the food security of the United States;

(11) on December 8, 1905, William Hornaday, Theodore Roosevelt, and others formed the American Bison

Society in response to the near extinction of bison in the United States;

(12) on October 11, 1907, the American Bison Society sent 15 captive-bred bison from the New York Zoological Park, now known as the "Bronx Zoo", to the first wildlife refuge in the United States, which was known as the "Wichita Mountains Wildlife Refuge", resulting in the first successful reintroduction of a mammal species on the brink of extinction back into the natural habitat of the species;

(13) in 2005, the American Bison Society was reestablished, bringing together bison ranchers, managers from Indian tribes, Federal and State agencies, conservation organizations, and natural and social scientists from the United States, Canada, and Mexico to create a vision for the North American bison in the 21st century;

(14) there are bison herds in National Wildlife Refuges and National Parks;

(15) there are bison in State-manage herds across 11 States;

(16) there is a growing effort to celebrate and officially recognize the historical, cultural, and economic significance of the North American bison to the heritage of the United States;

(17) a bison is portrayed on 2 State flags;

(18) the bison has been adopted by 3 States as the official mammal or animal of those States;

(19) a bison has been depicted on the official seal of the Department of the Interior since 1912;

(20) the buffalo nickel played an important role in modernizing the currency of the United States;

(21) several sports teams have the bison as a mascot, which highlights the iconic significance of bison in the United States;

(22) in the 2nd session of the 113th Congress, 22 Senators led a successful effort to enact a resolution to designate November 1, 2014, as the third annual National Bison Day; and

(23) members of Indian tribes, bison producers, conservationists, sportsmen, educators, and other public and private partners have participated in the annual National Bison Day celebration at several events across the United States and are committed to continuing this tradition annually on the first Saturday of November.

**SEC. 3. ESTABLISHMENT AND ADOPTION OF THE NORTH AMERICAN BISON AS THE NATIONAL MAMMAL.**

(a) In General.—The mammal commonly known as the "North American bison" is adopted as the national mammal of the United States.

(b) Rule of Construction.—Nothing in this Act or the adoption of the North American bison as the national mammal of the United States shall be construed or used as a reason to alter, change, modify, or otherwise affect any plan, policy, management decision, regulation, or other action by the Federal Government.

*Speaker of the House of Representatives.*

*Vice President of the United States and President of the Senate.*

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A short citation format is used throughout the text: author(s), year, and page(s). Where applicable, a pinpoint citation is provided for all sources incorporated herein.

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