Yellowstone's Wild Bison:

On the Brink of Extinction

James Horsley

Yellowstone's Wild Bison:
On the Brink of Extinction

First volume of petition

Figure 1. DRAWINGS BY SQUINT EYE (Tichkematse), Cheyenne, a prisoner artist. * See opposite page for continuation of caption.

Yellowstone's Wild Bison: On the Brink of Extinction

James Horsley

PEASANT PRESS | FARGO, NORTH DAKOTA

*** Two attitudes toward bison appear to be depicted—one of a person running from the animal in fear and another sustained by it. Raised in a culture based on buffalo hunting, Tichkematse was among a group of southern Plains warriors who were held as prisoners of war by the United States government from 1875 to 1878. After his release, he was employed by the Smithsonian, where he was trained in the preparation of bird and mammal specimens for study and display. *Drawings, including front cover, furnished by the Anthropology Department, Smithsonian National Museum of Natural History.***

Published by Peasant Press, Fargo, North Dakota

February 2018

ISBN: 978-0-9985285-1-9

First edition

Printed in the United States of America

To the glory of God,
to my wife Karen
and to the memory of Sitting Bull

"I will remain what I am until I die, a hunter,
and when there are no more Buffalo or game,
will send my children to hunt
and live on prairie mice."

— Sitting Bull, Wood Mountain, Saskatchewan, 1879
(*I am Looking to the North for My Life*, Joseph Manzione)

Preface

This is the first volume of a two-volume petition submitted to the Department of the Interior under the provisions of the Endangered Species Act to list wild bison that inhabit the Greater Yellowstone Ecosystem as threatened or endangered. The second volume is titled *Before the Secretary of the Interior: A Petition to Protect Yellowstone's Wild Bison from Extinction*. It was originally submitted January 12, 2017 to the Department of the Interior, but was returned by its evaluators, the US Fish and Wildlife Service (FWS), due to technical reasons and therefore was not considered a submission.

One of the new requirements was that states contiguous to the range of wild bison be notified of a petitioner's intent to submit the petition one month in advance to give them the opportunity to be involved, and the other that copies of all referenced documents be submitted concurrently with the submission of the petition.

The first volume, *Yellowstone's Wild Bison: On the Brink of Extinction*, was written after the non-acceptance of the petition submitted in early 2017. It focuses more narrowly on the two herds inhabiting the park as distinct subspecies and on factors warranting their listing. The second volume contains more extensive discussions on background and management.

With the technical reasons for the petition's non-acceptance addressed, the petition, now two volumes, was re-submitted February xxxx, 2018 to the Department of the Interior for its evaluation.

All told, this is the third petition submitted by this Petitioner to protect Yellowstone's wild bison. Chronologically, the first petition was a 10-page hand-written document submitted January 5, 1999. A 90-day finding on that petition in 2007 by the Fish and Wildlife Service (made eight-years after its submission) determined Yellowstone bison are a subspecies—technically termed a distinct population segment (DPS)—thereby qualifying the herd for listing. However, the FWS found that this subspecies did not warrant listing because it claimed wild bison were sufficiently abundant and for this reason neither threatened nor endangered.

A second petition, submitted March 2, 2015, was also denied, again on the issue of abundance. In the petition returned by the FWS in early 2017, I made a request for an emergency listing of Yellowstone's bison, which were in the process of being culled. Following its return, I made a written request for an emergency listing directly to the FWS February 13, 2017 (see Appendix A). My letter was not answered. Subsequently, 1,300 bison were lethally removed from the herd that winter.

I was about to re-submit the 2017 petition, now that I had met the new requirements, when it dawned on me that its focus was wrong. Yes, the total wild bison population in Yellowstone could be argued as abundant, in fact, at times increasing, but the status of the total herds was not the immediate and real problem. Rather, it was the status of the subpopulations. Yellowstone has two distinct wild bison groups—the central herd and the northern herd.

My original analysis, which comprises the second volume, was on the herds as one combined herd. Following the petition's return, my thinking began to change. As mentioned, one of the reasons for the return of the first submission in early 2017 was due to a new rule that copies of all referenced citations were required. Since I had included extensive quotations, I believed that was sufficient. In subsequent communications with the FWS on why my petition had been denied, I received the following email from Ron Vandervort, biologist, Fish and Wildlife Service:

> Concerning the question regarding providing excerpts instead of full references, because you have provided quotations excerpted from the sources, and given specific citations, including page numbers, that is an acceptable approach, and allowed for in the regulation. Our intent was that this provision be used in special circumstances (please see explanation below in a comment and response from the Petition Regulation), but in fact you are correct that, as stated in the actual regulation text, excerpts or quotations are acceptable. However, please note that when evaluating your request, we will not augment your petition in terms of looking up more information or obtaining references you cite to substantiate claims, but only consider whether the excerpts you provide substantiate your claims (Ron Vandervort, personal communication, March 7, 2017).

That the FWS would not "augment" the petition without being supplied with reference copies of works cited began to bother me. Possibly my petition in and of itself was defective in some way and, indeed, needed augmenting. Possibly I should expand on the species concepts. Possibly I should look more closely at the two herds. As I began to analyze these issues more closely, I drew a graph of the history of the two herds' populations and realized that in 2008 the population lines comprising the northern and central herds had crossed, meaning at that point the northern herd was gaining numbers annually and the central herd losing numbers. I saw that while the total herd population was stable, the central herd was crashing.

This was alarming. I had argued in the prior petitions that culling only the migratory eventually would be harmful to the survival of the park's bison. Now I saw distinctly why, and that it was happening *now*, not in the future. Somehow I had not paid attention to the disproportionate state of the two populations. Possibly I should investigate more deeply the information issued by Yellowstone National Park and the IBMP that has served to cover up the crash of the park's native herd and its significance. I started reading texts on probability and Bayes' theorem, such as Hossein Pishro Nik's *Introduction to Probability, Statistics and Random Processes* and Thomas Hobbs and Mevin B. Hooten's *Bayesian Models: A Statistical Primer for Ecologists*, because many of the ecological simulation studies that guide biologists' management of the park involved predictive mathematical models. I became convinced that in Yellowstone, science and mathematics—especially probabilistic simulation models—were being used to veil the truth.

Now the question became how to protect the declining herd in the face of these obstacles. I realized at that point my task was two-fold—first, to expose the errors being made by park biologists in interpreting scientific studies and in implementing their findings, and secondly, to prove that not only were the wild bison a distinct population segment in totality, but in addition, composed of two distinct population segments, compounding the task of having them listed.

But in fact, two distinct population segments *are* there. The central herd is comprised of descendants of a herd of wood bison that has never been extirpated and has continued to inhabit the land to which its ancestors migrated millennia ago. On the other hand, the northern herd was introduced into the park in 1902 from captive plains bison that had been taken from the landscape in a wild state.

The two herds have remained distinct, separate herds geographically, behaviorally and genetically for over a hundred years. The central herd is on the brink of extinction, endangered, due to disproportionate large-scale culling by a government coalition called the Interagency Bison Management Plan. The herd's migratory behavior brings them to Gardiner Basin, site of the Stephens Creek capture facility, where they are trapped and sent to slaughter, while the northern herd is threatened. Given time, that herd may also become extinct, since a preponderance now lacks an essential trait for survival in nature—migratory behavior—most likely eradicated by large-scale culling of its migratory members during the winter of 1996-1997, reducing the herd by half, the migratory half.

Ironically, it was this event over 20 years ago that was the impetus for the formation of the Interagency Bison Management Plan in 2000, established in part to avoid such slaughters. Ironically, it is this non-migratory behavior that is saving the northern herd, for the time being, because it keeps them out of Gardiner Basin and the Stephens Creek capture facility.

This first volume, Y*ellowstone's Wild Bison: On the Brink of Extinction*, contains a few chapters from the second volume that have been rewritten, included to preserve its logical flow as a stand-alone document from beginning to conclusion. It focuses on the need to preserve both the northern and the central herds, but more immediately the central herd, so as to prevent the extinction of bison that are truly wild—the descendants of the bison clade that came to the park millennia ago.

James Horsley
January 2018

Table of Contents

Figures

Tables

BEFORE THE SECRETARY OF THE INTERIOR

Figure 2. STEPHENS CREEK CAPTURE FACILITY, located inside Yellowstone National Park, where bison are trapped and shipped for meat processing. Park rangers swing doors open and shut with ropes. *Video by National Park Service.* (Bison—Stephens Creek Capture Facility, 2016).

PETITION TO PROTECT YELLOWSTONE'S WILD BISON HERDS (*BISON BISON BISON* AND *BISON BISON ATHABASCAE*) UNDER THE ENDANGERED SPECIES ACT

Notice of Petition

Secretary Ryan Zinke
U.S. Department of the Interior
exsec@ios.doi.gov

Sarah Quamme, Chief
U.S. Fish and Wildlife Service
sarah_quamme@fws.gov

Scott Aikin (National Native American Programs Coordinator)
U.S. Fish and Wildlife Service
Scott_Aikin@fws.gov

Ron Vandervort, Biologist
U.S. Fish and Wildlife Service
MS: ES, Unified Listing Team
ron_vandervort@fws.gov

Deputy Director Jim Kurth
U.S. Fish and Wildlife Service
Jim_Kurth@fws.gov

Secretary Wilbur Ross
U.S. Department of Commerce
docexecsec@doc.gov

Petitioner
James A. Horsley
Fargo, ND
jahorsley@yahoo.com

Both volumes submitted February 28, 2018

First volume *Yellowstone's Wild Bison: On the Brink of Extinction*, submitted this 28th day of February, 2018.

Second volume titled *Before the Secretary of the Interior: A Petition to Protect Yellowstone's Wild Bison from Extinction*, submitted January 12, 2017, returned by the Fish and Wildlife Service February 6, 2017, resubmitted this 28th day of February, 2018.

Petition
Pursuant to the Endangered Species Act, I, James Horsley, a private citizen, petition the Secretary of the Interior through the United States Fish and Wildlife Service, to protect the wild bison of the Greater Yellowstone Ecosystem as a threatened or endangered species in its range. The Petitioner also requests that critical habitat be designated for Yellowstone's wild bison concurrently with the species being listed.

Petitioner information
I, James Horsley, hereafter referred to as the Petitioner, am a resident of Fargo, North Dakota, and am the author of a petition submitted February 11, 1999 (see Appendix A, second volume of this petition), as well as a second petition submitted March 2, 2015, both to list the Yellowstone National Park (YNP) bison herd as threatened or endangered under the Endangered Species Act (ESA). Both petitions for listing have been denied (see Appendixes C and D, second volume of this petition). This petition is my third submission.

My work experience includes: publisher of the *Prairie Journal*, a regional newspaper; instructor in English composition at College of the Desert, Palm Desert, California; speech writer for the California Medical Association and the State Bar of California; and account executive with the public relations firm Daniel J. Edelman, San Francisco, California.

I am a graduate of the University of California at Berkeley, did undergraduate studies in mathematics and physics, but changed majors, obtaining a BA in English.

I also did graduate studies in English at California State University, San Bernardino and at North Dakota State University, Fargo.

FWS required to notify tribes of petition receipt

Yellowstone's wild bison are a tribal trust resource, that is, a natural resource "either on or off Indian lands, retained by, or reserved by or for Indian tribes through treaties, statutes, judicial decisions, and executive orders, which are protected by a fiduciary obligation on the part of the United States." According to a 1997 order by the Secretaries of the Interior and Commerce "Working with Tribes: American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the Endangered Species Act," in the listing of a species the departments:

> shall recognize that Indian tribes are appropriate governmental entities to manage their lands and tribal trust resources. The Departments acknowledge that Indian tribes value, and exercise responsibilities for, management of Indian lands and tribal trust resources. In keeping with the federal policy of promoting tribal self-government, the Departments shall respect the exercise of tribal sovereignty over the management of Indian lands, and tribal trust resources. Accordingly, the Departments shall give deference to tribal conservation and management plans for tribal trust resources that: (a) govern activities on Indian lands, including, for the purposes of this section, tribally-owned fee lands, and (b) address the conservation needs of listed species. The Departments shall conduct government-to-government consultations to discuss the extent to which tribal resource management plans for tribal trust resources outside Indian lands can be incorporated into actions to address the conservation needs of listed species.

Because of the policies of the IBMP and other government agencies, the relationship of various tribes to wild bison has been marginalized and the ecosystem sickened. The endangerment of wild bison's continued existence is the result. Because wild bison, especially those in the Greater Yellowstone Ecosystem, are a tribal trust resource, due to provisions in past treaties between various American Indian nations and the United States, the government has the additional burden to work with such tribes in the listing process and to promote a healthy ecosystem. The 1997 order by the Secretaries directs the Fish and Wildlife Service to:

> (1) Provide affected Indian tribes with timely notification of the receipt of petitions to list species, the listing of which could affect the exercise of tribal rights or the use of tribal trust resources. In addition, the Services shall solicit and utilize the expertise of affected Indian tribes in responding to listing petitions that may affect tribal trust resources or the exercise of tribal rights.

(2) Recognize the right of Indian tribes to participate fully in the listing process by providing timely notification to, soliciting information and comments from, and utilizing the expertise of, Indian tribes whose exercise of tribal rights or tribal trust resources could be affected by a particular listing (Working with Tribes, 1997).

Notification of the receipt of this petition should be made by the Fish and Wildlife Service to the tribal groups that have wild bison hunting rights operating under the IBMP, namely, the InterTribal Buffalo Council, the Confederated Salish and Kootenai Tribes, and the Nez Perce Tribe, as well as the Umatilla and the Shoshone-Bannock Tribes.

Further, notification of the receipt of this petition also should be made to those other tribes that would be affected by the listing (or not listing) of wild bison, especially tribes in states adjacent to the Greater Yellowstone Ecosystem and those signing treaty agreements pertaining to hunting rights, such as the Treaty of Ft. Laramie 1850.

Listing wild bison, yet allowing controlled hunting through the government working with the American Indian tribes, has the potential effect of benefiting both American Indians and wild bison by restoring their historic symbiotic relationship experienced for millennia.

Further discussions of tribal trust resources are found in the second volume of this petition, especially in “Declaration,” “Introduction” and chapter 4 “The buffalo commons.”

Consultation with the Secretary of Commerce requested

The Petitioner requests that the Fish and Wildlife Service in its evaluation of this petition do so in cooperation with the Secretary of Commerce, in addition to the Secretary of the Interior, because the FWS is under the authority of the Department of the Interior, along with the National Park Service, a member of the Interagency Bison Management Plan, thereby creating a conflict of interest, since this petition, if listing were granted, would subordinate the IBMP under the jurisdiction of the Endangered Species Act.

Such consultation would be appropriate and beneficial in reaching a fair finding because the concept of evolutionary significant units, which applies to fish species, is applicable also to herd animals, i.e., schools of fish are like herds—such groups have both migratory and non-migratory populations, as well as subpopulations critical to the survival of a species or subspecies.

Further, wild bison are a sustainable wild animal source, especially to the culture of American Indian tribes historically. Their protection affects the resilience of our ecosystems and the economy of local communities.

Emergency listing requested

The Petitioner requests an emergency listing be granted for Yellowstone's wild bison because of park biologists and the IBMP's failure to adhere to policies of adaptive management, in particular the management goal to keep both herd sizes equal, as recommended in "Yellowstone Bison—Should We Preserve Artificial Population Substructure or Rely on Ecological Processes?" by biologists Patrick J. White and Rick L. Wallen. They stated:

> the management plan for Yellowstone bison during winter 2012 clearly indicates a desire to progress toward approximately equal numbers of bison in each breeding herd and selectively cull bison from the northern herd (which is currently larger), while minimizing removals from the central herd.

Because of the inability to adhere to the adaptive management policies recommended, the existing regulatory mechanisms are inadequate in the operation of the park with regard to the prevention of the extinction of wild bison there, necessitating the intervention of the Fish and Wildlife Service in listing both herds as endangered or threatened. Because extinction could occur the winter of 2017-2018 due to the low population of the central herd (847 animals) and the high level of reductions recommended (up to 1,250 animals), an emergency listing is again requested (see Appendix A, an emergency listing request to the Fish and Wildlife Service—which was not acted on—made in a letter by the Petitioner prior to the 2017 culling that reduced the central herd to its present small population size).

Wild bison are a tribal trust resource. Because the extinction of the central herd is impending and because its existence is tied to the continued existence of both herds, an emergency listing should be instituted to give the FWS time to evaluate the merits of this petition now. If an emergency petition is not granted in time to stop the culling for 2017-2018, the Petitioner requests that an emergency petiton be ordered for 240 days beginning with the opening of hunting season for wild Yellowstone bison in 2018.

As of this submission, at least 96 wild bison have been trapped at the Stephens Creek capture facility and are being held for slaughter. IBMP and Yellowstone biologists' stated objective for culling in 2017-2018 is to "Focus population management reductions on the northern herd by using location information from radio-collared bison to inform the timing and magnitude of bison captures near the northern park boundary such that captures primarily remove bison that lived and bred in northern Yellowstone during summer 2017."

In practice, experience has shown that neither the IBMP nor park biologists can identify from which herd trapped bison belong prior to culling. Because of this inadequate regulatory mechanism, an emergency listing should be made prohibiting this wild species' capture and slaughter, as well as the release of the presently trapped bison at Stephens Creek capture facility. If the FWS does not act now, there may be no central herd to protect.

Summary

Say goodbye to Yellowstone's native wild bison herd, the herd that inhabits the central valleys of the park. For the sake of a few hundred cattle that graze in Gardiner Basin near the north entrance of Yellowstone National Park, state and federal agents are in the process of slaughtering up to 1,250 wild bison as they migrate this winter. Bison are subject to culling every year. This may be the last year the herd native to the park—the herd whose ancestors came here over 10,000 years ago—will remain in existence.

The culling goal this year far exceeds the population of the indigenous herd. Only the migratory are killed, those that attempt to escape the harsh weather of the park's central interior by leaving the park for lower, snow-free grasslands. Since the central herd is the predominately migratory herd, it is the herd getting the brunt of the killing. Even if the goal is only partially met, there is a high probability the native herd will be gone. We will find out when the aerial count is made in the summer.

Only 850 of this small, dwindling herd are left. Lethally remove 1,250 bison from 850 animals and what do you get? Extinction. The endemic herd has been systematically culled down to its current level from a population high of 3,500 in 2005. On the other hand, the northern herd—the herd composed of animals captured from the wild and trucked into the northern valleys of the park in 1902 to boost the genetic diversity of the central herd—has risen during the same time period to 4,000 today.

Bison are managed by park biologists whose decisions are guided by ecological studies, many involving probabilistic models. This two-volume petition, with the first volume titled *Yellowstone's wild bison: On the brink of extinction* and the second volume *Before the Secretary of the Interior: A petition to protect Yellowstone's wild bison from extinction,* requests the Fish and Wildlife Service list these herds as endangered or threatened because of a number of factors, including the use of studies to regulate bison populations that are either flawed or not followed.

Bison are culled under the authority of the Interagency Bison Management Plan—a group of government agencies consisting in part of the National Park

Service and Montana's Department of Livestock and Fish, Wildlife and Parks. The purpose is to lethally remove those animals attempting to leave the park so they can not come in contact with cattle. In Gardiner Basin up to 300 cattle are fattened for market each year in the summer months on wildlife habitat just outside the park.

Ranchers claim they fear migrating bison will infect their cattle with brucellosis, a disease that causes ungulates to abort, which is transmitted by contact with infected birthing material. Its spread is prevented by keeping the ranges of disease-free animals separate from diseased animals. Since the park can not be fenced, to achieve separation migrating bison attempting to enter Gardiner Basin are trapped on park property and shipped to slaughterhouses at a cost of $3 million annually.

It is a totally ineffective disease-control strategy, however, because elk also have brucellosis, but are allowed to migrate and mingle with the very same cattle from which bison are separated. Further, bison are allowed to migrate in the spring. This is when the potential for the spread of brucellosis is highest due to the shedding of the disease through calving and the discharge of infected placentas.

Only bison migrating into Gardiner Basin in the fall and winter are culled, first by hunting and then, beginning in mid-February, at the Stephens Creek capture facility located in the basin on park land. Wild bison come to this lower, often snowless grassland to escape the severe winter weather of the park's interior where forage is buried under snow sometimes seven feet deep and crusted with an impenetrable layer of ice. They come to the grassland to graze and later to calve, for most of the females, followed by their yearlings, are pregnant. Instead, all that reach this destination are killed.

The northern herd is primarily non-migratory. They usually do not enter Gardiner Basin, nor do they need to, for their valleys are lower than the central valleys. For this reason they escape most of the slaughter and grow in population.

Yellowstone biologists are targeting the central herd to weed out the troublesome migratory animals. In a study by park biologists C. Geremia, P.J. White and R.L. Wallen titled "Integrating populations- and individual-level information in a movement model of Yellowstone bison," published 2014 in *Ecological Applications*, the authors stated:

> Learning and experience may affect movements by allowing a behavior such as the use of migration paths or wintering areas to become increasingly entrenched. If a particular learned behavior increases conflict, it may be reasonable to target animals that exhibit the behavior for removal.

Yellowstone's wild bison have been determined to be a rare subspecies, technically a "distinct population segment" (DPS), by the Fish and Wildlife Service in its evaluations of petitions seeking the protection of the species from extinction under the provisions of the Endangered Species Act. This designation, however, has been for the park's wild bison as one herd composed of *both* northern and central subpopulations taken as a metapopulation. Taxonomically the two herds should not be lumped together, as they are actually *two* separate subspecies evolutionarily, genetically and reproductively. A species is defined under the biological species concept as groups of interbreeding natural populations that are reproductively isolated from other such groups and under the phylogenetic species concept as a group whose members are descended from a common ancestor and share certain traits or genetics. A subspecies is substantially the same as a species, but may have limited gene flow between the two populations and hybrids.

The central herd descended from wood bison, *Bison bison athabascae*. The northern herd descended from plains bison, *Bison bison bison*. They represent two evolutionarily distinct lineages. A team led by David Forgacs, Texas A&M University, reported in "Mitochondrial Genome Analysis Reveals Historical Lineages in Yellowstone Bison," published 2016 in *PLOS ONE*:

> Thus, we conclude that Clade I contains haplotypes that are more closely associated with the indigenous bison that lived in the area for hundreds of years while Clade II has haplotypes that resemble the bison introduced to the park from northern Montana in 1902.

The two herds are substantially separate breeding herds. In a study reported in the *Journal of Heredity* titled "Genetic Population Substructure in Bison at Yellowstone National Park," a team led by Natalie D. Halbert of Texas A&M University found genetic evidence for two biologically distinct herds. The authors reported, "Two genetically distinct and clearly defined subpopulations were identified based on both genotypic diversity and allelic distributions." They noted:

> From this analysis, there appears to be a strong association between the genetically defined clusters and sampling locations within Yellowstone National Park, with cluster 1 representing bison from the northern range and cluster 2 representing bison from the central range.

The team concluded:

> 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.

The US Fish and Wildlife Service reclassified wood bison *(Bison bison athabascae*) from endangered to threatened May 3, 2012. With the identification of the central herd as a separate breeding herd with a lineage of wood bison genetics, that herd should be listed as at least threatened.

The purpose of IBMP's culling regime is to bring the herds down to a combined population size of 3,000 animals. This is the theoretical level which simulation studies have identified as triggering migration out of the park. However, more recent studies and field observations demonstrate that wild bison will migrate at any population level, dependent on the severity of weather. Further, a recent study has shown that culling bison to prevent the spread of brucellosis out of the park is no better than not culling, that is, doing nothing at all. In fact, studies have shown that preventing dispersal, that is, migration, concentrates animals, increasing the risk of the spread of disease.

Coincidentally, the IBMP claims a herd size of 3,000 is also the number that has been determined to be a minimum viable population, that is, the minimum population size needed for a species to survive in the wild. The *Record of Decision* that established the IBMP in 2000 states:

> Considering the information currently available, the agencies believe they are providing for the conservation of Yellowstone bison genetics by balancing a spring bison population limit of about 3,000 animals with other management objectives.

However, a team led by David H. Reed, Macquarie University, Australia, in "Estimates of minimum viable population sizes for vertebrates and factors influencing those estimates," published September 2003 in *Biological Conservation*, concluded:

> The results of our simulations suggest that conservation programs, for wild populations, need to be designed to conserve habitat capable of supporting approximately 7000 adult vertebrates in order to ensure long-term persistence.

The park's advising biologists annually recommend to the IBMP the number of bison to be culled based on the size of the herds as though they were one large herd. However, past culling records show that culling primarily affects the central herd because it is the migratory herd. Basing culling calculation on the total size of both herds and the percent reduction that it will produce masks the impact on the central herd, bringing that herd closer to extinction each year.

Park biologists Geremia, Wallen and White recommended in "Status Report on the Yellowstone Bison Population, September 2016" the lethal removal of up to 1,300 animals for the coming winter. That recommendation was achieved with the slaughter of that number in 2017. Out of a total herd population of about 5,500 animals counted in 2016, the total of the two herds was reduced by 12 percent. However, while the northern herd was reduced by only one percent, the central herd was reduced by almost 50 percent. Biologists have watched and recorded the collapse of the native herd from a high of 3,531 in 2005 to its present status of 850 animals, while for that same time period the once-captive introduced herd has risen from 1,484 to 4,000 animals presently.

Park biologists argue there is no need to preserve the central herd, despite the conclusion of Halbert's team that "Population subdivision is a critically important force for maintaining genetic diversity." White and Wallen rebutted the Halbert study in a letter to the editor published 2012 in the *Journal of Heredity* titled "Yellowstone Bison—Should We Preserve Artificial Population Substructure or Rely on Ecological Processes?" The Yellowstone biologists stated:

> 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.

Having said that, the biologists recommended the culling of 1,300 bison in 2017 and 1,250 in 2018, with no attention being paid to "promoting the conservation of wildness and natural selection to retain adaptive capabilities" nor preserving genetic substructure. If anything, the northern herd was artificially created by transporting its original members from captivity in the plains to the park in 1902. The central herd, on the other hand, has been a distinct breeding herd from prehistoric times and has remained so, even after the introduction of the plains herd over a hundred years ago. At the most basic level, large-scale culling is not natural selection, but instead, its opposite, artificial selection. Instead of retaining adaptive capabilities, park biologists are destroying adaptive capabilities by killing the migratory.

Management of the park is under the Department of the Interior's guidelines for "adaptive management," a process wildlife managers are supposed to follow that is based on learning from experience and from the best available science, continually adjusting management actions according to their outcomes. Park biologists conceded in their letter to the editor rebutting the Halbert study that both herds should be kept equal in size. They stated:

> Thus, total population abundance is not the only primary factor considered in determining management actions for Yellowstone bison. As an example, the management plan for Yellowstone bison during winter 2012 clearly indicates a desire to progress toward approximately equal numbers of bison in each breeding herd and selectively cull bison from the northern herd (which is currently larger), while minimizing removals from the central herd.

However, the biologists have failed to carry out their intentions, accelerating a differential rate in genetic loss. In reality, they can not keep their stated goal. There is no plan in place at Yellowstone to determine which bison come from which herd prior to culling. The Halbert team noted:

> Therefore, the rate of loss of genetic diversity may be quite different between the 2 subpopulations. Although the winter movement of bison from the central herd to the northern range may be density dependent (Fuller et al. 2009) and therefore somewhat predictable, it is not possible to separate bison at the northern boundary (Gardiner) based on subpopulation origin (Central vs. Northern) without invasive methods (e.g., permanent identification methods or on-site genetic analysis).

Loss of the central herd will harm the genetic diversity of both herds. Although separate breeding herds for over 100 years, a small level of introgression among the two subspecies occurs, promoting genetic diversity and helping avoid genetic drift and inbreeding depression, which can lead to extinction. Obviously, beneficial introgression can not continue if the central herd ceases to exist. Ironically, the original members of the northern herd were transported into the park in 1902 to promote the genetic diversity of the indigenous central herd.

If Yellowstone's wild bison continue to be managed as one herd, extinction of both herds may occur, according to simulation studies by theoretical ecologist Stephen P. Ellner.

At Yellowstone the rule of thumb is maladaptive management. Park biologists are not learning and are not adapting.

In setting a lethal-removal goal of up to 1,250 bison in "Status Report on the Yellowstone Bison Population, September 2017," park biologists have again recommended more heavily culling the northern herd, but have no idea how to carry that out. What *is* known is that usually it is the central herd that is culled most heavily, since they are the migratory. If one subtracts 1,250 animals from 850 animals, that is, the present population of the central herd, the result is the central herd's extinction—the obliteration of millions of years of evolution.

The existing regulatory mechanisms that govern the park's wild bison and their range are inadequate. Historically, their range included habitat outside the park now designated Custer Gallatin National Forests, which contains Gardiner Basin and Hebgen Basin. Use of the national forests is governed by the Multiple-Use Sustained-Yield Act of 1960, which stipulates that "the national forests are established and shall be administered for outdoor recreation, range, timber, watershed, and wildlife and fish purposes," directing the "renewable surface resources" to be developed for "multiple use and sustained yield," and that "due consideration shall be given to the relative values of the various resources in particular areas." The act states that "The establishment and maintenance of areas of wilderness are consistent with the purposes and provisions of this Act."

Ranchers claim the right to graze cattle on national forest and public lands, claiming the multiple-use mandate gives that right, but disregard that such use must also provide sustained yield. According to the act, sustained yield is defined as "the achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable resources of the national forests without impairment of the productivity of the land.

Spending $3 million annually to separate bison from cattle to protect domestic animals in a biohazardous environment, driving a species to extinction in the process of doing this, and killing wolves and other predators to boot, to protect cattle grazing in a wilderness is not sustained yield. It is sustained loss.

Instead of reducing wild bison populations by culling, they should be allowed to increase to reach a minimum viable population of at least 7,000 for each herd, with both herds being equal in size. Further, the number of wild bison should be determined by natural selection, that is, by the park's carrying capacity, predation, disease and weather, as well as by regulated hunting. Yellowstone's wild bison are a tribal trust resource—a natural resource protected by treaty rights—requiring the federal government to work with the tribes for their conservation and to respect the exercise of tribal sovereignty over them.

A *cordon sanitaire* prohibiting the grazing of cattle on the grasslands of these wildlife habitats should be instituted beyond the borders of the park. Only by doing so can the disease of brucellosis be controlled from spreading out of the park while maintaining viable herds of wild bison and elk, both of which have the disease and pose a biohazard nationwide in the presence of cattle.

To avoid irrevocable extinction, this petition requests that the FWS order an emergency listing while considering the merits of this petiton seeking permanent listing.

Introduction

Yellowstone National Park is the last remaining reservoir of *Brucella abortus* in the nation. The bacteria causes a zoonotic disease that can infect humans and make cattle, bison and elk abort their young. The disease, called brucellosis, has cost billions of dollars to control nationwide. But here in Yellowstone it remains. In this biohazardous setting, cattle are fattened every spring and summer just outside the park, exposing these domestic animals to the transmission of brucellosis. The disease would be impossible to eradicate from the park without killing almost all the bison and elk in the park, since both have the disease. But under present park management, only bison are being killed under the mistaken notion that this will control the spread out of the park. If this futile epidemiology is continued, someday the disease will explode beyond the park's boundaries, causing millions of dollar to abate. This is a petition to the Department of the Interior to stop the senseless culling of wild bison, a practice that is driving this species to extinction.

It is the winter of 2015, the thirteenth day of February. Yellowstone National Park is in the process of capturing and slaughtering its iconic wild bison in an attempt to reach its goal of eliminating 900 this year and 900 next year, 100 percent of which are migratory. It is an artificially-selective process. Many of the animals are pregnant. Many of the mothers are followed by their calves. The non-migratory do not try to leave the park and thus do not get into the trap prepared for them, a funnel of fencing that leads into a stockade called Stephens Creek capture facility.

The bison escorts—our very own protectors of the park, the Yellowstone rangers—are mounted on horses to drive them into this funnel. They yell "Hey, hey, hey, yo, yo, yo!" as though they were herding cattle. Outside the facility, which is built on park land not far from the north entrance, is parked an array of pickups and livestock trailers. This is the staff's busiest time of year.

Once the bison enter the open arms of the fan of fencing, there is no return. They find themselves in a high-walled enclosure—the capture facility. Above them are rangers on catwalks manipulating ropes that open and close doors in the labyrinth of passageways, forcing the animals into its center. On the floor of the catwalk near a ranger are a whip and a cattle prod. The animals are processed through a series of narrowing corridors, sorted, immobilized in a hydraulic squeeze chute for testing, tagged and eventually marched single file onto a loading ramp, where they will enter the open doors of a livestock trailer. The doors will be shut and sealed by an official from the U.S. Department of Agriculture. Sometimes an entire family of bison, including mothers with calves, are trapped together. In fear they urinate, defecate, abort and bash the metal enclosure with their shaggy heads, some breaking off a horn, the bloody shard left hanging. From here they go on a long ride to the slaughterhouse. The area around the facility is closed to the public year-round.

While this is transpiring, hunting is still ongoing. Bison hunting is allowed in Montana from November 15 to February 15. Hunters can call Montana Fish, Wildlife and Park's buffalo hunt “hotline” or regional office for information about the location of bison that have come down from the higher altitudes and are leaving the park, entering the killing zone.

In 2017, 1,300 wild bison were killed this way. Culling up to 1,250 is scheduled for early 2018.

Yellowstone’s wild bison are being driven to extinction by a conflict between mutualists. Mutualists are two different species that share the same habitat and help each other survive by protecting one another. They engage in a symbiotic relationship that benefits both. In Yellowstone, Indian tribes historically were mutualists with wild bison, helping each other survive for the last 10,000 years, while more recently ranchers have been mutualists with cattle here. However, when one group of mutualists does not want to share a habitat with another group, conflict arises. Such a clash contributed to the destruction of the vast wild bison herds of the Great Plains, when settlers killed millions, eliminating much of the tribes' ability to sustain themselves as they had in the past, leaving the few wild bison that survived unprotected.

More specifically, a mutualistic relationship is when two species evolve together, working for the benefit of each other. Each is part of the other’s environment and as they adapt to it, they make use of one another in a way that helps both survive. An example is the ant and the aphid. Ants herd aphids, milking them like cows, and kill ladybird beetles, which prey on aphids. In the Yellowstone area, ranchers herd cattle, and wild bison are killed to keep them away from the grasslands on which cattle graze just outside the park. The two groups have radically different relationships with wild bison: American Indians are mutualists, while the ranchers’ relationship is parasitic.

Historically, European settlers depended on bison for food, but following the Civil War, the government, in an effort to subjugate the Plains Indians, allowed buffalo hunters to decimate the vast herds of bison, thereby gaining control of the plains to make way for ranching, agriculture and the transcontinental railroad.

Multiple millions of bison were killed in what today would be considered an act of genocide, for a race's food supply was destroyed.

Today, thousands of bison in the Greater Yellowstone Ecosystem have been culled by the government in an effort publicized as a means of controlling the spread of brucellosis, a disease deemed a threat to cattle which are shipped into the region in the spring. It is a futile effort at disease control, for the park's elk, which also have the disease, are allowed to mingle with the cattle. The impossibility of controlling the shedding of brucellosis in the park by excluding only bison, while elk roam everywhere is shown by Figure 3 below. Where cattle graze (black), *both* elk and bison shed brucellosis (gray areas). Culling bison focuses on Gardiner Basin.

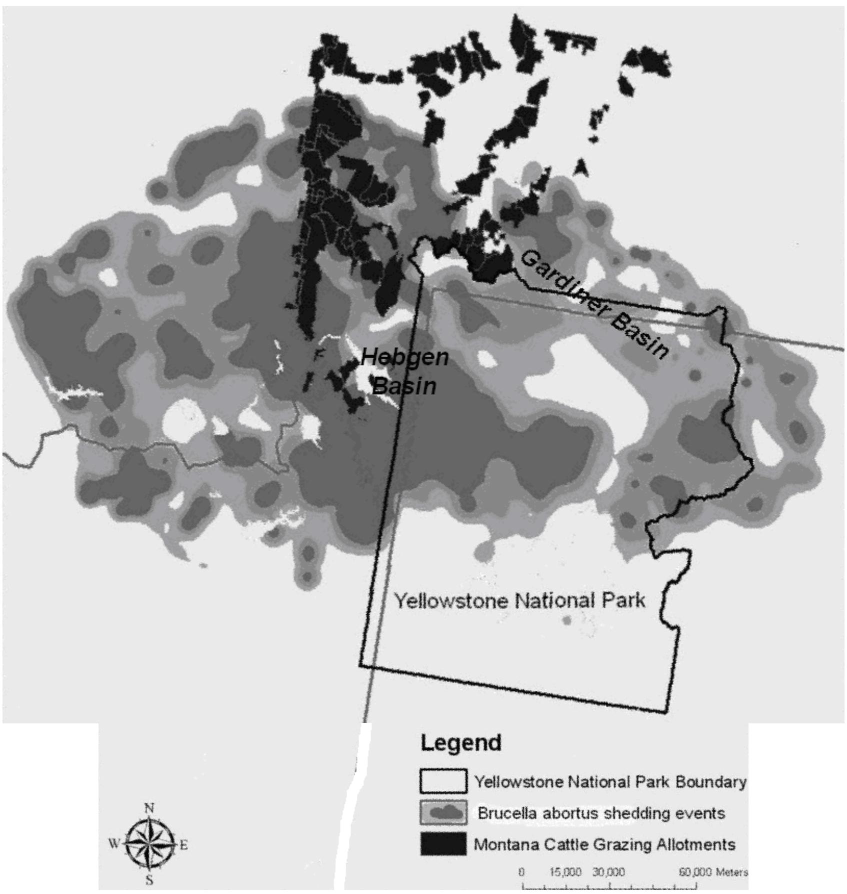


Figure 3. MAP OF TOTAL B. ABORTUS SHEDDING EVENTS from bison and elk populations during June in the northern portion of the greater Yellowstone area based on an average winter. Montana cattle grazing allotments are in black. Darker gray areas indicate higher levels of shedding while lighter gray areas indicate lower levels of shedding. ***Adapted from Schumaker, 2010, p. 69.***

Our government has subjugated American Indians by not allowing them to live on the land, that is, to substantially live off what is wild. This has been done by killing off what is wild and by fragmenting essential habitat for wildlife. Mutualists with wildlife include the Columbia Basin Indians and salmon and, as mentioned, the Plains Indians and bison. With the protectors of salmon and bison forced out of the picture and restricted to reservations, putting the land out of their control, the numbers of wild salmon and wild bison have plummeted.

Our government is still bent on destroying the backbone of the Plains Indian culture—wild bison—as they were when they reduced herds from millions down to twenty or so animals in the late 1800s. Those surviving remnants were the wild bison in Yellowstone. Last year, 2017, will go down in history as one of the greatest slaughters, proportionally, of what is left of wild bison on earth, that remote herd of bison in the park. It is the only herd that has remained on the same land to which its ancestors migrated in prehistoric times, specifically, the native herd, called the central herd, as opposed to the northern herd, a herd introduced a little over a hundred years ago into the park. The central herd numbered 1,283 bison in 2016. Following their large-scale culling, in 2017 the herd now numbers 847 animals, while the northern herd numbers 4,000 animals. For the central herd, that is almost a 50 percent reduction—creating a high potential for loss of genetic diversity and an increase in inbreeding depression—a result of two bottlenecks, one during the great slaughter in the 1870s and the other ongoing over a period of the last two decades due to government culling.

Wild bison are caught in a cultural and natural resource war between those who have traditionally hunted these animals for sustenance and those who want nothing but cattle and other domestic ungulates in their place. Behind this range war is a band of government agencies, specifically, three federal agencies: the National Park Service, Forest Service, and Animal and Plant Health Inspection Service, and two state agencies: Montana's Department of Livestock and the Department of Fish, Wildlife and Parks. This coalition is called the Interagency Bison Management Plan. It functions as a front for the cattle industry. It is essentially a race war, for it is continuing a history of destroying the primary and traditional food source of a hunting society through governmentally-sanctioned and -implemented culling—at this point in history the last remaining wild bison, those occupying the Greater Yellowstone Ecosystem. This interagency coalition often kills over 500 animals annually and in some years in excess of 1,000. In 2008 over 1,700 bison were killed. Such large-scale culling has driven wild bison to the brink of extinction.

The IBMP's reason for being is rooted in deception. It promotes its agenda by hiding the truth. It pretends such culling is necessary because, as mentioned, wild bison may carry brucellosis, a disease that can cause ungulates to abort. Because of this, the interagency claims it must keep wild bison separate from cattle, which are grazed on ranges contiguous to the park. Separation is achieved by hazing, and when that does not work, by slaughter. It is a useless epidemiological action, for elk also carry the disease yet are allowed to migrate and mingle with the very same cattle from which bison are separated, promoting the spread of the disease to cattle by elk.

This is all being done under the watch of Yellowstone's biologists who set the level of culling year by year. Either they do not know what they are doing, which in unlikely, or they lack the courage to do what they know should be done—stop wild bison's large-scale culling.

Historically, cattle paid a big price for their mutualistic relationship with humans. All cattle descend from a species of Eurasian wild cattle called aurochs, a large and fierce animal. Aurochs were driven into extinction by overhunting, habitat loss and disease. The last aurochs died in 1627. All that exists of this species today is the aurochs' domestic descendants--cattle. On the other hand, bison thrived in their mutualistic relationship with American Indian tribes during pre-settlement times. But they are protected no longer. They are about to pay the same price as the aurochs.

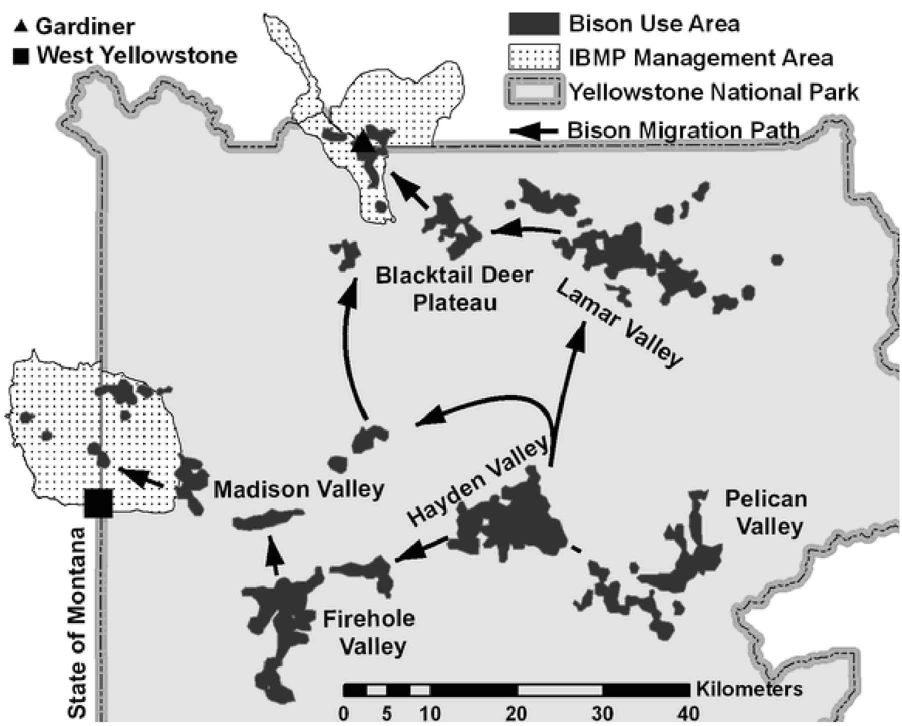


Figure 4. IBMP'S BISON CULLING AND HAZING AREAS (dotted areas called management areas), migration paths (arrows), and bison use areas, (black shaded areas, both herds) (Geremia, 2011). As of 2015, bison are allowed to use a portion of IBMP management area (Horse Butte) year-round at Hebgen Basin near West Yellowstone (Wright, 2015). Northern herd (Lamar Valley region) migrates north, while central herd (Hayden Valley region) migrates both north and west.

The only way to stop this relentless process of extinction is by obtaining the protection of wild bison through listing in the Federal Register the two subspecies here, that is, the central and northern herds, as endangered or threatened under the provisions of the Endangered Species Act. This petition has been submitted to the Secretary of the Department of the Interior to accomplish that end.

1

Depopulation of Yellowstone's native wild bison herd

Two wild bison subspecies inhabit Yellowstone National Park—the endemic herd that migrated here more than 10,000 years ago, called the central herd, and the introduced herd that was shipped here a little more than 100 years ago, called the northern herd. The central herd is composed of the evolutionary descendants of wood bison, also know as mountain bison, the subspecies *Bison bison athabascae.* As a herd, they have never been removed from the Yellowstone area to which they came in prehistoric times. The northern herd is composed of the evolutionary descendants of 22 captive female plains bison, brought here in 1902 to supplement the 22 indigenous remaining bison so as to develop a new breeding herd in the northern region of the park. However, two separate breeding herds still remain over one-hundred years after that introduction.

This winter may factually be the last time the central herd will come down from the park's central valleys to Gardiner Basin—where they go to seek forage for survival and where they are culled in droves each year inside the park—for by spring they most likely will be gone, culled by hunting squads and the Stephens Creek capture facility's ship-to-slaughter operation. In 2017 the two separate breeding herds of the park totaled 4,816 following a devastating disproportionate large-scale cull of 1,274 bison, leaving the northern herd with about 4,000 animals and the central herd, once the most populous, genetically and environmentally endangered, with only about 850 animals.

Incomprehensibly, biologists of Yellowstone National Park have publically written off the central herd, stating so in the *Journal of Heredity* as not needing preservation efforts, and are recommending courses of action that, if continued, could end in the extermination of the park's central wild bison herd in 2018.

The central herd is the herd that contributed to the Fish and Wildlife Service designating Yellowstone's wild bison as a distinct population segment (DPS), that is, a unique subspecies. In 2016 Chris Geremia, Rick Wallen and P. J. White, biologists with the Yellowstone Center for Resources, Yellowstone National Park, recommended to members of the Interagency Bison Management Plan in "Status Report on the Yellowstone Bison Population, September 2016" lethally removing for the coming winter of 2016-17 "less than 25% of the total summer population to reduce potential demographic effects," specifying culling between 900 and 1,400 bison. In 2016 the total population was 5,459 bison. With 1,451 bison in the central herd, the authors stated the culling objective should:

> Focus population management reductions on the northern herd. Under severe weather conditions, we anticipate a large migration of bison into the northern management area that could exceed 2,000 animals . . . There are currently nearly 4,000 animals in the northern herd and we recommend reducing the northern herd towards 3,000 animals.

The IBMP met its goal set by the biologists with the lethal removal of almost 1,300 wild bison in 2017. But how did they go about making sure the goal of reducing the northern herd to 3,000 animals was met, so as to spare the central herd?

Curious, I wrote Wallen on April 3, 2017 before the annual aerial summer count of the two herds was conducted, asking him, among other questions, the following:

> 2. How many of those animals lethally removed were from the Northern herd and how many from the Central herd?
>
> 3. For those animals that enter Zones 1 or 2 at Gardiner Basin, how does the IBMP determine what bison are from what herd prior to the act of culling?

Wallen responded the next day:

> There is no way to answer your 2nd question. We conduct aerial surveys during the summer months to count bison throughout the park and that is the time we can judge how each breeding group in the park may have been affected by the previous winters management actions.
>
> We have a monitoring program in which we track a representative sample of bison from each breeding group using radio telemetry methods. Through the years of monitoring we know that a portion of the central range bison migrate to the northern range and mingle with the northern range residents. (Rick Wallen, personal communication, April 4, 2017).

In other words, even with radio telemetry, which tracks a few animals as a *sample* and not the actual presence of a herd member about to be culled, there is no way to tell what animals from what herds are being culled prior to culling. The rangers find out by counting what population is left in each herd come summer. It is a crap shoot with the dice loaded against the central herd.

The reason for disregarding the population status of the central herd is outlined by White and Wallen in a letter to the editor published in a 2012 issue of the *Journal of Heredity* titled "Yellowstone Bison—Should We Preserve Artificial Population Substructure or Rely on Ecological Processes?" It was written in response to a study published in the same journal earlier that found two genetically distinct breeding herds in the park: the central and northern herds.

The gist of the letter was that even though there are "2 genetically distinct subpopulations (central, northern) based on genotypic diversity and allelic distributions" "there is evidence that the existing genetic substructure was artificially created," that is, by the introduction of plains bison into the park at the turn of the last century. Given that, the authors of the letter concluded:

> 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.

To allow natural selection to operate is sound wildlife management policy. However, culling is not natural selection, it is artificial selection. Further, in the hands of park biologists and managers what is proposed is often not followed. For instance, White and Wallen in their letter state:

> total population abundance is not the only primary factor considered in determining management actions for Yellowstone bison. As an example, the management plan for Yellowstone bison during winter 2012 clearly indicates a desire to progress toward approximately equal numbers of bison in each breeding herd and selectively cull bison from the northern herd (which is currently larger), while minimizing removals from the central herd (Geremia et al. 2012) (White et al., 2012).

Since the writing of their letter to the editor, the northern herd has experienced an increase in population of 49 percent, while the central herd has decreased by 46 percent, the differential solely due to culling by the IBMP, with culling levels set by the very biologists who wrote the letter to the editor quoted. In the case of Yellowstone's bison, culls target those with migratory behavior. Intervention by humans, which the authors of the letter decry and term "artificial," is magnified under their management through the recommendation, implementation and continuation of large-scale culling.

Yellowstone biologists are not learning from experience nor taking remedial action to fix the population imbalance, contrary to Department of Interior management protocol called "Adaptive Management," a formal process that involves learning from experience and taking corrective action, often using mathematical computer simulation models to predict ecological outcomes of planned actions, with one of the most popular models based on Bayesian probability analysis, a sophisticated, complex method of predicting what will happen in the future, given present trends, such as animal population increases or decreases. The populations of Yellowstone's two separate and distinct wild bison herds continue to diverge in the face of abundant evidence that a drastic decline of the central herd's numbers is transpiring.

Witness the most recent results of this management failure to address this critical issue fundamental to the continued survival of Yellowstone's bison. On August 4-5, 2017, an aerial survey of the park counted only 847 wild bison in the central herd, but 3,969 in the northern herd, reducing the herd from 5,459 to a total remaining population count of 4,816 for a total populations loss, including births, of 643 animals, as reported by Geremia, Wallen and White in "Status Report on the Yellowstone Bison Population, September 2017." This represents a reduction from the previous year of 42-48 percent for the central herd, 1 percent for the northern herd and 12 percent for the total herd. Obviously, this is not keeping the herds equal in size.

The park-approved decimation by the IBMP of its wild bison population disproportionately affects the central herd, is out of control and has been ongoing. In the status report for 2014, the trio stated "We recommend removing 900 bison during the forthcoming winter" from a total population of 4,865, with 1,441 in the central herd and 3,424 in the northern herd. A total of 737 animals were lethally removed, leaving a summer population in 2015 of 4,910, with 1,282 in the central herd and 3,627 in the northern herd. In the status report for 2015 they stated "We recommend removing 1,000 bison during the forthcoming winter" and that "Removal recommendations for last winter were aimed to allow central herd growth and reduce the size of the northern herd." A total of 552 were culled, leaving a population of 1,451 in the central herd and 4,008 in the northern herd.

The 2017 culling was the second largest in park history. Out of a dramatically dwindled population of 847 animals, the central herd now has less than 300 mature females left to propagate. The 2017 status report noted, "In addition, biologists counted less than 300 adult female bison in the central herd during aerial surveys in summer 2017." Despite the population crash of the central herd, biologists Geremia, Wallen and White recommend for 2018 the following:

> About 600 bison would need to be removed from the population during winter 2017-2018 to stabilize population growth. The removal of 1,000 bison (about 20% of the population) would likely decrease bison numbers to about 4,400

> after calving next summer. We do not recommend removing more than 1,250 bison, which would be greater than 25% of the current population.

Again, lethal removals were to be focused on the northern herd. The report stated:

> Focus population management reductions on the northern herd by using location information from radio-collared bison to inform the timing and magnitude of bison captures near the northern park boundary such that captures primarily remove bison that lived and bred in northern Yellowstone during summer 2017.

The 2017 status report noted:

> In addition, we monitored 49 adult females using radio telemetry collars during June 1, 2016 through May 31, 2017 for survival and detected a single natural mortality of a 15 year-old in central Yellowstone that died during June 2016. Human harvest continued to be the overwhelming source of mortality. . .

However, despite such monitoring, the central herd was disproportionately culled at a ratio of 50 percent versus one percent. As a remedy, the authors plan more of the same—to increase the number monitored and to evaluate the genetics of the two herds:

> Vital rates, demographic composition, movements, and genetic structure are important aspects of the bison population that require continued monitoring to ensure undesired impacts are not occurring. We intend to increase the number of radio-collared females in central Yellowstone prior to winter 2017-2018 to help track movements of central herd bison into northern areas of the park as winter progresses. Additionally, we intend to continue collaborative genetic studies with Texas A&M University to further evaluate distributions of the endemic and introduced lineages of Yellowstone bison.

But, despite these efforts, culling remains a crapshoot with the dice still loaded against the central herd because this is the herd that is overwhelmingly the more migratory of the two herds and, again, only a sample is being measured by radio telemetry. Such pre-culling sampling in the past has had no effect whatsoever on the number culled from either herd, nor will it in the future.

Culling by the IBMP targets female bison. The three biologists observed:

> The decrease in adult females was probably not due to natural mortality because 11 of 12 radio-collared females in central Yellowstone did not die during winter 2016-2017 due to natural causes such as accidents, predation, or

> starvation. Rather, several hundred bison likely migrated from central to northern Yellowstone during winter in groups consisting of adult females and young animals. Many of these bison were likely removed (cull, harvest) near the northern park boundary or remained in northern Yellowstone during summer 2017.

Since, according to the 2017 status report, "Groups consisting of pregnant females and young animals appear to disproportionately migrate outside the park during years with severe winter conditions," since "The sex ratio of adult bison removed was 30% males and 70% females," and since the last culling reduced the population of the central herd by up to 48 percent, given heavy winter migration, the probability is high that at any of the levels of culling recommended, the reproductive potential of the central herd would be terminated, ending in its extinction.

The 2017 lethal removals were the second largest culling of wild bison in the history of the park. The largest culling was 1,726 in 2007-2008. It reduced the northern herd by 570 animals, from 2,070 to 1,500, while the central herd was reduced by 1,155 animals, from 2,624 to 1469. By 2016, the northern herd had grown by 167 percent, while the central herd's growth had flattened. And then in 2017 culling whittled it down to almost half its size the year before.

The report's tabulated data on the number of bison removed from the park and nearby areas of Montana during winter from 1985 to 2017 reveal dramatic fluctuations in population size, caused primarily by culling and hunting, but also by winterkill (starvation), predation and disease. (see below Tables 1 and 2, Figures 5 and 6, this petition, first volume).

The population of the two herds has diverged sharply since 1985 when the central herd numbered 1,552 animals and the northern herd 695. The first culling of over 1,000 animals was experienced in the winter of 1996-1997 when a total of 1,083 animals were lethally removed, reducing the population from 3,584 to 2,170, a 40 percent decrease. The northern herd experienced the greatest reduction, from 860 animals to 455, a 47 percent decrease, while the central herd fell from 2,724 to 1,715, a 37 percent decrease. However, while the central herd that year had less of a percentage loss than the northern herd, it was at a price: a numerical loss of 1,009 animals, compared to 405 for the northern herd. But thereafter, the central herd has been hit the hardest. Since 1996-97, the northern herd has risen from 860 to 3,969 animals in 2017, an increase of over four-fold, while the central herd has gone from 3,584 to 847, a decrease of over four-fold.

The 2017 culling has almost wiped out the central herd. Recall, this is the herd whose ancestors migrated to these parts over 10,000 years ago and has remained on this land since then. It is this herd that is responsible for the Fish and Wildlife Service designating in 2007 (and then again in 2015) the park's wild bison as a distinct population segment, that is, a unique subspecies. It is this herd that survived the great slaughter of the late 1800s that reduced bison from multiple millions down to possibly 100 animals. Most of those that survived had been captured and put on ranches. Only about 23 bison survived in the wild—those that huddled in remote portions of what is now Yellowstone National Park. In the early 1900s a small herd of plains bison was introduced into the park. The two herds have co-existed since then, remaining in substantially separate breeding herds.

Table 1. Numbers of bison removed from Yellowstone National Park or nearby areas of Montana during winters from 1970 to 2016.

	Maximum No. Bison Counted Previous July-August			Sent to Slaughter/ Management Culls		Hunter Harvest[a]		Sent to Quarantine		Total	Age and Gender Composition of Culls/Harvests			
Winter	North	Central	Total	North	West	North	West	North	West		Male	Female	Calf	Unknown
1970-84				0	0	13	0	0	0	13	4	7	0	2
1985	695	1,552	2,247	0	0	88	0	0	0	88	42	37	8	1
1986	742	1,609	2,351	0	0	41	16	0	0	57	42	15	0	0
1987	998	1,778	2,776	0	0	0	7	0	0	7	5	2	0	0
1988	940	2,036	2,976	0	0	2	37	0	0	39	27	7	0	5
1989	NA[b]	NA[b]	NA[b]	0	0	567	2	0	0	569	295	221	53	0
1990	592	1,885	2,477	0	0	1	3	0	0	4	0	0	0	4
1991	818	2,203	3,021	0	0	0	14	0	0	14	0	0	0	14
1992	822	2,290	3,112	249	22	0	0	0	0	271	113	95	41	22
1993	681	2,676	3,357	0	79	0	0	0	0	79	9	8	9	53
1994	686	2,635	3,321	0	5	0	0	0	0	5	0	0	0	5
1995	1,140	2,974	4,114	307	119	0	0	0	0	426	77	66	31	252
1996	866	3,062	3,928	26	344	0	0	0	0	370[c]	100	71	10	189
1997	785	2,593	3,378	725	358	0	0	0	0	1,083[d]	329	330	144	280
1998	455	1,715	2,170	0	11	0	0	0	0	11	0	0	0	11
1999	493	1,399	1,892	0	94	0	0	0	0	94	44	49	1	0
2000	540	1,904	2,444	0	0	0	0	0	0	0	0	0	0	0
2001	508	1,924	2,432	0	6	0	0	0	0	6	6	0	0	0
2002	719	2,564	3,283	0	202	0	0	0	0	202	60	42	16	84
2003	813	2,902	3,715	231	13	0	0	0	0	244	75	98	43	28
2004	888	2,923	3,811	267	15	0	0	0	0	282	58	179	23	22
2005	876	3,339	4,215	1	96	0	0	0	17	114	23	54	20	17
2006	1,484	3,531	5,015	861	56	32	8	87	0	1,044	205	513	245	81
2007	1,377	2,512	3,889	0	4	47	12	0	0	63	53	6	0	4
2008	2,070	2,624	4,694	1,288	160	59	107	112	0	1,726	516	632	332	246
2009	1,500	1,469	2,969	0	4	1	0	0	0	5	5	0	0	0
2010	1,839	1,462	3,301	3	0	4	0	0	0	7	7	0	0	0
2011	2,245	1,653	3,898	6	0	Unk	Unk	53	0	260	106	102	52	0
2012	2,314	1,406	3,720	0	0	15	13	0	0	28	14	12	2	0
2013	2,669	1,561	4,230	0	0	148	81	0	0	250	116	85	28	0
2014	3,420	1,504	4,924	258	0	258	69	60	0	645	202	287	152	4
2015	3,421	1,444	4,865	511	0	201	18	7	0	737	276	297	161	3
2016	3,627	1,283	4,910	101	0	378	24	49	0	552	175	227	146	4

a. Total includes bison harvested by game wardens and State of Montana hunters during 1973 through 1991, and state and tribal hunters after 2000.

b. Aerial survey data not available during summer survey period (July-August).

c. The Final Environmental Impact Statement reported 433 bison, but records maintained by Yellowstone National Park only indicate 370 bison.

d. Total does not include an unknown number of bison (less than 100) captured at the north boundary and consigned to a research facility at Texas A&M University (Status Report on the Yellowstone Bison Population, September 2016).

Table 2. Numbers of bison removed from Yellowstone National Park or nearby areas of Montana during winters from 1970 to 2017 (revised).

	Maximum No. Bison Counted Previous June-August[h]			Sent to Slaughter/ Management Culls		Hunter Harvest[a]		Sent to Quarantine Research		Total	Age and Gender Composition of Culls/Harvests			
Winter	North	Central	Total	N	W	N	W	N	W		M	F	C	Unk
1970-84				0	0	13	0	0	0	13	4	7	0	2
1984-85	695	1,552	2,247	0	0	88	0	0	0	88	42	37	8	1
1985-86	742	1,609	2,351	0	0	41	16	0	0	57	42	15	0	0
1986-87	998	1,778	2,776	0	0	0	7	0	0	7	5	2	0	0
1987-88	940	2,036	2,976	0	0	2	37	0	0	39	27	7	0	5
1988-89	1,058[h]	2,089[h]	3,147[h]	0	0	567	2	0	0	569	295	221	53	0
1989-90	432[h]	2,075[h]	2,507[h]	0	0	1	3	0	0	4	0	0	0	4
1990-91	818	2,203	3,021	0	0	0	14	0	0	14	0	0	0	14
1991-92	822	2,290	3,112	249	22	0	0	0	0	271	113	95	41	22
1992-93	681	2,676	3,357	0	79	0	0	0	0	79	9	8	9	53
1993-94	636[h]	2693[h]	3329[h]	0	5	0	0	0	0	5	0	0	0	5
1994-95	1,140	2,974	4,114	307	119	0	0	0	0	426	77	66	31	252
1995-96	866	3,062	3,928	26	344	0	0	0	0	370[c]	100	71	10	189
1996-97	860[h]	2,724[h]	3,584[h]	725	358	0	0	0	0	1,083[d]	329	330	144	280
1997-98	455	1,715	2,170	0	11	0	0	0	0	11	0	0	0	11
1998-99	489[h]	1,622[h]	2,111[h]	0	94	0	0	0	0	94	44	49	1	0
1999-00	540	1,904	2,444	0	0	0	0	0	0	0	0	0	0	0
2000-01	590[h]	2,118[h]	2,708[h]	0	6	0	0	0	0	6	6	0	0	0
2001-02	719	2,564	3,283	0	202	0	0	0	0	202	60	42	16	84
2002-03	805[h]	3,240[h]	4,045	231	13	0	0	0	0	244	75	98	43	28
2003-04	888	2,923	3,811	267	15	0	0	0	0	282	58	179	23	22
2004-05	876	3,339	4,215	1	96	0	0	0	17	114	23	54	20	17
2005-06	1,484	3,531	5,015	861	56	32	8	87	0	1,044	205	513	245	81
2006-07	1,377	2,512	3,889	0	4	47	12	0	0	63	53	6	0	4
2007-08	2,070	2,624	4,694	1,288	160	59	107	112	0	1,726	516	632	332	246
2008-09	1,500	1,469	2,969	0	4	1	0	0	0	5	5	0	0	0
2009-10	1,837[h]	1,464[h]	3,301[h]	3	0	4	0	0	0	7	7	0	0	0
2010-11	2,246[h]	1,652[h]	3,898[h]	6	0	Unk	Unk	53	0	260	106	102	52	0
2011-12	2,314	1,406	3,720	0	0	15	13	0	0	28[e]	14	12	2	0
2012-13	2,669	1,561	4,230	0	0	148	81	0	0	250[f]	116	85	28	0
2013-14	3,420	1,504	4,924	258	0	258	69	60	0	645[g]	202	287	152	4
2014-15	3,424[h]	1441[h]	4,865	511	0	201	18	7	0	737	276	297	161	3
2015-16	3,627[h]	1,282[h]	4,910[h]	101	0	378	24	49	0	552	175	227	146	4
2016-17	4,008	1,451	5,459	753	0	389	97	35	0	1,274	311	585	342	36

a. Total includes bison harvested by game wardens and State of Montana hunters 1973 through 1991, and state and tribal hunters after 2000.

c. The Final Environmental Impact Statement reported 433 bison, but records maintained by Yellowstone National Park only indicate 370 bison.

d. Total does not include an unknown number of bison captured at the north boundary and consigned to a research facility at Texas A&M University (about 100 bison).

e. There is a report of 29 removals with differences owing to reported harvests.

f. There is a report of 260 removals with differences owing to reported harvests.

g. There is a report of 650 removals with differences owing to reported harvests.

h. Flight totals were reevaluated during summer 2017 using updated count areas for each herd and including flights occurring June 1-August 31 (Status Report on the Yellowstone Bison Population, September 2017).

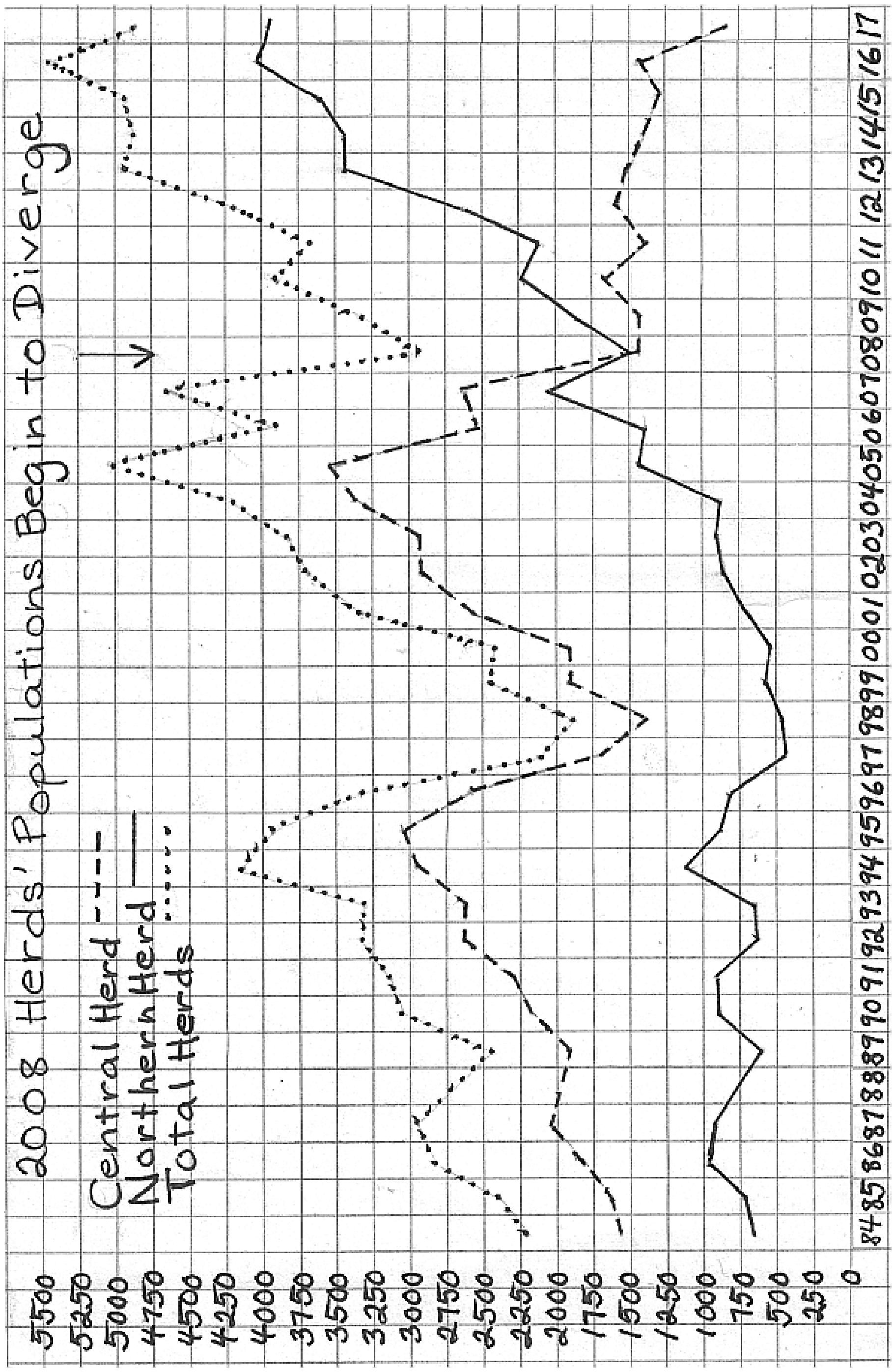


Figure 5. CENTRAL HERD'S POPULATION CRASH. Due to intensive and disproportionate culling by the IBMP, Yellowstone's endemic wild bison herd is declining, while the introduced northern herd is increasing. Population figures on left, years at bottom. ***Chart by Petitioner from Table 1 and 2.***

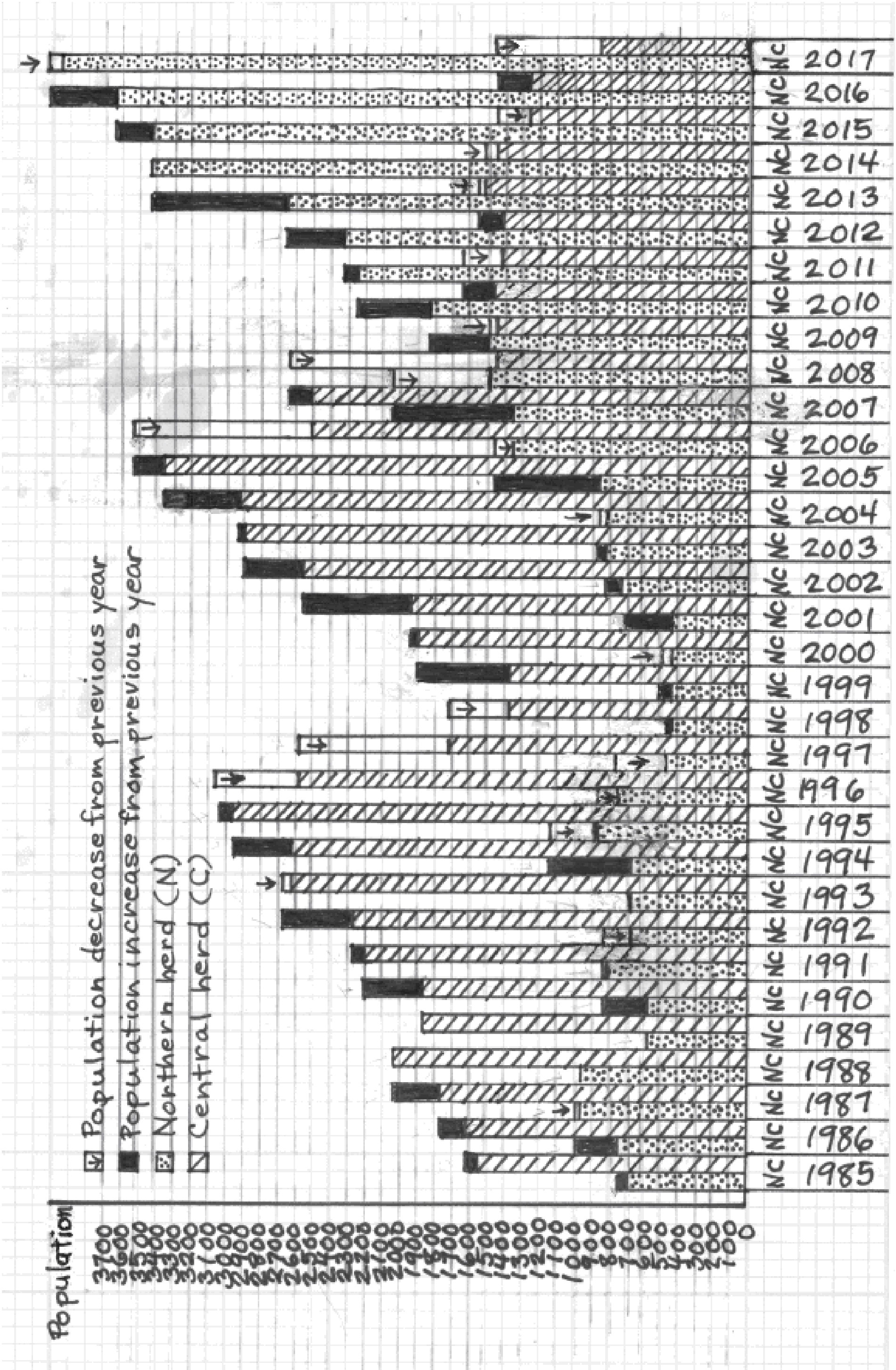


Figure 6. DISPROPORTIONATE CULLING is the result of IBMP targeting Yellowstone's central herd, with that herd bearing the brunt of lethal removals. ***Chart by Petitioner from Table 1 and 2.***

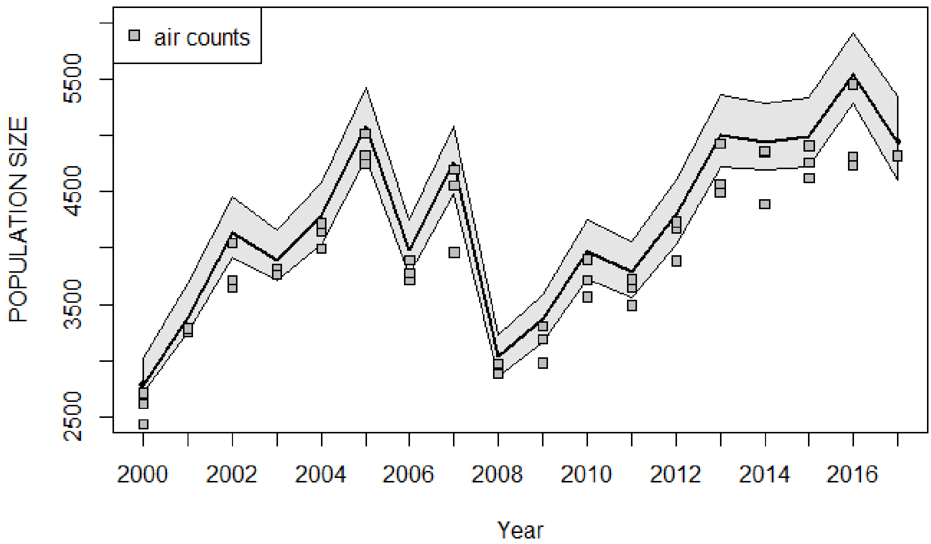


Figure 7. TOTAL ANNUAL POPULATION of both Yellowstone bison herds, as shown in IBMP's "Status Report on the Yellowstone Bison Population, September 2017," masks the crash of the central herd. Bold line connects annual estimates of total abundance during 2000 to 2017. Gray boxes represent actual numbers of bison observed during aerial counts. Gray shaded area depicts the 95% credible interval (i.e., range) around the population estimates (Geremia et al., 2017).

As can be seen in Figures 5 and 6, graphs of the data show widely divergent survival rates between the two herds beginning in 2008, when 570 animals were culled from the northern herd and 1,155 animals from the central herd. Since then, the northern herd has increased and the central herd has decreased. Years ago, the central herd outnumbered the northern herd. That demographic has been reversed, due to the systematic assault directed toward the more migratory herd, the central herd.

The downward fluctuations in population experienced by the central herd are masked by the upward fluctuations experienced by the northern herd when the two herds are totaled together as one deme. This is a stark distortion of what is really going on inside the park—the central herd is headed for extinction, if it is not genomically there already due to the massive culling and hunting that took place in the winters of 2005-2006, 2007-2008 and 2016-2017.

Historically, as the total population began to rise, the IBMP initiated increased culling goals, resulting in paradoxical increases in the northern herd and continued decreases in the central herd. Apparently, the northern herd had learned its lesson: migration does not pay, a lesson learned back in 1997 when almost half the population was destroyed—the total migrating population. The northern herd has substantially stopped migrating since then and is surviving.

The central herd never recovered from the total lethal removal of 1,726 animals from both herds the winter of 2007-2008. Due to the large-scale culling in 2016-2017, as well as prior years, the central herd is endangered because of the low size of its census population and effective population. If the recommended population reduction for the winter of 2017-2018 of 1,250 animals is met, it could totally destroy the central herd, which numbers 847 animals. If remnants of the herd survive, its low effective population size could increase the potential for inbreeding and genetic drift, setting the stage for a rapid decline to extinction, even if rescued by listing.

The central herd is not learning its lesson as meted out by the IBMP—what is left of it is still migrating, a migration that leads to the Stephens Creek capture facility and shipment to a slaughterhouse. The herd is perishing right before the very eyes of those who are supposed to be protecting it.

Part of the reason is that the FWS, in its 90-day findings, considers only total populations of the two herds and reasons that, due to total abundance, Yellowstone bison are doing just fine. The other part is Yellowstone biologists' inability or refusal to keep the two herds equal in size when culling—their stated goal.

If both herds had been kept at equal levels, this skewing of proportions would not have happened. But all too true to form, wildlife managers' actions did not match their words.

Instead of acting on the information it had in hand about the threatened status of the central herd, the IBMP, on the recommendation of the Yellowstone biologists, set as a goal the lethal removal of 1,300 wild bison for 2017 and met that goal. And this is adaptive wildlife management? No, this is astoundingly bad wildlife management.

The cull of 1,300 wild bison was a result of park biologists setting a lethal removal goal of 1,300 in the summer and then reaching that goal in the winter. If park biologists had used adaptive management practices, they would have determined the likelihood of the percentage level of population reduction for the at-risk central herd compared to the northern herd. They would have had to use a mathematical analysis to do this, because park biologists do not know what animals come from what herd at the time of culling.

Bayesian probability analysis could have been used to achieve an accurate guess, but was not. But even a rough, back-of-the-envelope calculation could have shown the risk involved for the central herd with such a massive cull. The prior three large-scale culls on average reduced the central herd by 35.3 percent: 1997 (33 percent), 2006 (29 percent) and 2008 (44 percent). If this average reduction was applied to the cull of 2017, it would have meant a reduction of 459 bison from a population of 1,283, leaving a population of 824 animals. As it turned out, the surviving population of the central herd was about that amount—847 animals.

Instead of adaptively managing the lethal removal levels, Yellowstone biologists played dumb to the impending endangerment of the central herd and saw to it that wild bison were culled to the maximum in complete disregard for subpopulations they previously stated merited equal conservation.

Thomas Pringle, a molecular biologist on the genomic team for the University of California at Santa Cruz, compared the state of Yellowstone's wild bison to that of the last mammoths, which went extinct over 4,000 years ago on Wrangel Island, a mountainous island off the Siberian coast in the Arctic Ocean.

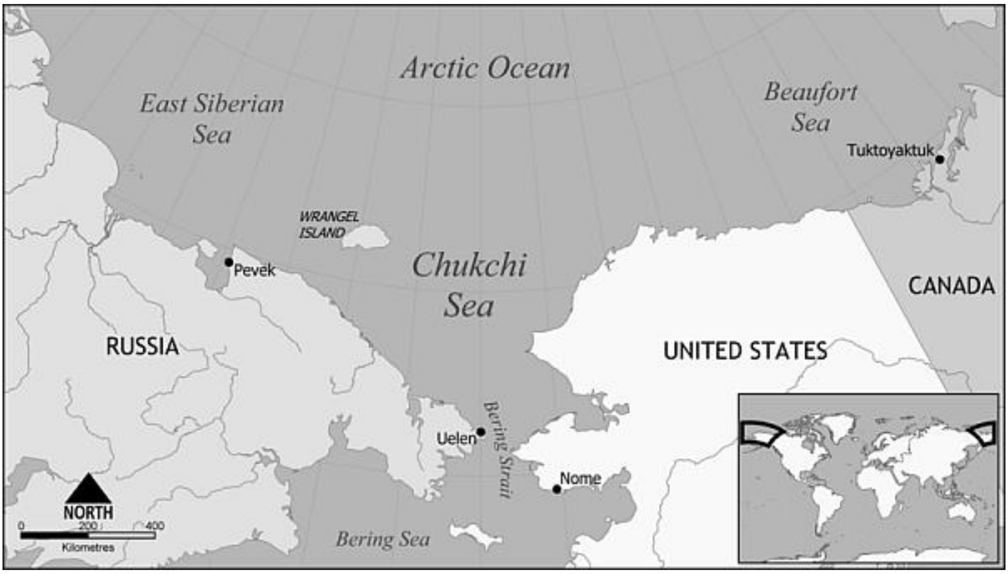


Figure 8. WRANGEL ISLAND, with an area of about 3,000 square miles and where the last of the wooly mammoths went extinct, is about the same size as Yellowstone National Park, with an area of about 3,500 square miles. ***From Wikimedia Commons. Created by Norman Einstein, May 31, 2006.***

Woolly mammoths, which roamed across Eurasia and North America by the tens of thousands, went extinct about 10,000 years ago on the mainland, but small populations persisted on islands, isolated from human contact. To find out what made them go extinct, researchers in 2017 compared the complete DNA sequence from a 4,300-year-old mammoth bone found on Wrangel Island with that of a 45,000-year-old specimen that lived on the Siberian mainland. They found that a series of harmful genetic mutations appears to have led to what authors call a "genomic meltdown" in the population. Harmful mutations are predicted to build up in small, isolated populations that become inbred (Price, 2017).

With years of successive government culling, the central herd, trapped on the "island" of Yellowstone National Park, has been reduced to a fraction of its population only a decade ago, making it vulnerable to inbreeding and an irreversible decline into extinction.

"In bottlenecked species like bison or the last mammoths on Wrangel Island, the situation is invariably far worse because deleterious alleles attain high frequency of homozygosity over time, despite Darwinian selection against it. There's nobody else left to mate with," Pringle said.

"Bison will prove worse off than the Wrangle Island mammoths because the bottlenecking was far worse," he said, adding, "I find the 'shoot first, ask questions later' approach of NPS to be appalling. They needed to first learn what they had before embarking on irreversible massive slaughters that have a serious risk of wiping out important reservoirs of left-over genetic health diversity" (Thomas Pringle, personal communication, December 13, 2017).

At the end of 2017, the breeding population of the central herd is down to 300 animals (Geremia et al., 2017). This is a catastrophic loss. But, as bad as this is, genetics is not the immediate concern. Culling in early 2018 is set to lethally remove up to 1,250 animals. With only 847 animals remaining, say goodbye to the central herd, the last wild bison left on earth.

2

Heterozygosity and other genetic terms

To grasp the deleterious effect IBMP's present culling practices is having on the genetic diversity and continued existence of the park's wild bison herds, an understanding of such terms as heterozygosity, allelic diversity, genetic drift, effective population size and minimum viable population is important.

These terms all involve the basic unit of heredity, the gene, which controls the characteristics, that is, traits or behaviors that a parent's offspring will have following the fusion of sperm with egg through fertilization. It is this combination that transmits the recipe for the new individual's cellular structure and function. Each gene is found at a certain location, called a locus (plural loci), on a pair of chromosomes, threadlike structures of DNA inside the nucleus of a cell. Genes mutate and can take two or more alternative forms, each form called an allele. For example, the gene for eye color has several variations (alleles) such as an allele for blue eye color or an allele for brown eyes. An allele is found at a fixed spot on a chromosome. Chromosomes occur in pairs so organisms have two alleles for each gene—one allele in each chromosome in the pair. Since each chromosome in the pair comes from a different parent, organisms inherit one allele from each parent for each gene. The two alleles inherited from parents may be the same (homozygous) or different (heterozygous). High heterozygosity is equated with greater genetic diversity and a higher potential for survival in a changing environment because a parent has more genetic alternatives for an offspring to inherit.

The word heterozygosity comes from the word heterozygote, whose etymology is from Greek "heteros," meaning different, and "zygotos," meaning yoked, that is, a harness, collar or coupling.

A heterozygote is defined as "an organism whose somatic cells have two different allelomorphic genes on the same locus of each pair of chromosomes. It can produce two different types of gametes." A gamete is a cell whose nucleus unites with that of another cell to form a new organism. Animal egg and sperm cells are gametes. A gamete contains only a single (haploid) set of chromosomes. Gametes are formed during cell division (meiosis) when the alleles for each gene segregate from one another. As a result, each gamete contains only one allele per gene. On fertilization, when these cells unite, the new cells are called zygotes. The zygote develops into the embryo following the instruction encoded in its genetic material.

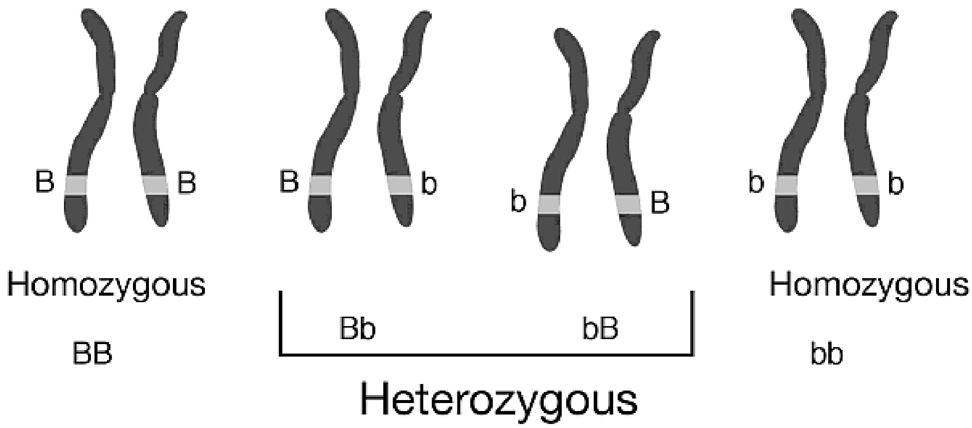


Figure 9. HETEROZYGOUS refers to having inherited different forms of a particular gene from each parent. A heterozygous genotype stands in contrast to a homozygous genotype, where an individual inherits identical forms of a particular gene from each parent. ***Author: Darryl Leja, National Human Genome Research Institute, June 12, 2010. Work in public domain.***

More simply put, heterozygous means two different forms (alleles) of a trait (such as eye color) are yoked together side by side on two strands of chromosomes at the same location. The same two forms or the dominant form when linked together through fertilization will be the trait that is expressed in the animal or plant produced.

What does this mean in a real life animal or plant? Let us take a look at pea plants. A gene is composed of a pair of alleles. The gene for seed shape in pea plants exists in two forms, one form or allele for a round seed shape, which can be denoted as “R” and the other for a wrinkled seed shape “r.” A heterozygous plant would contain the following alleles for seed shape: (Rr). One of the pairs is dominant and the other is recessive. In the case of peas, the round seed shape R is dominant and wrinkled seed shape r is recessive.

When these forms are combined following pollination and fertilization, this outcome can be produced: a plant with round seeds by means of the combination (RR) or (Rr), or wrinkled seeds (rr).

A heterozygous plant would contain the alleles for seed shape (Rr). This quality is valuable because it promotes genetic variation. Here is why.

When an (Rr) individual produces a gamete, a reproductive cell, it splits R from r. Shifting from the plant example to animals, in male mammals splitting makes a sperm with either R or r and in females an egg with either R or r. When mating occurs, this can thus produce an offspring that is either (RR), (Rr) or (rr).

Thus, high heterozygosity means a population with the potential for lots of genetic variation. Lots of genetic variation is important because it provides for the production of lots of potentially adaptive traits.

As an illustration of what this can mean, let us take a look at fruit flies feeding on the landscape of an apple. Fruit flies are attracted to rotten fruit because it contains yeast on which their maggot progeny feed. As we all know, over-ripe apples are often not uniformly rotten, but instead have rotten spots. These are the favorite grazing plots for fruit fly larvae.

Fruit flies have a particular gene that controls foraging behavior. It governs whether a maggot will be a sitter or a rover, whether it will stay put or migrate to another nutritional source, say another rotten spot.

Researchers found that when the fruit fly larvae were competing for food, those that did best had a version of the foraging gene that was rarest in a particular population. For example, rovers did better when there were lots of sitters, and sitters did better when there were more rovers.

"If you're a rover surrounded by many sitters, then the sitters are going to use up that patch and you're going to do better by moving out into a new patch," says Professor Marla Sokolowski, a biologist at the University of Toronto Mississauga, who discovered the gene. "So you'll have an advantage because you're not competing with the sitters who stay close to the initial resource. On the other hand, if you're a sitter and you're mostly with rovers, the rovers are going to move out and you'll be left on the patch to feed without competition" (University of Toronto, 2007).

But what would happen if one were to selectively destroy all the fruit fly maggots that were rovers? Let us take a look. Let us say (RR) and (Rr) are those that display the rover behavior and R is dominant, while (rr) are the sitters. If one destroys all the rovers, then only the sitters will be left. Once the rotten spot is eaten up, since none will have looked for alternative food sources, fewer of this sitting group of maggots will survive due to competition. In a group consisting of both rovers and sitters, the rovers would have migrated to another rotten spot. By the rovers leaving, it would take the competitive pressure off the sitters and by migrating the rovers will have more food. The (Rr) maggots are of particular value because they enable a population to adjust to whether more or fewer rovers or sitters are needed to adapt to environmental changes.

Heterozygosity is thus the genetic tool kit nature provides animals to help them adapt to changes in the environment. Lower heterozygosity (and more homozygosity) translates into fewer tools and less opportunity to fix the problem of survival. The more tools, the more variation of genes there are to select from—such as the behavioral traits of migration and non-migration—the more fit to adapt.

Over time, populations tend to shift due to chance from Rr to either rr or RR, that is, more homozygous—less capable of variation. This may happen relatively quickly or over long periods of time. While heterozygosity at a given locus decreases over time as alleles become fixed or lost in the population, variation is maintained in the population through new mutations and gene flow due to migration between populations. Also, the smaller the population size (N), the faster the decline in heterozygosity. This decline in heterozygosity is due to the increase in frequency, that is, proportion, of one of the alleles, which approaches fixation: RR or rr

Heterozygosity is measured by allele frequency, that is, how common an allele is in a population. It is calculated by dividing the number of times the allele of interest is observed in a population by the total number of copies of all the alleles at that particular genetic locus in the population. Allele frequencies can be represented as a decimal, a percentage, or a fraction. In a population, allele frequencies are a reflection of genetic diversity. Changes in allele frequencies over time can indicate that genetic drift is occurring or that new mutations have been introduced into the population.

Heterozygosity can be used as a measure of a population's capacity to respond to selection immediately after a bottleneck—such as experienced by both Yellowstone's northern and central herds in the past. On the other hand, allelic diversity (the actual number of alleles present at a locus) determines a population's ability to respond to long-term selection over many generations, and ultimately the survival of the population (perhaps even of the species) (Beals, 1999)—such as being experienced presently by the central herd.

Armando Caballero and Aurora García-Dorado, writing in "Allelic Diversity and Its Implications for the Rate of Adaptation," discussed the differences between the two methods of measuring diversity for conservation management:

> The partition of diversity in gene frequency diversity or allelic diversity components leads to rather different conservation strategies (e.g. Caballero et al. 2010), suggesting a complementarity between both types of diversity measures. There is, however, a lack of knowledge about the evolutionary implications of allelic diversity. An aspect on which allelic diversity might have important implications is the response to selection for adaptation towards a changing environment. Whereas short-term response to selection depends on additive genetic variance and, thus, on the expected heterozygosity (Falconer and Mackay 1996), long-term response and selection limits might be more related to the number of alleles initially available for selection. Biallelic locus selection models have shown that the contribution of rare alleles to the

> selection limit is strongly influenced by the initial population size, so that population bottlenecks restrict the overall response to selection (Robertson 1960; James 1970; Hill and Rasbash 1986). This suggests that the response to long-term selection will increase with the overall number of alleles segregating in the loci controlling the selected trait, and could be expected to be larger when more alleles are initially segregating per locus in a set of multiallelic marker loci. Accordingly, in a structured population it may be hypothesized that the long-term rate of adaptation is more dependent on allelic differentiation among subpopulations than on gene frequency differentiation.

The authors concluded:

> Thus, the possibility of a given subpopulation to adapt under a changing environment may depend on the possibility of receiving rare advantageous alleles by migration from other subpopulations (Blanquart and Gandon 2011) (Caballero at al., 2013).

How does this perspective apply to Yellowstone's bison? What if one of two events happened, namely, what if an entire subpopulation is destroyed, or what if the trait of migration is destroyed—both eventualities now being faced in Yellowstone, especially by the central herd? Migration between the two populations, the central and the northern, is essential for the capacity to adapt. But the opposite scenario is being promoted here. If the trait of migration in either herd is destroyed, either by eliminating one herd or by eliminating the trait of migration in either herd, diversity is reduced and the ability to adapt to a changing environment is curtailed.

IBMP is stripping variation from Yellowstone's bison gene pool because of its excessive and relentless culling and because it is playing favorites. The favored form of bison in Yellowstone are members of the northern herd, because they tend not to migrate and thus do not get culled. But it is not nature's favor, it is man's. One of the most important measurements when attempting to identify the probability of extinction for a given species is the population's capacity for variation, which is dependent on population size. Darwin observed:

> as the favoured forms [of animals] increase in number, so, generally, will the less favoured decrease and become rare. Rarity . . . is the precursor to extinction. We can see that any form which is represented by few individuals will run a good chance of utter extinction, during great fluctuations in the nature or the seasons, or from a temporary increase in the number of its enemies . . . We have seen that the species which are most numerous in individuals have the best chance of producing favourable variations within any given period (Darwin, 1859, p. 109).

David S. Woodruff, Department of Biology, University of California, San Diego, La Jolla, discusses the importance of variability:

> The causes of extinction and extirpation are well-known and include habitat loss and fragmentation, overkill, introduced species, secondary (cascade) effects associated with removal of keystone mutualists, and failure to evolve fast enough to biotic or physical changes in the environment. The ability of a population to adapt to the consequences of range fragmentation and other changes is determined, in part, by its innate genetic variability. Such variability is a characteristic of all living species and involves differences ranging from the single gene to the chromosomal levels of organization . . . it is this genetic variability that ultimately determines a population's ability to evolve, to remain evolutionarily viable.

Fred W. Allendorf and Jeffrey J. Hard observed in "Human-induced evolution caused by unnatural selection through harvest of wild animals," *Proceedings of the National Academy of Sciences*:

> With regard to the loss of genetic diversity that can result from hunting mortality, Harris et al. (52) and Allendorf et al. (6) focused on the relationship between harvest and decline in heterozygosity or allelic diversity and how they are reflected in reduced effective population size (Ne) and the ratio of Ne to census size (Nc). These metrics are important indicators of a population's evolutionary potential, and substantial reductions in them can indicate unsustainable practices.

However, variation, such as behavior and traits, are not important measurements for the preservation of a species, according to the Fish and Wildlife Service. All that counts is the size of the population in general when it comes to the survival of a species. According to the FWS in answer to my April 18, 2016 letter asking why my petiton in 2015 was denied:

> One thing we considered at great length is your concern over the preservation of the "wildness" trait (as expressed through migratory behavior) in the context of the purpose of the Endangered Species Act (Act) in conserving species (as defined in the Act). The Act is not designed to conserve behaviors/traits . . . Distribution, abundance, and trends of the bison population in Yellowstone National Park do not support a conclusion that this population is endangered, either now or in the foreseeable future (Assistant regional director of the FWS's Mountain-Prairie Region, personal communication, April 18, 2016).

This is in stark contrast, however, to Woodruff's findings. He continues:

> As a generalization, genetic variation is a highly beneficial character and is positively correlated with such traits as growth rate, adult size, metabolic efficiency, fertility and disease resistance. The loss of genetic variation in a population therefore has serious harmful effects on that population's viability. Wildlife and forest managers will increasingly have to monitor and maintain the genetic variability of the populations in their care.

To measure the degree of genetic variation of a population so as to determine the population's viability, one obviously needs to know what populations to measure. Does one measure the entire population or certain components? In general, a census is conducted to determine a minimum viable population by counting all individuals of all ages. This value is symbolized as "N" for number. However, to get a more accurate picture of this population's viability, one needs to measure the population that is capable of passing down its genetics to the next generation—the reproductive population. This would exclude juveniles and post-reproductive animals from the census. This number is called the effective population size or the genetic effective size and is symbolized as Ne. One of the ways to do this is through a population viability analysis (PVA) of a species, which is a risk assessment that determines the probability that a population will go extinct within a given number of years. Woodruff explains:

> Genetic variation is thus an important component of population viability analysis (PVA)—a new methodology being developed to quantify overall persistence from a consideration of population genetics, demography, dispersion, dispersal and population structure. In PVA we recognize the important distinction between a population's actual size or census count (N) and its genetic effective size (Ne). The presence of non-reproducing individuals, unequal numbers of males and females, variance in family size, and the degree of inbreeding all reduce Ne to below N. The effective size of a population can be 1 or 2 orders of magnitude less than the census size (Gilpin, 1987). For example, the Australian mainland population of eastern barred bandicoot, *Perameles gunnii* was found to have approximately 633 individuals but an effective size of only 67 (Sherwin and Murray, 1990). As Ne not N determines a population's fitness, evolutionary potential and extinction probability, many species with apparently adequate population sizes may actually be in genetic trouble already.

Genetic drift can also affect genetic variation. Genetic drift, along with natural selection, mutation and migration, is one of the basic mechanisms of evolution. In each generation, some individuals may, just by chance, leave behind a few more descendants (and thereby genes) than other individuals. The genes of the next generation will be the genes of the "lucky" individuals, not necessarily the healthier or more fit individuals. Genetic drift affects the genetic makeup of the population but, unlike natural selection, through an entirely random process. It is survival of the luckiest, instead of the fittest. So although genetic drift is a mechanism of evolution, it does not work to produce adaptations. Random drift is accelerated by recurring small population sizes, severe reductions in population size called "bottlenecks" and founder events where a new population starts from a small number of individuals. Historically, wild bison have been exposed to all these forces.

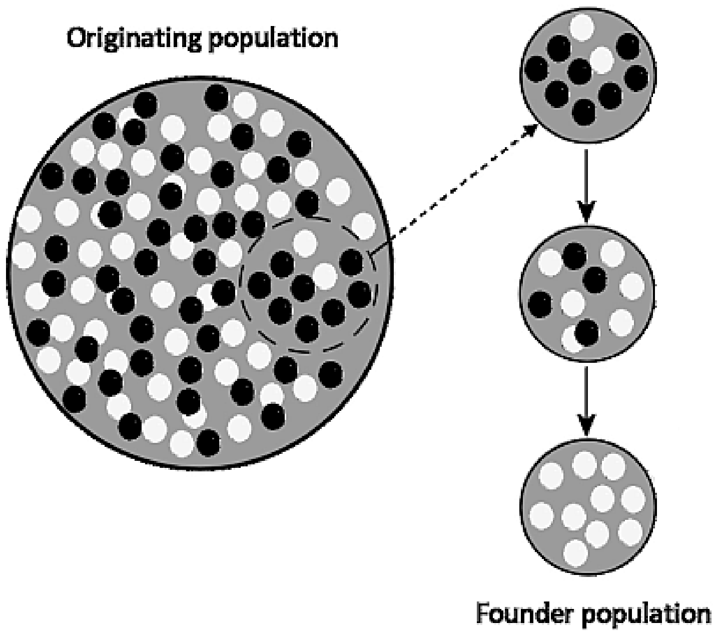


Figure 10. PERMANENT SEPARATION from a group produces genetic drift. Black and white balls represent two alleles for a specific locus on a chromosome in a hypothetical population. Once a random subgroup is separated from its ancestral population, either by migration or transportation (the founder effect) or by the annihilation of the parent group (a bottleneck), the allele frequencies in subsequent generations can diverge widely due to random selection of alleles for reproduction, especially in small remaining populations. ***Adapted from Wikimedia Commons. Author Professor marginalia.***

Genetic drift leads to fixation of alleles or genotypes in populations—that is, instead of a plurality of traits for a certain characteristic, such as eye color, say blue or brown eyes, or for behavior, say migratory or non-migratory—the species has only one trait for a particular characteristic. Without genetic variation for various characteristics, the organism has fewer choices for adaptation. Small populations are more prone to fixation of traits to one particular characteristic, in part because the gene pool collectively has fewer options—fewer genes, fewer varieties. To conserve a species, the effective population size is thus important to measure. Woodruff continues:

> The concept of the genetic effective size (Ne) allows us to estimate the genetic effects of range or habitat fragmentation. In the absence of factors promoting genetic variation (mutation and gene flow), uncommon variants are lost by random or chance events in a process called genetic drift. On theoretical grounds we know that the expected rate of loss of neutral variation may be very high in small populations of sexually reproducing species . . . Habitat fragmentation reduces N rapidly and such demographic bottlenecks further reduce Ne by one or two orders of magnitude within a generation. Thus many fragmented populations of interest to wildlife and natural resource managers are at high and immediate genetic risk (Woodruff, 1990).

Genetic drift may be illustrated by what could happen hypothetically to a cluster of 100 beetles on an asphalt road, composed, say, of 30 black beetles and 70 white beetles. Let us say a person walking down that path steps on the cluster just by chance, with his foot landing on 20 of the 30 black beetles. This would leave only 10 beetles to reproduce the black color. The black-color trait would be less prevalent in the gene pool and thereby have a lower chance of being passed on to succeeding progeny. This is random drift. Genetic drift can lead over time to the fixation of genes favoring one or the other trait, regardless of whether that fixation is adaptive.

But let us now consider what would happen when an element of what one might call "non-random genetic drift" is introduced by humans, that is artificial selection. Let us say that the next person coming down the road sees the cluster, does not like the black beetles, and steps on purpose, not by chance, on several of the black beetles, as do others who pass by. Result? The progressive elimination of the black color trait and at an exponentially higher rate than if the beetles, both black and white, had been exposed to only random squashing events over time.

Let us say a count of the cluster of beetles the following year revealed that the population was composed of four black and 96 white bugs. Let us say that this cluster of black and white beetles was a rare species of beetle, that a petition had been submitted asking the Fish and Wildlife Service to protect beetles with both the black and white traits from being stepped on to prevent extinction of that beetle group. The petition was denied because the agency found that the total number of beetles was stable with a count, as before, of 100, stating that conserving traits was not important. Then let us say that some chickens crossed the road and saw the beetles milling around and ate up all those they could see, which would be the white beetles, but left uneaten those harder to see against the black background of the asphalt road, the black beetles. This left in existence only the black beetles of this rare species. Then let us say another person comes dancing down the road and steps on these last four beetles left on this planet. Result? Extinction. Why? Because a protective advantage of the species, the white color, had been eliminated, reducing the remaining population to a small, vulnerable size that was easy to destroy completely.

Or let us say that the four black beetles survived. Because all the white beetles had been killed, the species now only contained black beetles. The species genetic structure had become fixed, capable of only expressing the black color. It had become homozygous for the black color trait and thereby less adaptive, less fit as a species, less capable of surviving environmental change. And now let us say that it began to snow, unlike prior years, making the black beetles stand out. Some more chickens came along and ate all the ones they could see--all that remained of the entire beetle species, the black ones--all because subpopulations had not been protected, all because the agency established under the laws of the land to protect species said it was not important to preserve traits.

Yellowstone's biologists promote management that does not count the central herd as important enough to preserve. In 2018 they may find the herd indeed does not count, for there may be no central herd left to count.

3

Conserve both herds

Yellowstone bison historically roamed over 8,000 square miles of habitat at the headwaters of the Yellowstone and Madison Rivers. Today, they are limited to Yellowstone National Park and two small adjacent areas north and west of the park in Montana, less than half their original range. The two adjacent areas are officially termed "Bison Management Areas" just inside and outside the park where bison are subject to culling. The bison population is subdivided into two breeding herds: the central and northern herds. This petition requests that Yellowstone's central herd be listed as endangered and the northern herd as threatened. According to the National Park Service:

> The northern breeding herd congregates in the Lamar Valley and on adjacent plateaus for the breeding season. During the remainder of the year, these bison use grasslands, wet meadows, and sage-steppe habitats in the Yellowstone River drainage, which extends 62 miles (100 km) between Cooke City and the Paradise Valley north of Gardiner, Montana. The northern range is drier and warmer than the rest of the park, and generally has shallower snow than in the interior of the park.
>
> The central breeding herd occupies the central plateau of the park, from the Pelican and Hayden valleys with a maximum elevation of 7,875 feet (2,400 m) in the east to the lower elevation and thermally influenced Madison headwaters area in the west. Winters are often severe, with deep snows and temperatures reaching -44°F (-42 C). This area contains a high proportion of moist meadows comprised of grasses, sedges, and willows, with upland grasses in drier areas. Bison from the central herd congregate in the Hayden Valley for breeding. Most of these bison move between the Madison, Firehole, Hayden, and Pelican valleys during the rest of the year. However, some bison

travel to the northern portion of the park and mix with the northern herd before most return to the Hayden Valley for the subsequent breeding season. In addition, some females switched breeding ranges and successfully bred and reared young on their new range (Bison, 2017).

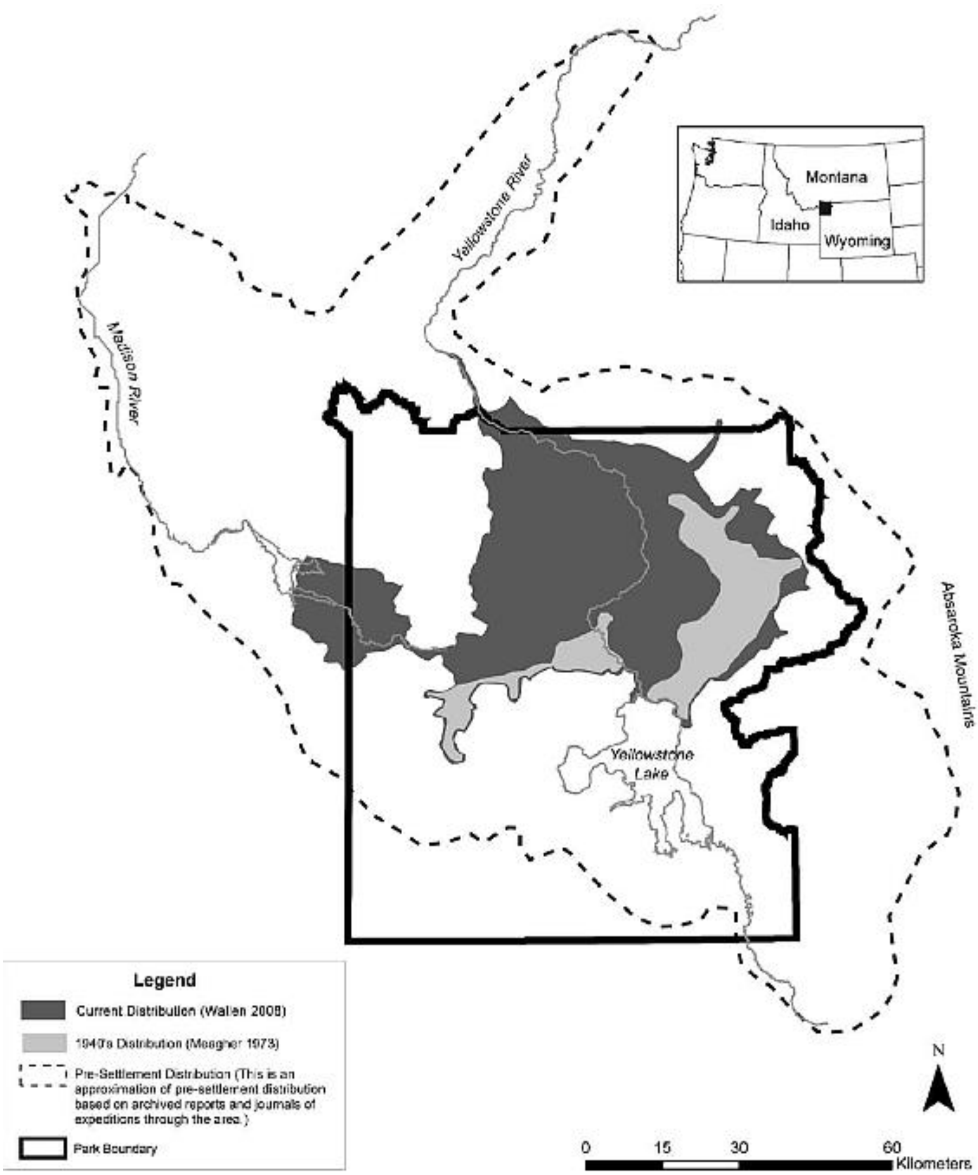


Figure 11. PRE-SETTLEMENT DISTRIBUTION (DOTTED LINE) based on archived reports and journals of expeditions through the area, 1940s distribution (light gray) (Meagher, 1973) and current distribution (dark gray) (Wallen, 2008); (Plumb, 2009).

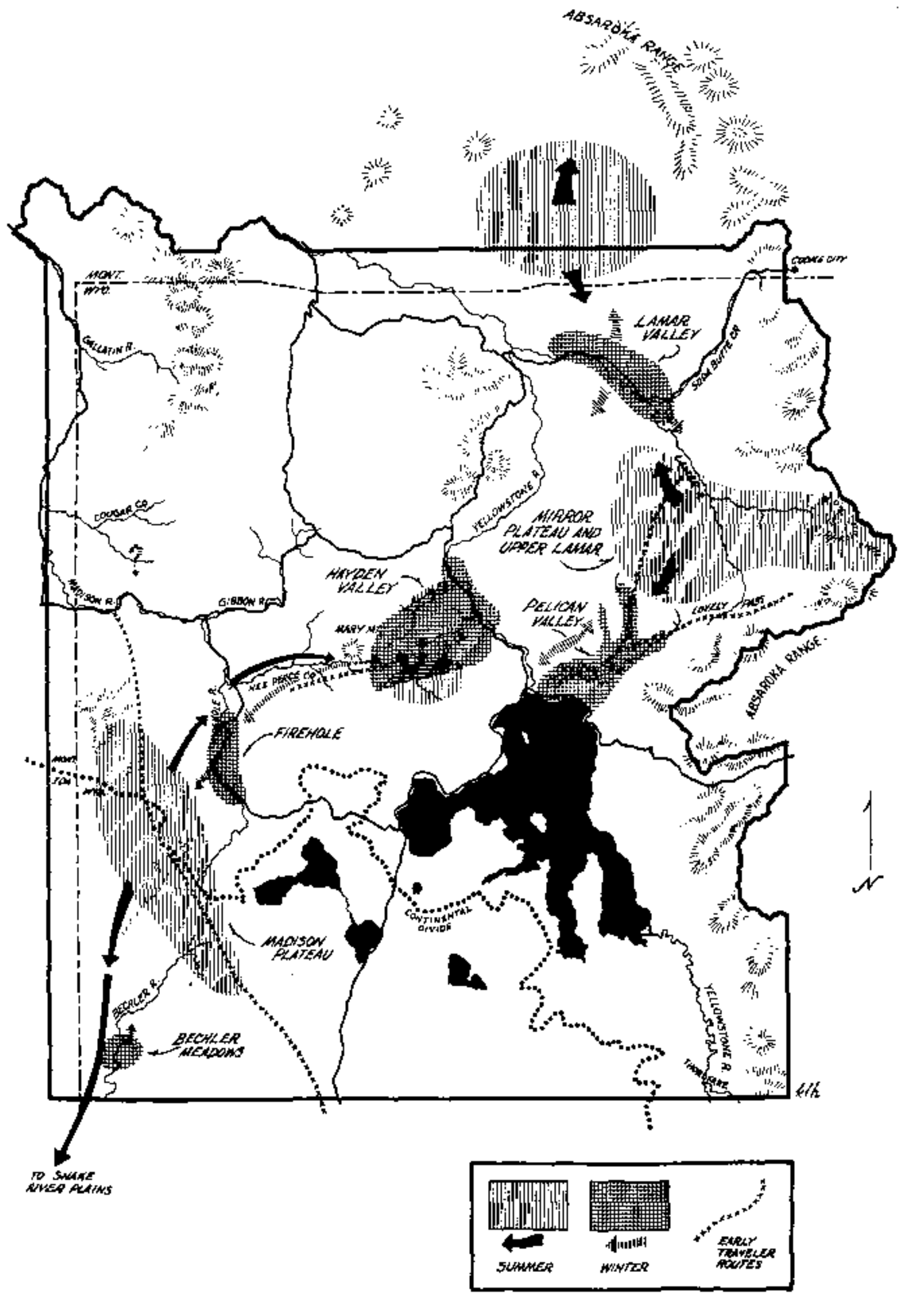


Figure 12. HISTORICAL DISTRIBUTION and movements of Yellowstone bison (Meagher, 1973, p. 24).

Historically, the Yellowstone native herd, from which the central herd has descended, occupied habitat that included drainages of the Yellowstone River and Madison River. During the spring and summer the herd remained in the interior of the park, but in winter moved down the rivers to escape the harsh winter conditions of the park. The herd displayed altitudinal migration habits, returning to the park's interior in the spring. The claim made by the National Park Service that this dispersal must be stopped by trapping migrating bison at the Stephens Creek capture facility "to reduce the potential for a mass migration of bison into Montana" is hyperbole, as the map of the historic migration patterns in Figure 11 shows. Only a small portion of Montana would be entered, even if the herd returned to pre-settlement distribution.

Both herds should be protected from extinction so as to ensure the survival of this country's only wild bison populations. The two herds are substantially separate geographically, genetically distinct and each represent a distinct population segment.

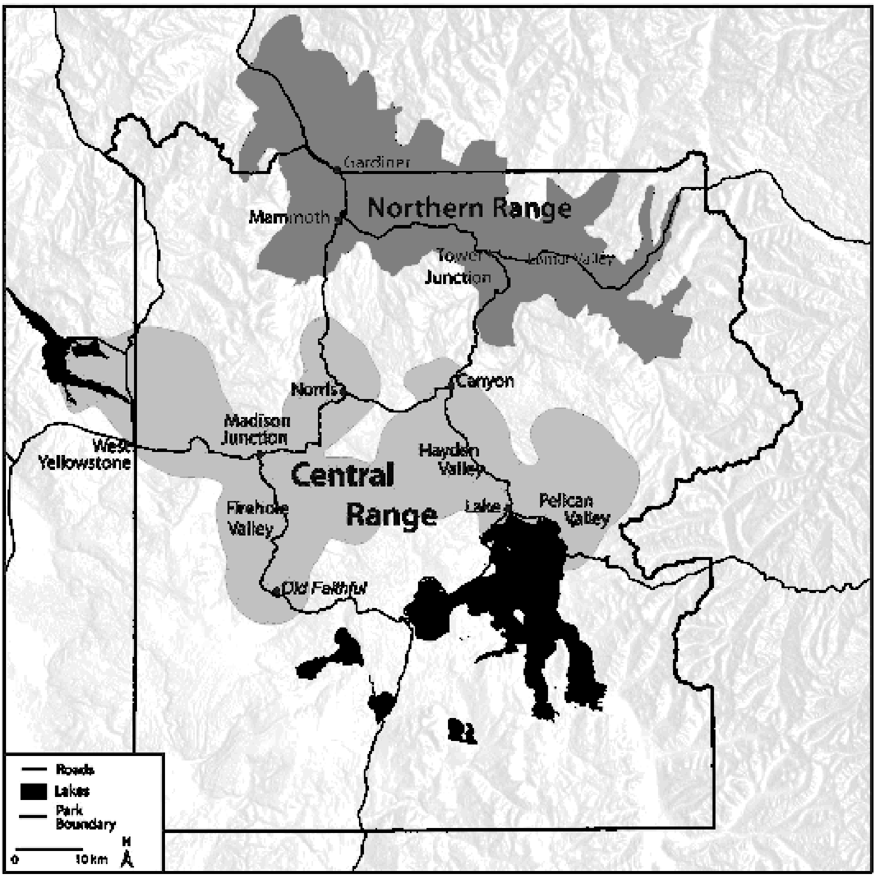


Figure 13. THE CENTRAL RANGE in Yellowstone National Park is an ecological unit defined by the range of the migratory central bison herd and includes the range of the non-migratory elk herd that occupies the headwater drainages of the Madison River along the western edge of the park. The northern range of the park is generally defined by the wintering area of the northern elk herd (Garrott et. al., 2009, p. 6).

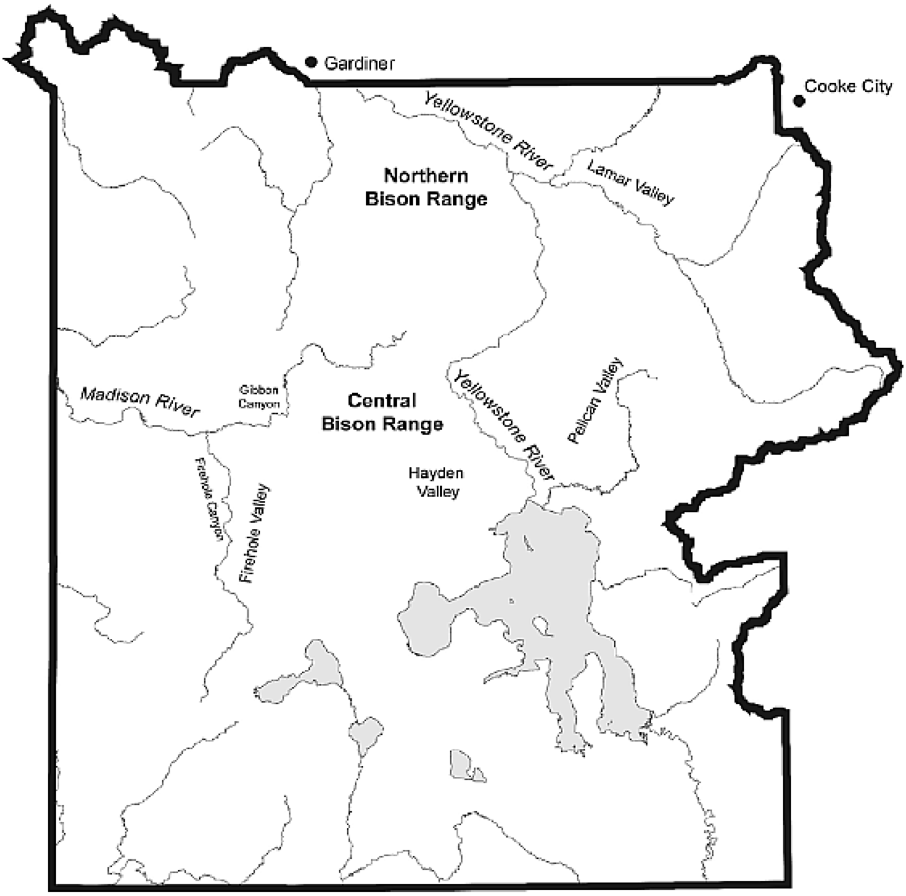


Figure 14. PRESENT DAY DISTRIBUTION of Yellowstone bison showing location of northern and central herds (Plumb, 2009).

The Endangered Species Act describes two categories of declining species of plants and animals that need its protections: endangered species and threatened species. Any species that is in danger of extinction throughout all or a significant portion of its range is defined as endangered, while any species that is likely to become endangered is defined as threatened. In simple terms, endangered species are at the brink of extinction now and threatened species are likely to be at the brink in the near future.

The term "species" includes any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature. Note that the species definition includes what is called the "biological species concept," but is not limited to that concept. This petition requests the Fish and Wildlife Service list both herds as distinct population segments or as two evolutionary significant units.

Listing a species as a distinct population segment is guided by determining three elements, as specified by the FWS, namely, the population segment's discreteness in relation to the remainder of the species to which it belongs, its significance and its conservation status.

Lastly, its status is evaluated. If a population segment is discrete and significant (i.e., it is a distinct population segment) its evaluation for endangered or threatened status will be based on the act's definitions of those terms and a review of the factors enumerated in section 4(a) of the ESA. In this petition, these factors are elucidated in both the first and second volumes and summed under "Factors warranting listing" in the first volume, chapter 15. According to the FWS, it may be appropriate to assign different classifications to different DPS's of the same vertebrate taxon (Laws & Policies, Regulations and Policies, Interagency Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the ESA, 1996).

History of DPS determinations for wild bison

The Petitioner originally submitted a petition February 11, 1999 to list Yellowstone's wild bison as endangered or threatened (see Appendix A, second volume of this petition). A 90-day finding by the FWS determined August 15, 2007 that the herd was a distinct vertebrate population segment in that it was both discrete and significant (see Appendix C, second volume of this petition). The finding stated:

> ***Subspecies***
>
> The bison in Yellowstone National Park are considered to be plains bison (*Bison bison bison*). As mentioned previously, Boyd (2003, p. 38) estimated the plains bison population in North America at 500,000, and identified 50 herds (containing approximately 19,200 head) currently being managed with clear conservation objectives. Given the abundance and management status of the subspecies, we have concluded that the petition has not presented substantial information indicating that its listing under the Act may be warranted.
>
> ***Distinct Vertebrate Population Segment***
>
> The petitioner asked us to list the YNP bison herd as a "distinct population group." We assume that the petitioner meant a Distinct Vertebrate Population Segment (DPS) for purposes of listing under the Act. Under section 3(15) of the Act, we may consider for listing any species, subspecies, or, for vertebrates, any DPS of these taxa. In determining whether an entity constitutes a DPS, and is therefore listable under the Act, we follow the Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act (DPS Policy) (61 FR 4722; February 7, 1996). Under our DPS Policy, we must address three analytical steps prior to listing a possible DPS:

(1) The discreteness of the population segment in relation to the remainder of the taxon; (2) the significance of the population segment to the taxon 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 FR 4722, February 7, 1996). This finding considers whether the petition states a reasonable case that the petitioned population may be a DPS.

Discreteness

Under the DPS Policy, a population segment of a vertebrate species may be considered discrete if it satisfies either one of the following two 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; or (2) it is delimited by international governmental boundaries within which significant differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist (61 FR 4722, February 7, 1996).

Information Provided in the Petition on Discreteness

The petitioner asserts that the YNP bison "herd is the only wild, unfenced buffalo herd in the nation," but no specific citations are provided to support this conclusion. Information in our files support the conclusion that the YNP bison population is the only herd in the United States that has remained in a wild state since prehistoric times (Gates et al. 2005, p. 93). All other bison in the United States are reconstituted herds and are confined with fencing, or otherwise range restricted. Individuals from the Jackson bison herd in Grand Teton National Park and the National Elk Refuge have been known to migrate north into YNP, but this is a rare occurrence (Gates et al. 2005, p. 109). Therefore, we find that the YNP bison herd may be discrete from other members of the taxon *Bison bison* because of physical distance and barriers.

Significance

Under our DPS Policy, in addition to our consideration that a population segment is discrete, we consider its biological and ecological significance to the taxon to which it belongs. This consideration may include, but is not limited to: (1) Evidence of the persistence of the discrete population segment in an ecological setting that is unique or unusual for the taxon; (2) evidence that loss of the population segment would result in a significant gap in the range of the taxon; (3) evidence that the population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historical range; and (4) evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics (61 FR 4721; February 7, 1996).

Information Provided in the Petition on Significance

The petitioner asserts that the YNP bison herd is significant within the meaning of our DPS policy because it is the last wild, unfenced herd in the United States, and exhibits quasi-migratory behavior when members of the herd leave YNP during the winter in search of food. The petition also asserts that the herd may be a unique hybrid of the wood and plains bison, and the herd has historical and cultural significance to Native Americans. No citations are provided to substantiate these statements.

(1) *Evidence of the persistence of the discrete population segment in an ecological setting that is unique for the taxon.* The petitioner asserts that YNP is the only area in the lower 48 States where bison have existed in the wild state since prehistoric times. This statement is consistent with Gates et al. (2005, p. 245), and indicates that the YNP bison herd may exist in a unique ecological setting within the meaning of our DPS Policy.

The petitioner's assertion that the YNP bison were important to Native Americans also is supported by Gates et al. (2005, p. 77) (e.g., "The Lamar Valley and the Yellowstone River Valley north to Livingstone was an important area for bison and Native peoples throughout the Holocene."). We agree with the petitioner that the YNP bison herd has substantial cultural and historical value. However, the significance criteria in our DPS Policy are based on biological factors identified in the Act that show that the population is significant to the taxon, and not on human cultural or historical significance. Therefore, we did not evaluate cultural and historical significance in our DPS analysis, but rather relied solely on the scientific criteria in the DPS Policy.

The petitioner asserts that the YNP [bison] is significant because of its "quasi-migratory behavior." Gates et al. (2005, p. 160) concludes that YNP is a forage-limited system, and that, "Bison move beyond park boundaries in winter in response to forage limitation caused by interactions between population density, variable forage production (driven by spring/early summer precipitation), snow conditions, and herbage removal primarily by bison and elk." Winter movement of large herbivores, such as bison and elk, in search of forage is normal behavior. The fact that bison and elk range outside the Park is not unusual. Based on this information, we would not consider the YNP bison herd movements to winter range outside the Park boundary as a unique behavior within the meaning of our DPS Policy.

(2) *Evidence that loss of the population segment would result in a significant gap in the range of the taxon.* The petition alleges that the YNP bison herd is

the only remaining wild, unfenced bison herd. As discussed under "Biology and Distribution," there are 3 other Federal bison herds that show no evidence of introgression with domestic cattle, based on sampling done to date. Because of the limited number and extent of bison herds that show no evidence of introgression with domestic cattle, we find that loss of the YNP bison herd might result in a significant gap in the current range of the taxon.

(3) *Evidence that the population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historical range*. The petition provides no specific information to indicate that the YNP bison herd would meet this criterion. As noted above, Gates et al. (2005, p. 245) indicate that YNP is the only area in the lower 48 States where bison have existed in a wild state since prehistoric times. Bison originally ranged across western North America; because numerous herds have been reintroduced in the historic range, we have determined that the YNP herd is not the only surviving natural occurrence within its range. Additionally, the species is not more abundant elsewhere outside its historic range.

(4) *Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.* The petition alleges that the YNP bison herd may be a unique hybrid of the wood and plains bison. No citations are provided, but this conclusion was stated in Meagher (1973, pp. 14-16), who considered the "mountain" bison a separate species. This controversy has since been resolved, and YNP staff now considers the remnant population, as well as the introduced bison, as being of plains bison origin (Boyd 2003, pp. 182-183; Wallen 2006).

Additional information in our files compiled after this petition was submitted indicates that the YNP bison herd is one of three Federal herds that do not display genetic introgression with cattle. Maintenance of genetic diversity is an important long-term goal for management of species populations. Halbert (2003, p. 94), concluded her study by stating: "In conclusion, this study has assessed levels of domestic cattle introgression in 10 federal bison populations and identified at least 2 populations, Wind Cave and YNP, which at this time do not have any evidence of domestic cattle introgression and also have high levels of unique genetic variation in relation to other federal populations. As such, these populations should be given conservation priority * * *" Thus, we conclude that the YNP bison herd satisfies this genetic criterion of significance under the DPS Policy.

DPS Determination

The Grand Teton National Park/National Elk Refuge bison herd is separate from the YNP herd (Gates et al. 2005, p. 93), and there are less than a dozen other unconfined bison herds in the entire lower 48 States (Gates et al. 2005, p. 2). Therefore, the YNP herd is discrete from other members of the taxon. Recent genetic research confirms that the YNP bison herd is significant because of a lack of nuclear domestic cattle introgression. Although 3 other Federal herds exhibit this characteristic, the YNP bison are the only remnant population that has remained in a wild state since prehistoric times and, therefore, is important to the management of bison genetic diversity. Halbert (2003, pp. 44-45) found only four Federal herds that were sufficiently unique to contribute significantly to overall bison genetic diversity.

On the basis of the preceding discussion, we believe that there is substantial information to conclude that the YNP bison herd may be discrete and significant within the meaning of our DPS Policy, and therefore may constitute a DPS.

Baileys' 2009 petition

On February 24, 2011 the U.S. Fish and Wildlife Service announced a 90-day finding on a 2009 petition by private citizens James Bailey and Natalie Bailey to list wild plains bison, *Bison bison bison*, or each of four distinct population segments, as threatened, again deciding wild plains bison do not deserve protection under the act. Further, the decision reversed the original finding that the Yellowstone herd was a distinct population segment, stating "the basis for our 2007 DPS determination was erroneous."

On March 2, 2015, I submitted another petition to list Yellowstone's wild bison as endangered or threatened. That petition argued for the reinstatement of Yellowstone's wild bison as a distinct population segment. That petition said:

> In 2009 the FWS received a petition from Biologist James A. Bailey and his wife Natalie A. Bailey requesting that the wild plains bison be listed as threatened or that each of its four major ecotypes be considered DPSs and listed as threatened. The petitioners specified four ecotypes (population segments) of wild plains bison: the northern Great Plains, the southern Great Plains, the Rocky Mountains, and the Great Basin-Colorado Plateau. A 90-day finding concluded that the petition did not provide substantial information to conclude that each of the four population segments may be discrete.
>
> The finding included the wild bison of Yellowstone National Park, which were labeled as not being any more wild than other bison in conservation herds. This reversal from its previous determination in 2007 was achieved by re-defining the term "wild" to simply mean any bison from herds not being used for commercial purposes, reasoning that all bison today are a mixture of

genes. Further, from their usage by the FWS, the terms "wild" and "natural occurrence" have only genetic meaning.

Specifically, the finding stated:

> However, we note that the wild plains bison is a generalist with regard to its habitat requirements, as evidenced by its broad historical range, and none of the ecological settings of the four population segments is unique or unusual. Each of the population segments contains multiple herds managed under different Federal, State, municipal, or private regimes, and the complete loss of any population segment is very unlikely. No population segment represents the only surviving natural occurrence of the taxon. Lastly, due to multiple, diverse origins and subsequent translocations, no population segment is genetically, behaviorally, or ecologically unique.

As noted, this finding of 2009 contradicts the finding of 2007. The 2009 FWS finding states:

> We recognize that this conclusion differs to some extent from an earlier decision. In a previous negative 90-day finding published on August 15, 2007 (72 FR 45717), we determined that the Yellowstone plains bison herd may meet the criteria of discreteness and significance as defined by our policy on DPS. However, this finding and the previous 90-day finding differ in scope. The August 15, 2007, finding only addressed plains bison in the Yellowstone herd. The current finding addresses wild plains bison in all conservation herds.
>
> The 2007 finding concluded that the Yellowstone herd may be discrete from other plains bison, because it was considered the only herd that has "remained in a wild state since prehistoric times" and because of physical distance and barriers. The best available information now indicates that the basis for our 2007 DPS determination was erroneous. We still use the term "wild plains bison" to describe the Yellowstone herd because they are managed as a conservation herd, rather than as a commercial herd. However, we no longer consider the Yellowstone herd to have remained in more of a "wild" state than any other conservation herd.

And how has the herd not remained in more of a "wild" state than any other conservation herd? Because the 2009 finding claims they have not remained "unaltered." The 2009 finding explains (bold emphasis added):

> Specifically, these wild plains bison are no longer thought to have remained in an unaltered condition from prehistoric times, as implied in the previous
> determination. In 1902, no more than 30 wild plains bison remained in Yellowstone (Halbert 2003, p. 24). In the same year, 18 female plains bison from the captive Pablo-Allard herd in Montana and 3 bulls from the captive Goodnight herd in Texas were purchased to supplement the Yellowstone herd (Halbert 2003, pp. 24-25). Additionally, intensive management (supplemental feeding, roundups, and selective culling) of the Yellowstone herd occurred from the 1920s through the late 1960s (Gogan et al. 2005, p. 1719). Wild plains bison from Yellowstone also have been used to start or augment many later conservation herds (Halbert and Derr 2007, p. 2). **Despite geographic separation, the Yellowstone herd is essentially part of one metapopulation and is not markedly separate from other herds.**

Like scrambled eggs, the FWS has whipped together the YNP herd with other conservation herds, saying in effect that the YNP herd is just part of a species omelet called a "metapopulation." Further, it has reduced the meaning of the term "wild" to mean any animal that is not for commercial use, namely, as the 2009 finding states: "We still use the term 'wild plains bison' to describe the Yellowstone herd because they are managed as a conservation herd, rather than as a commercial herd."

When one considers that the term "wildlife" is part of the agency's name, maybe the Fish and Wildlife Service should be renamed to more accurately define its new perspective. How about Fish and Non-Commercial Life Service?

In point of fact, the term wild has been eroded by the FWS. It is now defined in terms of economic and genetic status only. Wildness in this new world of the FWS is a factor determined by human management practices, and since no herd has remained in "an unaltered condition from prehistoric times, as implied in the previous determination," no bison herd is more wild than any other herd.

The distortion of the actual position of both the 1999 petition and the 2007 determination is a "straw man" tactic, representing a logical fallacy. . .

The straw man attack in this case is the phrase "these wild plains bison are no longer thought to have remained in an unaltered condition from prehistoric times, as implied in the previous determination."

As used in the FWS's 2009 finding, the term being challenged, namely, "unaltered," refers to the breeding status of bison only. The 2009 finding stated that the 2007 finding "implied" that the herd had remained genetically unaltered. The 2009 finding then refuted that implication, noting that herds had been genetically mixed throughout history, including post-settlement history through translocations and other government management practices.

If either the 1999 petition or the 2007 finding implied that the Yellowstone bison were wild because they had been unaltered, the concept of "unaltered" was broader than merely a genetic interpretation limited to breeding between bison herds. As stated in my 1999 petition (bold emphasis added):

> The Yellowstone herd is the only wild, unfenced buffalo herd in the nation . . .
>
> These herds, protected by the mountains and by the Yellowstone National Park status as a national park, escaped the slaughter of the mid to late 1800s. A few score survived, creating in part a genetic pool responsible for the thousands of buffalo that now populate the United States.
>
> Some scientists believe that because the herd inhabited mountainous regions that it consisted of Mountain Buffalo, often also called Wood Buffalo. **It is this remnant herd that helped save the buffalo from extinction**.
>
> The herd grew from a few score to about 3,000 in 1966. Part of its growth stems from the introduction of Plains Buffalo into the Yellowstone National Park. The Mountain or Wood Buffalo as a pure species is now extinct in the United States. **However, a hybrid or cross between the Mountain Buffalo and the Plains Buffalo may exist at Yellowstone, thus being the only such herd in the nation.** Over 1,000 animals of this unique group were shot or slaughtered by the Montana Department of Livestock as the animals crossed the border of the Park in 1997 to escape the severe winter.

The 2007 FWS determination said this under the heading of "Biology and distribution" (bold emphasis added):

> Numerous Federal, State, and private bison herds currently exist in the United States, **but YNP is the only area in the United States where bison have existed in the wild state since prehistoric times** (Gates et al. 2005, p. 92). Boyd (2003, p. 38) estimated the plains bison population in North America at 500,000, and identified 50 herds (containing approximately 19,200 head) currently being managed with clear conservation objectives.

And under the heading of "Information provided in the petition on discreteness," recall the passage where the FWS said this (bold emphasis added):

> The petitioner asserts that the YNP bison ‘‘herd is the only wild, unfenced buffalo herd in the nation,’’ but no specific citations are provided to support this conclusion. Information in our files support the conclusion that the YNP bison population is the only herd in the United States that has remained in a wild state since prehistoric times (Gates et al. 2005, p. 93). **All other bison in the United States are reconstituted herds and are confined with fencing, or otherwise range restricted**. Individuals from the Jackson bison herd in Grand Teton National Park and the National Elk Refuge have been known to migrate north into YNP, but this is a rare occurrence (Gates et al. 2005, p. 109). Therefore, we find that the YNP bison herd may be discrete from other members of the taxon Bison bison because of physical distance and barriers.
>
> The position in the 2007 determination was that the "YNP is the only area in the United States where bison have existed in the wild state since prehistoric times (Gates et al. 2005, p. 92)."

The Gates et al. citation is from *The ecology of bison movements and distribution in and beyond Yellowstone National Park,* Chapter 4, "History of bison management in Yellowstone National Park: Yellowstone bison in prehistory." The relevant passage stated:

> Yellowstone National Park is the only place in the lower 48 States where bison have existed in a wild state since prehistoric times. Bison occupied the region encompassing the park from shortly after recession of the last glaciers 10,000 to 12,000 years ago, until the 19th century when they came close to extirpation (Gates et al. 2005, p. 92.)

Apparently such unaltered ecological conditions as "unfenced," not being "reconstituted," not being "confined with fencing, or otherwise range restricted" and being "the only area in the United States where bison have existed in the wild state since prehistoric times" do not qualify for the designation "unaltered." The mere and unproven possibility that Yellowstone wild bison genes may have cross-bred with other bison of the same species from another location is interpreted by the FWS as meaning the wild bison in the park have not remained in an unaltered condition from prehistoric times and therefore are not a distinct population segment.

And ironically, while my 1999 petition specifically mentioned that the YNP herd may be a hybrid between plains bison and wood or mountain bison, and while altered, unique and distinct, this was disregarded in the 2009 determination.

The conclusion in the 2009 determination that "we no longer consider the Yellowstone herd to have remained in more of a 'wild' state than any other conservation herd" is fallaciously supported by refuting a position that has been misrepresented, saying that "these wild plains bison are no longer thought to have remained in an unaltered condition from prehistoric times, as implied in the previous determination." The 2009 finding tamed the wild Yellowstone bison by recounting a history of the possibility of the original park inhabitants interbreeding, citing genetic evidence only, reducing wildness to a factor of genes only, instead of including environment, behavior (such as migratory behavior) and the historical record.

The 1999 petition and the 2007 determination did not imply that the herd's genetic purity has been unaltered since prehistoric times, but instead that the bison's continuous and in that respect unaltered relationship with the land in Yellowstone National Park has retained its wild ecology by not being extirpated or fenced.

To add insult to injury, the 2009 determination ignores a finding of the 2007 determination concerning one area demonstrating an instance of unaltered genetics, so the 2009 finding is selective in where it sees examples of the significance of altered and unaltered conditions regarding wildness. The 2007 determination by the FWS stated that:

> Additional information in our files compiled after this petition was submitted indicates that the YNP bison herd is one of three Federal herds that do not display genetic introgression with cattle. Maintenance of genetic diversity is an important long-term goal for management of species populations. Halbert (2003, p. 94), concluded her study by stating: "In conclusion, this study has assessed levels of domestic cattle introgression in 10 federal bison populations and identified at least 2 populations, Wind Cave and YNP, which at this time do not have any evidence of domestic cattle introgression and also have high levels of unique genetic variation in relation to other federal populations. As such, these populations should be given conservation priority * * *" Thus, we conclude that the YNP bison herd satisfies this genetic criterion of significance under the DPS Policy.

But the 2009 finding now implies that genetic purity and this unaltered genetic condition do not mean much, after all. It states (bold emphasis added):

> The presence of cattle DNA in the genetic makeup of wild plains bison appears widespread, but occurs at low levels. Conservation herds are managed according to their genetic background, so as to maintain genetic diversity and introgression-free herds. We expect the frequency of cattle DNA to remain low in conservation herds. Wild plains bison from introgressed herds conform morphologically, behaviorally, and ecologically to the scientific taxonomic description of the native

> subspecies. Some wild plains bison herds with evidence of cattle introgression also contain valuable genetic diversity that is not found elsewhere and should be conserved. **We do not believe that there is substantial information indicating that listing may be warranted due to introgression with cattle genes**.

This is a complete and historically tragic abrogation of the original position by the FWS that found value in a bison population such as the YNP herd that was free of cattle genetics. The 2009 determination concluded:

> In summary, the petition does not present substantial information that wild plains bison may require listing either as a subspecies or a DPS. The conclusion that impacts from the various factors discussed above may constitute a threat is not supported by the available information regarding distribution, abundance, and population trends of wild plains bison. Wild plains bison are distributed in parks, preserves, other public lands, and private lands throughout and external to their historical range. The current population of wild plains bison is estimated to be 20,500 animals in 62 conservation herds. Recent population trends appear stable to slightly increasing in conservation herds (as noted by the petitioners).

With the magic of government speak, wild bison have just been increased by a magnitude of five and are everywhere in "metapopulations." The only problem with this position is that it is not true. The only wild, unfenced bison herd without cattle genes in the United States is in Yellowstone National Park.

Metapopulations are defined as a set of local populations within some larger area, where typically migration from one local population to some other habitat is possible (Definitions and synonyms of terms used in metapopulations studies, 2011). But where are the migrations between the habitats of the various conservation herds? These "migrations" are achieved by shipping bison by truck and other "translocations" by government agencies. This is "wild"? And when migration is attempted by natural means, i.e., buffalo crossing the border of Yellowstone National Park into the Gardiner Basin, they are shot or captured for slaughter by government agents positioned there.

According to government speak, bison that are fenced are still wild, bison that have cattle genes are still wild and bison carted around by truck from pasture to pasture are still wild. Under these governmental parameters, a mule trucked from zoo to zoo would be wild (Horsley, 2015).

Several months prior to my submission of the 2015 petition, the Buffalo Field Campaign and the Western Watersheds Project submitted November 14, 2014, a similar petition. On January 12, 2016, the Fish and Wildlife Service rejected both requests made by the separate petitions to list Yellowstone's wild bison.

However, the FWS found that Yellowstone's wild herd was, indeed, a DPS, reversing its reversal. It stated:

> In 2011, we made a not substantial 90-day finding on a petition to list the wild plains bison or each of four distinct population segments as threatened under the Act (FWS 2011, entire). In that finding, we determined that the YNP bison did not qualify as a DPS and, therefore, a listable entity under the Act (FWS 2011, pp. 10309-10310). The present finding evaluates new information provided by the petitioners that has become available since the 2011 decision, to determine whether the YNP bison may meet the discreteness and significance criteria needed to qualify as a DPS.

Citing new information meeting the criteria of discreteness, namely "White and Wallen 2012, pp. 752-753" and meeting the criteria of significance, namely "White and Wallen 2012, pp. 752-752" and "Halbert et al., 2002, pp. 1-2," the FWS stated:

> In summary, we find that the first and second petitions, together, provide substantial scientific or commercial information indicating the YNP bison may qualify as a DPS.

The two pieces of new information that won the reinstatement of the DPS designation for wild bison were, according to the 90-day finding by the FWS, a letter to the editor referenced as: "White, P.J. and R.L. Wallen. 2012. Yellowstone bison—should we preserve artificial population substructure or rely on ecological processes? Journal of Heredity 103:751-753" and a genetic study, referenced as: "Halbert, N.D., P.J. Gogan, P.W. Hedrick, J.M. Wahl, and J.N. Derr. 2012. Genetic population substructure in bison at Yellowstone National Park. Journal of Heredity 103:360-370."

Note that both documents were published in different issues of the same publication: the *Journal of Heredity*. The abstract of the Halbert et al. study, published February 8, 2012, stated:

> The Yellowstone National Park bison herd is 1 of only 2 populations known to have continually persisted on their current landscape since pre-Columbian times. Over the last century, the census size of this herd has fluctuated from around 100 individuals to over 3000 animals. Previous studies involving radiotelemetry, tooth wear, and parturition timing provide evidence of at least 2 distinct groups of bison within Yellowstone National Park. To better understand the biology of Yellowstone bison, we investigated the potential for limited gene flow across this population using multilocus Bayesian clustering

> analysis. Two genetically distinct and clearly defined subpopulations were identified based on both genotypic diversity and allelic distributions. Genetic cluster assignments were highly correlated with sampling locations for a subgroup of live capture individuals. Furthermore, a comparison of the cluster assignments to the 2 principle winter cull sites revealed critical differences in migration patterns across years. The 2 Yellowstone subpopulations display levels of differentiation that are only slightly less than that between populations which have been geographically and reproductively isolated for over 40 years. The identification of cryptic population subdivision and genetic differentiation of this magnitude highlights the importance of this biological phenomenon in the management of wildlife species.

The White and Wallen letter to the editor, published almost a half year after the Halbert et al. study August 23, 2012 stated:

> 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 (White et al., 2012).

It has been established by the FWS that the Yellowstone herds together are a distinct population segment. To protect these herds from extinction, the purpose of this 2018 petition is to establish that both herds are separate subspecies, that both are discrete and significant and that both should be listed due to numerous factors. The Petitioner will closely read four documents relevant to the preservation of Yellowstone's wild bison to illuminate what each text says explicitly and to make logical inferences.

4

Yellowstone's disinformation campaign masks native herd's impending extinction: four close readings

If one closely examines the issues going on at Yellowstone National Park, a vendetta appears to exist against the park's central bison herd. It goes something like this. Iconic, endemic, but nevertheless "bad" bison hang out in the central valleys of the park. They are the migrants. They are easy to spot. They try to escape every winter from the interior—a habit they have when their forage gets covered with ice and snow and they are starving—and cross over the border to survive. Their neighbors, those from the northern herd, are the more stay-at-home type and keep in their place, the lower elevations. The roving ones from the high country are the problem. They have been surviving this way ever since they came here, over 10,000 years ago, unlike the northern herd, who are relative newcomers. But now a new sheriff is in town with a posse called the Interagency Bison Management Plan. When the central herd descends to the lowlands, they graze on grass just outside the park, but the grass is reserved for cattle, not bison. Migrant bison are looked down on as second-class denizens of the park now, illegals not knowing their place—and are killed if they try to mix with the high-class cows.

The vendetta is being carried out by the Montana Department of Livestock and backed by reports from biologists with Yellowstone National Park. While the northern herd continues to grow, the central herd is dramatically shrinking, now on the verge of extinction, with over a thousand wild bison scheduled to be culled in the winter of 2017-2018 and only 850 left in the central herd, but no one is blowing the whistle to stop this ecological carnage. A million years of evolution is about to be wiped out by the very government agents who are supposed to protect wildlife.

Apparently, an odd type of natural selection is going on in the park, but it is not wildlife undergoing selection in his case. Instead, it is park employees. Only those who get on board with the vendetta against the central herd seem to persist.

The vendetta is carried out something like this. Since the northern herd is growing or has stabilized—because most are non-migratory and don't cross the border and get culled—even though the central herd is disappearing from sight, biologists, like guards at a prison, turn their backs and let the execution of the central herd transpire, telling the world that all is okay, for the prison population is actually growing—wink wink, nudge nudge—lumping the central herd population with the count of the northern herd.

With the last culling of almost 1,300 animals, resulting in an almost 50 percent reduction of the central herd, the results of the vendetta have become harder to camouflage. In a recent news story, an interviewed Yellowstone biologist expressed mock amazement over the fact that so many animals of the central herd did not return to their old summer haunts in 2017, pretending not to realize that bison culled mid-migration can not resurrect themselves to migrate back in the spring.

The vendetta is going on under the cover of disinformation—false information that is intended to mislead—another word for fake news, that is, propaganda. It is primarily being generated by scientists, who are supposed to be objective. They have been able to get away with it because of the arcane nature of their studies.

It is a vendetta that Congress should investigate.

Following is a close reading of four pieces on this subject: a news story, two letters to the editor of a research journal, and a chapter of a book. My comments (Petitioner's comments) will be embedded in each of the written pieces examined.

A. "Yellowstone's bison dynamics raise questions": A close reading of a news story

The following article appeared October 22, 2017 under the headline "Yellowstone's bison dynamics raise questions" by Brett French in *Montana Untamed,* an outdoor section that appears in the Billings Gazette, Missoulian, Helena Independent Record, Montana Standard and online. It includes an interview with Rick Wallen, Yellowstone's lead bison biologist:

> **Yellowstone's bison dynamics raise questions**
>
> Many Yellowstone National Park bison move from summer to winter ranges in search of food. Recently, more central herd bison seem to be migrating to the Northern Range. Exactly why is unclear.

> Figuring out what's happening with wildlife based on annual counts is not easy. So many factors affect where and when they travel, from predators to weather, habits to habitat.
>
> So when Yellowstone National Park did its summer count of bison this year, it was somewhat surprising to see that although the animals suffered their second highest culling and killing since 2000—1,274 animals—it was the untargeted central herd that shrank substantially and not the northern herd, which is the main target of the bison removals.

Petitioner's comment: Targeting of bison has no substantive meaning under the present management practices of the Interagency Bison Management Plan because the location by herd of individual animals is unknown prior to culling. The IBMP sets its goals primarily on the recommendation of three Yellowstone National Park biologists: Chris Geremia, Rick Wallen, and P. J. White. In their "Status Report on the Yellowstone Bison Population, August 2016" the three biologists recommended lethally removing between 900 and 1,400 bison for 2017, mostly from the northern herd:

> About 900 animals (70% adult, 10% yearlings, 20% calves; 60% females, and 40% males) would need to be removed during winter 2016-2017 to stabilize population growth. Removal of 1,400 animals, which is 25% of the current population, would lead to a forecasted bison population of 4,850 (95% range: 4,300-5,300) next summer.
>
> We recommend that population management actions during winter 2016-2017 substantially reduce the number of bison in northern Yellowstone (estimated at 4,000 animals).

The document does not mention how the percentages of adults, yearlings, calves, females and males are to be measured prior to culling, nor how to "substantially reduce" the northern herd. In practice, these measurements are not made prior to culling, but instead are made by counting and classifying each culled animal by sex and age and then by making aerial surveys the next summer to ascertain the population levels and demographics of each herd, which reflect the effects of culling, winter-kill and births. The goals stated by the biologists are wishful thinking. There is no way under present management schemes to know anything about the history of each particular animal, including herd origin, prior to culling.

- The article continues:

> It's unknown what happened, but something changed in Yellowstone this spring that made a whole bunch of bison from the park's central herd decide

> not to migrate back to their traditional Hayden Valley home. That was revealed in the park's summer bison counts, which showed the central herd declining by 42 percent.
>
> "So something really big happened this year to change the distribution dynamic on the landscape," said Rick Wallen, the park's lead bison biologist.

Petitioner's comment: Yes, "something really big happened this year." It is called large-scale culling. That mysterious something that made almost half the central bison herd "decide not to migrate back to their traditional Hayden Valley home" was not mysterious at all—half of the herd had been lethally removed. Dead bison can not decide to do, or not to do, anything. They had been culled. If they had indeed returned, there would have been no reduction in the total aerial count conducted in the summer of 2017. But there was a total reduction of about 1,300 animals. Wallen's surprise is disingenuous.

- The article continues:

> The first thought was that maybe those central herd animals were disproportionately killed during the winter by hunters outside the park's boundaries and through the Interagency Bison Management Plan agreement that ships a portion of the herd to slaughter. The winter slaughter program, which donates the animals to tribes for meat, is an attempt to reduce the bison population and slow outmigration from the park into Montana.
>
> Nearly 7,500 Yellowstone bison have been killed since 2000. Yet the park's bison have, once again, proven to be incredible survivors. Between 2000 and 2016 the population more than doubled, rising from 2,600 to 5,400 animals. Between 2008 and 2017, the northern herd has increased by 275 percent.
>
> "They just know how to survive on our landscape," Wallen said.

Petitioner's comment: Bison in the northern herd are "incredible survivors" because they usually do not migrate in the winter into Gardiner Basin, site of the culling facility and hunting parties, but instead reside year-around in the northern valleys of the park's interior, which are lower in elevation with a milder climate than those regions inhabited by the central herd in the park's interior. The demographics of the northern and central portions of the park are significantly different. As explained in *Yellowstone bison: conserving an American icon in modern society,* co-edited by Rick Wallen:

> Bison in central Yellowstone occupy the central plateau, extending from the Pelican and Hayden valley areas (Figure 1.2) with a maximum elevation of 2,500 meters (8,200 feet) in the east to the lower-elevation (2,000 meters [6,570 feet]) and geothermally influenced Madison headwaters area in the

> west (Meagher 1973; Bruggeman 2006). Winters are often severe, with temperatures reaching -42 degrees Celsius (-44 degrees Fahrenheit) and snow pack exceeding 1.8 meters (6 feet) in some areas. Bison in central Yellowstone congregate in the Hayden Valley for breeding (Meagher 1973; Geremia et al. 2011, 2014b). Afterwards, most bison move between the Madison, Firehole, Hayden, and Pelican valleys, but some travel to the northern region of the park before returning to the Hayden Valley for the subsequent breeding season (Geremia et al. 2011, 2014b; White and Wallen 2012).
>
> Bison in northern Yellowstone primarily occupy the Yellowstone River drainage and surrounding mountains between the Lamar Valley and Mirror Plateau in the east (maximum elevation = 2,740 meters [9,000 feet]) and the lower-elevation Gardiner basin in the west (1,615 meters [5,300 feet]) (Meagher 1973; Houston 1982; Barmore 2003; Geremia et al. 2011, 2014b). The northern region of Yellowstone is drier and warmer than the rest of the park, with average snow depths ranging from about 1 meter (3.5 feet) at higher elevations to less than 0.3 meter (1 foot) at lower elevations. Bison in northern Yellowstone congregate in the Lamar Valley and on adjacent plateaus during the breeding season (Meagher 1973; Geremia et al. 2011, 2014b) (White et al., 2015, p. 7).

In short, bison in the park's central region experience significantly harsher winters than bison in the northern region. Central Yellowstone has higher altitudes, a colder climate, sometimes as low as -44 degrees Fahrenheit, deeper snows, sometimes more than six feet—with all combined weather forces producing a climate promoting migration so as to survive.

- The article continues:

> That doesn't seem to be the case with the central herd, though. Since 2008 that group of bison has exhibited "a lower potential for population growth," according to Yellowstone's survey. Maybe they are migrating to the Gardiner area in winter and being slaughtered, killed by hunters, or simply not returning to the central herd's usual haunts after winter.
>
> Strangely, out of 12 collared central herd bison, 11 survived the winter and six wintered on the western side of the park, not to the north where the slaughter program takes place.
>
> "So it appeared they had high survival," Wallen said. "It makes you wonder how many migrated to the Northern Range."

Petitioner's comment: Wallen can stop wondering about how many migrate to the northern range, for he took part in a study that determined that issue. All he has to do is recalled what he wrote in 2013, along with fellow Yellowstone National Park biologists Chris Geremia, P. J. White and Doug Blanton, titled "Managing the

Abundance of Yellowstone Bison, Winter 2014." The authors noted: "Despite this decrease in numbers, about 2% (0-10%) of bison from the central herd have emigrated into the northern herd each year" (Geremia et al., 2013). Further, while the few collared central bison may have had "high survival," that does not explain what happened to the rest, the uncollared. One might get a better idea of what has happened to the majority of the central herd by looking at the culling numbers in Tables 1 and 2 above, which Wallen helped prepare. They show the population of the central herd beginning in 2006 plummets after repeated large-scale culling year after year—from a high in 2005 of 3,531 to 2,624 in 2007 to 1,451 in 2016 to 847 in 2017. If Wallen cannot find the mysteriously disappearing bison of the central herd, possibly he should look in the slaughterhouse to which the culled animals have been shipped by the IBMP under his recommendation.

- The article continues:

> More than 100 years ago, only 23 free-ranging wild bison remained alive in Yellowstone's remote Pelican Valley.

Petitioner's comment: These are the ancestors of the central herd, which migrated from Asia to this location over 10,000 years ago.

- The article continues:

> Giving that remnant herd U.S. Army protection was one leg of the park's historic bison restoration, but it wasn't believed to be enough. So the Army imported 21 more bison that were essentially treated like cattle.
>
> That herd started out in the Lamar Valley, where buildings from the Buffalo Ranch still stand to mark that early era in bison management. By the 1930s, with the Lamar herd grown to more than 1,000, the National Park Service decided to set the bison free and let them roam the park as wild animals.

Petitioner's comment: This is partly true. However, introduced plains bison were not set free in the park until the 1950s (see Figure 33 "Timeline of Bison Management" as well as Wallen's own comment below).

- The article continues:

> Wallen said some of those bison were moved to create the central herd, which now occupies the Madison, Gibbon, Firehole, Hayden and Pelican valleys.

Petitioner's comment: This is a false claim. In 1936 a deliberate attempt was made by park management to have the two herds interbreed. That year some bison from the northern herd were trucked to the park's central Firehole and Hayden valleys for release. This translocation, however, did not "create the central herd." That herd, as mentioned above and throughout this petition, was created over 10,000 years ago by migration from Asia to its present location in the park. What was created, most likely, were some hybrids, but as research by Texas A&M University has found, the two herds have remained genetically distinct and form separate breeding herds to this day, as discussed throughout this petition.

- The article continues:

> According to research by Texas A&M University, for about 40 years the Northern Range animals, which inhabit the Lamar Valley, Little America and higher elevations in the region, were largely separated from their central herd cousins.

Petitioner's comment: Source of this reference is unclear. Following the introduction of captive plains bison into the park in 1902, according to Wallen and White in a letter to the editor discussed below, the herds were physically separated for about 50 years:

> A few individuals from the endemic central herd were introduced into the northern herd in the early 1900s, whereas 71 bison from the northern herd were relocated to central Yellowstone during 1935–1936 (Cahalane 1944). The northern herd was not released from traditional livestock management practices and allowed to evolve natural patterns of distribution until the 1950s—which likely contributed to some geographic separation between the herds (Meagher 1973) (White et al., 2012).

The two herds are only loosely "cousins," as wood and plains bison evolutionarily diverged thousands of years ago.

- The article continues:

> Now that seems to be changing for most, but not all, of the bison.
>
> "There was some stirring in the pot of genetics," Wallen said.

Petitioner's comment: Yes, the result has most likely been the creation of some hybrids, but as discussed in this petition, the two herds remain separate breeding herds, that is, separate subspecies or distinct population segments.

- The article continues:

> Bison No. 3225 is a central herd stalwart. She was collared 12 years ago and has remained free of the disease brucellosis, which can cause cattle to abort. Brucellosis is the main reason cited for sending bison to slaughter. The slaughter is a cooperative attempt by the many federal and state agencies to try and keep Montana's cattle herds from being quarantined should a cow test positive for exposure to brucellosis.
>
> Not everyone agrees with the tactics of slaughter, noting that elk roam free between Yellowstone and Montana and also test positive for exposure to brucellosis. But for now, this is the compromise the many agencies have worked out.

Petitioner's comment: It is a compromise that has no epidemiological value in controlling the spread of brucellosis to cattle, because elk also have the disease, but are not separated from contact with cattle and are allowed to migrate. The compromise has no scientifically defensible basis, as shown throughout this petition. The compromise is not a compromise but a skillful takeover of the park by cattle interests, with Yellowstone National Park, under the umbrella of the NPS, serving as its public relations agency to legitimize private, commercial dominance of public land, with the elimination of range competition from bison by the IBMP, paid for by taxpayers. This news story appears to be the result of a news release generated by the NPS, with Wallen as the spokesman. It is not information, but instead disinformation.

- The article continues:

> 3225 has also remained faithful to the old migration route out of Hayden Valley toward West Yellowstone.
>
> "I don't remember her ever going on a different movement pattern than Hayden to West," Wallen said. "She has stuck to that longstanding pattern of the central herd."
>
> Wallen guessed 3225 could be 15 years or older, and so may be one of the oldest bison in that herd.
>
> "There are not a lot that live beyond 12," he said.

Petitioner's comment: Most likely, Bison 3225 is a resident member of the central herd, meaning she in non-migratory. That is why she has lived so long—she does not get culled by migrating north to Gardiner Basin. When she does migrate out of the park, it most likely would be to Hebgen Basin in the spring for calving. Here they are not culled.

According to Wallen and colleagues' "Managing the Abundance of Yellowstone Bison, Winter 2014," members of the central herd in winter move to the Firehole River drainage on their way west out of the park. This is a stopover enroute to calving in the spring in Hebgen Basin just outside the park. It is a stopover for good reason, for here the Firehole River is fed by geothermal activity, keeping the water warm and the banks more free of deep snow, making foraging possible (see photo below).

As the winter proceeds, the central herd moves either north to the Blacktail Deer Plateau at 7,113 feet elevation, on the way to Gardiner Basin, at 5,300 feet elevation, where snow depths average 1 inch in February (Gardiner, Montana (243378), 2017), or heads west toward Hebgen Basin, at 6,600 feet elevation and an average snow depth in February of 38 inches, i.e., over three feet, waiting until spring to access the region.

Figure 15. BISON WINTER FEEDING on bank of Firehole River. ***Photo by JR Douglass; 1969, from the Yellowstone Photo Collection.***

In “Managing the Abundance of Yellowstone Bison, Winter 2014, the authors describe migration characteristics of the central herd:

> Large fluctuations in abundance, from several thousands of bison during the breeding period to hundreds of bison at the conclusion of the winter migration, were observed each year in the Hayden and Pelican valleys. Similar numbers of bison remained in this summering area across years despite large differences in central herd size, which suggests a relatively constant, food-limited carrying capacity by the end-of-winter. Bison migrating from the Hayden and Pelican valleys primarily moved to the Firehole River drainage, and these movements were largely affected by time since snow pack establishment and annual snow pack severity. The Firehole River drainage served as a stop-over site for most migrating bison from the central herd, with

abundance in this drainage peaking between 500 and 1,100 animals during January and February. Bison migrating from the Hayden and Pelican valleys also moved directly to the Gibbon and Madison River drainages, which also served as a stop-over site. Bison abundance in this area peaked during January and April, with most animals eventually moving either north to the Blacktail Deer Plateau in northern Yellowstone or west to the Hebgen basin in Montana. Movements of bison from the central herd to northern Yellowstone increased as their abundance increased to record levels during the early 2000s. Management removals since that time have reduced bison numbers in the central herd, but movements to northern Yellowstone continue during winter—perhaps indicating the importance of learning on bison migration patterns. Movements by bison from the central herd west into the Hebgen basin increase rapidly late in the migration period, with movement probabilities peaking during May (Geremia et al., 2013, pp. 16-17).

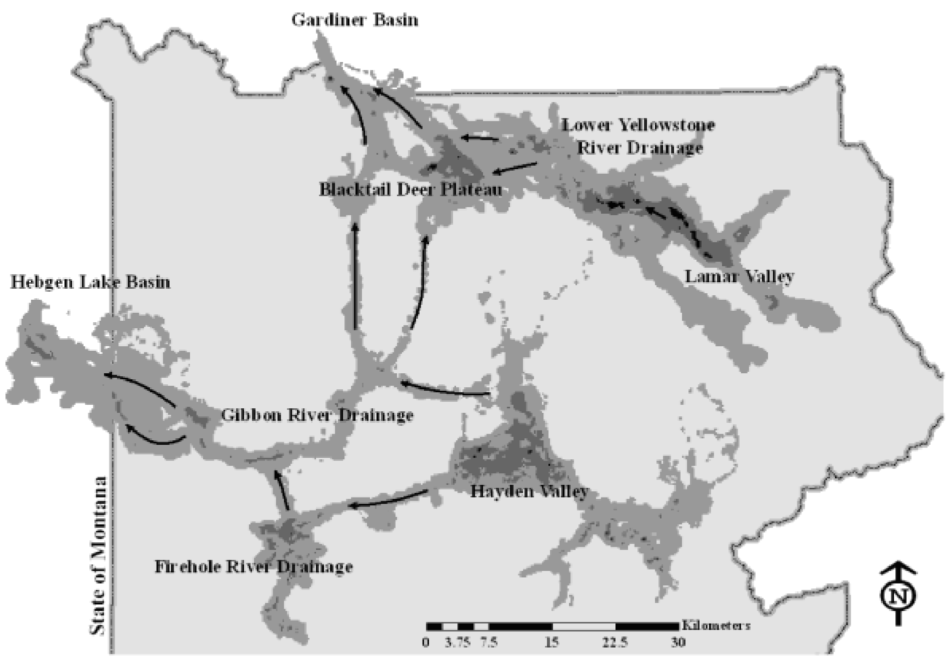


Figure 16. WINTERING AREAS AND MIGRATION ROUTES of Yellowstone bison in Yellowstone National Park and nearby areas of Montana, with darker colors representing core use areas (Geremia et al., 2013).

Except for mild winters, members of the central herd do not migrate to Hebgen Basin because of severe weather conditions there due to its high altitude. It is spring, during calving season, that the central herd moves to Hebgen Basin. Otherwise, movement out of the park in winter is confined to Gardiner Basin.

- The news article continues:

> One of the reasons bison populations can grow steadily is they have few predators. Wolves and grizzly bears will kill a few, mostly calves but also a few injured or aged adults. Most die after getting injured—either from falling or being hit by vehicles—or contract parasites and can't convert their food into enough energy to survive. One dead bison, which may weigh 1,000 pounds or more, can feed a lot of predators.

Petitioner's comment: As a lump sum, "bison populations can grow steadily" for certain years, but viewed separately, the northern herd is growing exponentially while the central herd is shrinking exponentially because the central herd is migratory, while the northern herd is much less so, exposing the central herd to culling as members attempt to access Gardiner Basin.

- The news article quotes Wallen:

> Bison 3225's ancestors tried to pioneer outside the park into the West Yellowstone area in the 1980s, but weren't welcomed by the state of Montana until 2015 when Gov. Steve Bullock agreed to let the animals stay year round on about 400 square miles of mostly Custer Gallatin National Forest. Prior to that agreement, bison were annually hazed back into the park by helicopters and horsemen every spring.

Petitioner's comment: As noted, in winter bison avoid movements west outside the park because of the harsh weather, including an average snow depth in Hebgen Basin of over three feet, making foraging either impossible or energy expenditures too costly. Since bison do not usually enter Hebgen Basin until spring, recently allowed year-round occupancy of Horse Butte in Hebgen Basin means bison can complete calving before returning to the park on their own accord, instead of being hazed back prior to the end of calving in the spring.

- The article continues:

> Would the central herd have expanded into that forest area and grown in population if it hadn't been repeatedly hazed? Wallen thinks so, and speculated that maybe after being turned back so many times more bison began migrating to join the northern herd.
>
> "There's never been a year we didn't get migrants," Wallen said. "The question is how long was it happening?"

Petitioner's comment: Bison do not expand into forested areas because they avoid such regions by instinct. Yellowstone bison feed primarily on grasses, sedges, and other grass-like plants (more than 90 percent of their diets) in open grassland and meadow communities throughout the year (Bison, 2017). Further, hazing and culling have been ongoing at *both* west and north locations at the borders of the park for several decades. Culling was stopped in 2009 at the west location and hazing in 2015. Culling and hazing continue in the north at Gardiner Basin.

- The article continues:

> A removal of about 750 bison in 1997 seems to indicate central herd animals either moved in to fill the missing Northern Range bison's vacancies, or had migrated over in winter and were slaughtered, since the roughly 750 bison in that northern population, in theory, should have been wiped out by such a removal, Wallen said.
>
> "They are such social animals, it's easy to see how some would stay with the group" after hanging out together during the winter, he said.
>
> Yet park biologists rarely see a northern herd animal migrate to the central herd's summer pastures, so the flow seems to be largely one-way traffic.

Petitioner's comment: The northern herd was not augmented by the central herd. Both lost substantial numbers by the large-scale removals. Regardless of intermingling in the winter, wild bison return to their own breeding herds in the spring. Summer aerial counts determine how many bison were culled from each herd. In 1997, one of the harshest winters on record, 725 bison were culled in Gardiner Basin and 358 at Horse Butte, Hebgen Basin, for a total of 1,083 bison lethally removed. The previous year, there were 860 northern bison and 2,724 central bison, reducing the northern herd to 455 animals, a 47 percent decrease and the central herd to 1,715, a 37 percent decrease. Since that time, the northern herd has essentially ceased to migrate, while the central herd continues to migrate.

- The article continues:

> Bison like this one are collared to provide park staff with information on their movements and the timing of those treks.
>
> In hopes of providing more information to researchers, Yellowstone will collar an additional 15 or so bison before this winter. By being able to track their migration in real time with GPS, the Park Service could reduce its capture of bison for slaughter when those depleted members of the central herd arrive in the Gardiner Basin.
>
> "The question is: how many bison does that one collar represent?" Wallen said.

Petitioner's comment: The other question is, how are you going to identify the other members of the central and northern herds, the non-collared ones, which are the vast majority? As shown in this petition, at present there is no way to determine the herd status of a bison prior to culling, nor after. Herd totals are known only when numbers are counted the following summer.

- The article continues:

> The agency has also asked, as it has in the past, that tribal and sport hunters limit their harvest outside Yellowstone's western boundary, which is all central herd bison. Park officials are also recommending that no more than 1,250 bison be killed by hunters or shipped to slaughter this winter.

Petitioner's comment: Subtract 1,250, the amount to be culled in 2018, from the 847 wild bison left in 2017 in the central herd—the herd that migrates and thus gets culled—and what do you get? If you guessed extinction, you are right.

- The article continues:

> In the future, Wallen said he'd like to see the bison use the landscape how they'd like.
>
> But for now, the interagency plan is guiding management as the annual debate over bison slaughter and the carrying capacity of Yellowstone's grazing lands continues. A 2000 court-mediated agreement between the secretaries of agriculture and interior and then-Gov. Brian Schweitzer requires Yellowstone to reduce the bison population in Yellowstone to around 3,000 animals. The park has a way to go to reach that figure.
>
> The aerial count of bison in August was 4,816. Of that total, 3,969 were counted in the northern herd and 847 in central Yellowstone. Overall, the population decline from last year was about 12 percent, with 389 bison killed in the Gardiner area and 97 on the western side of the park.

Petitioner's comment: The decline of the total herd was 12 percent because the brunt of the decimation was absorbed by the central herd. While the northern herd's population following culling went from 4008 bison in 2016 to 3,967 in 2017—a loss of 39 bison—the almost 50 percent reduction of the central herd brought the 2016 herd total of 1,451 down to 847 in 2017, a loss of 604 animals. These figures are totals after births the next year. Incidentally, Wallen forgot to remind readers that the figures 389 and 97 were hunting totals of bison killed on location, while the rest of the 1,274 animals were killed at a slaughter house.

- The article continues:

> So what's going on? Why is the central herd declining even though fewer are harvested? Why are more central animals migrating north instead of west like they used to do? In the future will the central herd disappear after animals like 3225 die and take with them the habit of moving west? Will bison ever occupy the land west of Yellowstone that has been opened to them?

Petitioner's comment: Asking why the central herd is "declining even though fewer are harvested" in the context of this article is word salad. Fewer than what? The central herd experienced a small increase in population in 2016 but a decrease of almost 50 percent in 2017. What we have here is a sentence just tossed before the reader in hopes, I suppose, that the bepuzzlement sounds authentic. Further, asking why more of the central herd is not going west like they used to do is misleading. As mentioned, the central herd goes both north and west, depending on the weather and season. The central herd avoids Hebgen Basin to the west in winter because its elevation is 6,600 feet and often uninhabitable, unlike the lower Gardiner Basin to the north, with an elevation of 5,300 feet, milder climate and less snow cover. And the answer to the question "Will bison ever occupy the land west of Yellowstone that has been opened to them?" (referring to Gov. Bullock's recent order allowing bison year-round occupancy of the Horse Butte peninsula jutting into Hebgen Lake) is "probably not in the winter, since deep snow often covers the forage there." But they do go there in the spring to give birth, and about half of the 2016 number did just that in 2017—half, because of the central herd's almost 50 percent reduction. According to the Buffalo Field Campaign, "BFC patrols in the past few springs had noticed that we were seeing about half the number of buffalo coming to their calving grounds on and around Horse Butte (Yellowstone Causes Tragic Shift in Bison Behavior, 2017).

- The article continues:

> "It's unlikely to see new exploratory patterns to the west if that subgroup is declining in abundance," Wallen said. "You need more animals to develop a migratory pattern out to the west to explore some of those new areas."

Petitioner's comment: That the "subgroup is declining in abundance" is for one reason only—disproportionate culling of that subgroup, the central herd, resulting from recommendations of Wallen himself and his Yellowstone biologist colleagues. If bison do explore these "new areas" in the winter, they will find that, just as in the past, the ground is covered with an average of over three feet of snow in the deep of winter (February) and will go to where there is less snow, Gardiner Basin, with an average of one inch of snow in February.

- The article continues:

> Bison populations and their migratory habits are always going to change, he added.
>
> "That's part of preserving the ecological processes, letting them figure out how to live in here."

Petitioner's comment: Rick, you can help wild bison of the central herd "figure out how to live in here," that is, in Yellowstone National Park, and preserve the "ecological processes" by not wiping out members of the central herd—the indigenous herd, the herd that came here over 10,000 years ago, the herd that has made Yellowstone famous—so that enough of them are left with brains to figure.

B. A close reading of two letters to the editor of the *Journal of Heredity*

How wild bison herd management is viewed by Yellowstone's biologists is laid out in a letter to the editor of the *Journal of Heredity* by Patrick J. White and Rick L. Wallen of Yellowstone National Park, titled "Yellowstone Bison—Should We Preserve Artificial Population Substructure or Rely on Ecological Processes?" It is a masterpiece of doubletalk.

Yellowstone biologists appear to be on a campaign to exterminate the central herd under cover of preserving one herd and one herd only. Why would wildlife managers hold such a view? It could make sense only if the overriding objective is to placate cattle interests, for the central herd is the migratory herd, the major herd that threatens to come in close proximity to cattle fattening on the park's perimeters.

White is Yellowstone's chief wildlife biologist and Wallen is the lead wildlife biologist for the bison program. Their letter is in response to a 2012 study by a team led by Natalie D. Halbert, Department of Veterinary Pathobiology, Texas A&M University, titled "Genetic Population Substructure in Bison at Yellowstone National Park" that found the park to have two genetically distinct bison subpopulations, the central herd and the northern herd (Halbert, 2012).

I. Park biologists' letter

One immediately gets the gist of the White and Wallen letter: the two herds' populations are artificial substructures that do not merit preservation as distinct entities. Instead, it argues that wildlife managers should let nature take its course, that is let natural selection operate. What a close reading of the letter reveals is that according to its twisted logic “ecological processes,” i.e., natural selection, include the artificial act of culling, i.e., artificial selection. This of course is absurd. The authors begin by describing the findings of the Halbert study—that the park contained two genetically distinct subpopulations and that disproportionate culling of the subpopulations raised concerns:

> Halbert et al. (2012) analyzed microsatellite genotypes collected from 661 Yellowstone bison sampled during winters from 1999 to 2003 and identified 2 genetically distinct subpopulations (central, northern) based on genotypic diversity and allelic distributions. On the basis of these findings, they raised concerns about the management and long-term conservation of Yellowstone bison because of disproportionate culling of the 2 subpopulations in some winters. The data and findings of Halbert et al. (2012) are significant and useful for managers charged with conserving these iconic wildlife.

But White and Wallen claim that portions of the study are not accurate historically or presently:

> However, their article provides information regarding the behavior and management of Yellowstone bison that does not accurately portray historic or current conditions. This response clarifies those conditions and challenges some of their apparent deductions and recommendations.

White and Wallen launch into a refutation of the Halbert et al. study with an interesting use of the straw man argument, misrepresenting the study’s line of reasoning to more easily knock it down, and draw conclusions based on misunderstanding the study’s use of Bayesian methodology. Instead of clarifying, White and Wallen muddy the Halbert et al. investigation, making it difficult to see to the bottom of the issue. In the letter White and Wallen note:

> Halbert et al. (2012, p. 1) indicate that Yellowstone bison provide an opportunity to examine a “. . . natural population substructure, which could have important implications for the long-term evolution of these populations.” They assume “. . . the Yellowstone population was not subdivided before 1936” and that “these 2 subpopulations [central, northern] have differentiated in a relatively short period of approximately 8 generations [64 years]” (Halbert et al. 2012, p. 5, 7).

Halbert et al. are not assuming in the ordinary sense of the word, but instead are making a mathematical assumption for a Bayesian analysis of genetic differentiation. Let us look at the context of the two above quotes. The first quote (contained in passage 1. below) is taken from a passage under the Halbert et al.

study's subheading "Migration between Subpopulations." The second quote (in 2. below) is from a passage two pages later. (Halbert et al.'s lines quoted by White and Wallen are in italics). The passages by Halbert et al. are:

(1.) To give a perspective on the amount of differentiation that we have documented, let us assume that genetic drift is the main factor causing the subpopulations to diverge while gene flow between them acts to reduce the extent of divergence. Let us use the ''island model'' of Wright (1940) so that the expected amount of differentiation in generation t + 1, $F_{ST(t+1)}$, is the result of the amount of genetic drift due to the finite effective population size Ne, the amount of gene flow (migration) m between the subpopulations, and the amount of differentiation in the previous generation (e.g., Hedrick 2011) or

$$F_{ST(t+1)} = (1 - m)^2\left[\frac{1}{2N_e} + \left(1 - \frac{1}{2N_e}\right)F_{ST(t)}\right]. \qquad (1)$$

First, let us *assume that the Yellowstone population was not subdivided before 1936* (Meagher 1973) so that F_{ST} = 0 at that point. Next, let us assume that on average our sample was taken around 64 years later (Table 1). Finally, let us assume that the generation length, the average age of a parent for their average offspring, is 8 years (Hedrick 2009), so that 64 years constitutes about 8 generations. Using the above expression, we can then find what combinations of m and Ne result in an F_{ST} after 8 generations equal to the observed 0.0321.

(2.) Although the observed value of differentiation is low compared with the F_{ST} value of 0.2 that is sometimes used to indicate strong differentiation (Mills and Allendorf 1996; Wang 2004), *these 2 subpopulations have differentiated in a relatively short period of approximately 8 generations*. Furthermore, F_{ST} for neutral microsatellite loci provides an indicator of the potential for differential adaptation. In other words, it appears that the isolation between these 2 groups is significant—8.4% of the maximum possible from the calculation of G''_{ST} above—and could lead to divergence of adaptively important genetic attributes given that their environments are significantly different (Christianson et al. 2005; Olexa and Gogan 2007).

The mathematical context of the word "assume" is readily apparent in quote 1. Further, note that an above finding of the study (quote 2.) provides evidence for the separation of the northern and central herds, that is, discreteness, namely: "In other words, it appears that the isolation between these 2 groups is significant," yet the general intent of the White and Wallen letter is to discredit the importance of this difference.

White and Wallen have gone on their quote-mining expedition to disprove the study, disregarding the mathematical nature of the passages from which the quotes were taken, disregarding a passage following quote (1.) where Halbert et al. state: "In this discussion, we have made a number of simplifying assumptions," and instead criticize the passages as though they were historical omissions, instead of recognizing those passages for what they are: discussions of mathematical probability analysis that are based on making assumptions so as to simplify for the purpose of making equations.

In the letter White and Wallen state:

> However, these statements ignore that humans contributed to the observed population and genetic substructure in Yellowstone bison by nearly extirpating them in the late 19th century (except for approximately 23 bison that survived in central Yellowstone) and then by creating another breeding herd in northern Yellowstone at the turn of the 20th century from 21 bison of unrelated breeding descent and divergent genetic stock that were relocated from northern Montana and Texas (Meagher 1973).

At the get-go, White and Wallen treat as parenthetical the statement that bison were nearly extirpated "except for approximately 23 bison that survived in central Yellowstone." The value of this remnant population has been brushed aside by White and Wallen, even though it has been the focus of on-going conservation actions and studies aimed at preserving this historically important native herd. The body of the Yellowstone biologists' letter is merely a reflection of their abiding attitude that discounts the significance of the endemic central herd.

Their letter continues:

> A few individuals from the endemic central herd were introduced into the northern herd in the early 1900s, whereas 71 bison from the northern herd were relocated to central Yellowstone during 1935–1936 (Cahalane 1944). The northern herd was not released from traditional livestock management practices and allowed to evolve natural patterns of distribution until the 1950s—which likely contributed to some geographic separation between the herds (Meagher 1973). Further, each herd was sporadically culled from the 1950s to present (Meagher 1973, White et al. 2011b). Thus, the history of Yellowstone bison suggests the population substructure and genetic differentiation was substantially influenced by a human-induced bottleneck in the late 1800s and the effects of human stewardship thereafter. As a result, there is evidence that the existing genetic substructure was artificially created.

Halbert et al. do not ignore the artificial status of many present bison herds. In fact, it is one of the reasons for their study. The authors state:

> Genetic isolation among subpopulations affects many demographic and evolutionary processes. For example, reduced gene flow can lead to the

> accumulation of genetic differences between subpopulations from genetic drift, mutation, and/or selection. Genetic substructure does not always coincide with obvious morphological or geographical differences between subpopulations, and cryptic substructure has only been revealed in recent decades through analysis of molecular genetic data (e.g., Proctor et al. 2005; Yoshio et al. 2009). The recognition of population substructure is fundamental to the identification of management units and an important consideration for wildlife conservation.

The overarching conclusion of the Halbert et al. study is that despite the artificial creation of a subpopulation in Yellowstone, separate and distinct breeding herds persist and are important to preserve.

The study continues, noting the artificial constitution of remaining herds following population reductions (study's use of the word "artificial," put in italics by Petitioner for emphasis):

> Range contraction and landscape fragmentation have led to the restriction of many terrestrial mammals to isolated populations, thereby creating *artificial* population substructure. For example, the largest extant land mammal in North America, American bison (*Bison bison*), ranged across the continent in large intermixing herds of thousands of individuals in the 19th century (McHugh 1972) but now exists in isolated populations generally of less than 1000 individuals (Gates et al. 2010). The *artificial* isolation of these populations has led to detectable levels of genetic differentiation (Wilson and Strobeck 1999; Halbert and Derr 2008).

Halbert et al. acknowledge this substucture existed historically at Yellowstone:

> Historically, 3 bison herds within Yellowstone were documented based on winter distributions (Mary Mountain, Pelican Valley, and Lamar Valley), although none of the herds remained isolated year-round (Meagher 1973). As the total number of bison increased to more than 3000 in the mid 1990s, 2 herds have been generally recognized: the central herd consists of the former Mary Mountain and Pelican Valley herds and the northern herd consists of the former Lamar Valley herd (Olexa and Gogan 2007). The smaller northern herd moves northwestward during the winter toward Gardiner, Montana, and the central herd moves westward toward West Yellowstone, Montana (Figure 1). In some winters, segments of the central herd have been observed moving northward toward Gardiner, Montana, and the herds may intermingle during these times (Gates et al. 2005). Radiotelemetry data indicate that the herds remain isolated during the summer breeding season (Olexa and Gogan 2007). However, the question of whether the recognized herds represent genetically distinct units remains unanswered. In this study, we use nuclear microsatellite

markers and a multilocus Bayesian clustering method to evaluate the possibility of genetic substructure among Yellowstone bison and assess patterns of genetic variation among subpopulations.

The above quote from Halbert et al. demonstrates that White and Wallen's claim that the Halbert et al. "article provides information regarding the behavior and management of Yellowstone bison that does not accurately portray historic or current conditions" is a false claim. Instead, Halbert et al. explicate the history. Further, the significance of the Yellowstone herds, the population's "high levels of genetic diversity and heterozygosity compared with other populations" and their genetic substructure as critical for the species' conservation is underscored by the Halbert et al. authors:

> Populations of more than 5000 bison are currently supported on only 2 landscapes: the Greater Yellowstone Area in Wyoming/Montana/Idaho, USA (including Yellowstone and Grand Teton National Parks) and the Greater Wood Buffalo Area in Alberta/Northwest Territories, Canada (Gates et al. 2010). The large number of bison on these complex landscapes provides opportunity for natural population substructure, which could have important implications for the long-term evolution of these populations. In this study, we investigate genetic substructure within the Yellowstone National Park bison population, which is among the most critical to bison conservation. The Yellowstone population is one of only a few ''occupying extensive native landscapes where human influence is minimal and a full suite of natural limiting factors is present'' (Gates et al. 2010), although large numbers have been culled along the park boundaries intermittently since the 1980s (Cheville et al. 1998; US Department of Interior and US Department of Agriculture 2000). Additionally, the population is a valuable genetic resource. Unlike most populations examined to date, no evidence of domestic cattle genetic introgression has been identified in Yellowstone bison (Ward et al. 1999; Halbert et al. 2005; Halbert and Derr 2007). Furthermore, this population has high levels of genetic diversity and heterozygosity compared with other populations (Wilson and Strobeck 1999; Halbert and Derr 2008), underscoring the significance of Yellowstone bison in species conservation.

White and Wallen distort the meaning of the Halbert et al. study by quoting passages out of context and twist the meaning of words away from their intended mathematical use. Recall, Halbert et al. made the following statements (italics by Petitioner to show portions of passages quoted—out of context—by White and Wallen):

> First, let us *assume that the Yellowstone population was not subdivided before 1936* (Meagher 1973) so that F_{ST} = 0 at that point" and "Although the

> observed value of differentiation is low compared with the F_{ST} value of 0.2 that is sometimes used to indicate strong differentiation (Mills and Allendorf 1996; Wang 2004), *these 2 subpopulations have differentiated in a relatively short period of approximately 8 generations*.

That "these statements ignore that humans contributed to the observed population and genetic substructure in Yellowstone bison," as White and Wallen claim, is not true, as shown by the foregoing full paragraph quote from the Halbert et al. study. Moreover, White and Wallen imply that by fixing the year 1936 as the point where the two herds diverged has incorrectly omitted the prior histories of the herds. Far from it. The year was picked as the year the two herds became genetically mixed. The study used that date to measure *mathematically* how much mixing occurred thereafter. As White and Wallen themselves state in their letter:

> A few individuals from the endemic central herd were introduced into the northern herd in the early 1900s, whereas 71 bison from the northern herd were relocated to central Yellowstone during 1935–1936. The northern herd was not released from traditional livestock management practices and allowed to evolve natural patterns of distribution until the 1950s—which likely contributed to some geographic separation between the herds (Meagher 1973).

The year 1936 was chosen by Halbert et al. as a date in time when the fixation index (F_{ST})—a measure of population differentiation due to genetic structure—equals zero. The fixation index is among the most widely used measures for genetic differentiation and plays a central role in ecological and evolutionary genetic studies. The values range from 0 to 1. A zero value implies complete panmixia, that is, that the two populations are interbreeding freely. A value of one implies that all genetic variation is explained by the population structure, and that the two populations do not share any genetic diversity. As Halbert et al. mention, an F_{ST} value of 0.2 is sometimes used to indicate strong differentiation, but can be lower. F_{ST} can be used to demonstrate genetically a significant population segment or an evolutionarily significant unit.

Figure 33 illustrates the position of the year 1936 in the history of the two Yellowstone herds.

In order to establish a point were gene flow began between the two herds for the purpose of Bayesian probability calculations, Halbert et al. simplified the blurred interbreeding timelines by designating the year 1936—the year northern bison were released into the central bison herd—when interbreeding may have begun.

White and Wallen continue their criticism of the Halbert et al. study, laying the groundwork for their eventual claim that preserving distinctions between the two herds has become meaningless through interbreeding:

> Halbert et al. (2012, p. 2,5) state that "Radiotelemetry data indicate the [central and northern] herds remain isolated during the summer breeding season" and "the number of migrants into and out of each subpopulation each generation is about 2 (N_m = 2.3) or approximately 1 every fourth year." This statement and estimate may generally reflect conditions during the period of intense human stewardship (1900–1968) and subsequent increase in bison abundance and distribution during the period of ecological process management (Plumb et al. 2009).

However, White and Wallen argue that this separation has been reduced by presumably increased interbreeding between the two herds, writing:

> However, extensive monitoring of the movements and productivity of radio-collared bison since 2005, when the population reached an abundance of approximately 5000 bison, suggests that emigration and gene flow is now much higher. Since 2007 (one half of one generation), biologists have detected 17 radio-collared bison emigrating between the central and northern herds and remaining through one or more breeding seasons (see Supplementary Table 1 online). Female bison rarely travel alone, so dispersal by these marked females likely represents emigration in groups of 25–40 bison each time, which increases the probability that gene flow occurred. Eleven of these 17 radio-collared bison produced calves on their new range (e.g., northern) that were conceived on the range they left (e.g., central). At least 23 calves were produced by these dispersing bison through mating and calving on their new range. These observations of female emigration and subsequent reproduction on a new breeding range are supported by low FST estimates derived from microsatellite genotypes collected from 152 feces of Yellowstone bison sampled during breeding seasons between 2006 and 2008 (Gardipee 2007; G. Luikart, unpublished data). The low FST estimates suggest that there are approximately 10–20 emigrants per generation (see Supplementary Table 2 online). The natural process of emigration by bison was likely facilitated by the pioneering behaviors of animals responding to higher abundance (density) and deep snow conditions that limit forage availability and foraging efficiency (Gates et al. 2005). Some biologists suggest these increased movements of bison between the central and northern herds during winter reflect the effects of packing snow-covered roads to facilitate over-snow vehicle recreation during winter. However, grooming has occurred since the 1970s and scientific findings suggest that bison use of travel corridors that include these groomed road segments would persist whether or not roads were groomed (White et al. 2009). Regardless, recent observations of gene flow between the central and northern breeding herds are substantially higher than previous estimates.

To clarify this paragraph, I wrote Wallen on August 12, 2017, the following:

> In your letter to the editor . . . you state that:
>
> > These observations of female emigration and subsequent reproduction on a new breeding range are supported by low FST estimates derived from microsatellite genotypes collected from 152 feces of Yellowstone bison sampled during breeding seasons between 2006 and 2008 (Gardipee 2007; G. Luikart, unpublished data). The low FST estimates suggest that there are approximately 10–20 emigrants per generation (see Supplementary Table 2 online).
>
> However, the Halbert et al. study takes into consideration the Gardipee 2007 thesis, stating:
>
> > Between the 2 populations of Yellowstone bison identified above, the estimate of FST for nuclear markers is 0.0321. Gardipee (2007) examined mtDNA variation in samples from the northern population from Lamar Valley (2006) and from the central populations from Hayden Valley (2005 and 2006). The 2 estimated FST(f) values between these 2 locations were 0.218 (Hayden Valley 2005 and Lamar Valley 2006) and 0.367 (Hayden Valley 2006 and Lamar Valley 2006) for an average of 0.2925. Using the equation above and this mean estimate, the estimate of FST(m) is 0.0325, nearly equal to the overall estimate of 0.0321, suggesting that nearly all of the gene flow is from males. The ratio of male to female gene flow was then estimated to be 12.31, also suggesting that most of the gene flow is from males. This difference in male and female gene flow is consistent with significantly higher female philopatry than male philopatry in bison, as discussed by Gardipee (2007).
>
> You continue in your letter stating: “Regardless, recent observations of gene flow between the central and northern breeding herds are substantially higher than previous estimates.”
>
> Could you quantify the approximate value of the gene flow differences that are “substantially higher than previous estimates”? To help me understand where you are coming from, could you provide me with the G. Luikart unpublished data you cited and the “Supplementary Table 2 online,” which I can not locate?

Wallen replied August 14, 2017:

> Our argument was that we started seeing radio marked females emigrating to the northern herd and Natalie and Jim noted that female emigration was nearly non existent. I will look for the Supplementary Table you asked for and send you a copy directly.
>
> We should probably just have a phone conversation. We don't dispute what their data set represents. We only wanted to show that there is more to the story than they had data to share. RW (R. Wallen, personal communication, August 12, 2017).

The White and Wallen argument, however, is a mere opinion, a hypothesis, that is not quantified—only a guess, based on field observations, as opposed to genetic analysis, that could confirm the claim that "observations of gene flow between the central and northern breeding herds are substantially higher than previous estimates." Gene flow that is "substantially higher" would have to be a finding by a peer-reviewed study to have credibility. The letter was not a peer reviewed study.

White and Wallen proceed to arrive at a conclusion that:

> 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.

What is disheartening about this statement is that the authors have the gall to say this while being the key players in setting the extraordinarily high lethal removal goals that are the epitome of artificiality. Their stated conclusion, which sounds reasonable on the surface, i.e, that "managers should be promoting the conservation of wildness and natural selection to retain adaptive capabilities," is a non sequitur in the context of what these biologists, who have life and death control of the park's bison, are routinely recommending. What they say does not match what they do in the field, regardless of the academic tone of what they say to support that conclusion and regardless of their authoritative positions as wildlife managers. In short, what they say should be done is crazy when you look at their actions.

Their logic fails because they misuse the concepts of "natural selection" and "adaptive capabilities." The authors begin their argument by quoting a passage from the Halbert et al. study that questions managing the two herds in Yellowstone as one herd, as is now the practice:

> Halbert et al. (2012, p. 9) deduce that ". . . the identification of genetic subpopulations in this study raises serious concerns for the management and long-term conservation of Yellowstone bison" which ". . . 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."

White and Wallen agree that while the number of bison to be culled is based on the "abundance for the entire population," they say *both* breeding herds should be considered when culling, because the herds have been disproportionately culled in the past and because large-scale culls may harm genetic diversity:

> It is correct that the Interagency Bison Management Plan (USDI and USDA 2000) provides guidelines for managing toward an end-of-winter abundance for the entire population around 3000 bison. However, management plans and monitoring/research to inform and adjust actions, including culling activities, have considered the two breeding herds (Angliss 2003, Clarke et al. 2005, Gates et al. 2005, Gardipee 2007, Fuller et al. 2009, Geremia et al. 2012). Although the 2 subpopulations have been disproportionately culled in some years, biologists have clearly warned of possible demographic effects if large culls were continued over time (White et al. 2011b). Biologists have also acknowledged that it is not clear how large-scale culling might influence the genotype diversity and allelic distributions of the subpopulations over time (White et al. 2011b).

But, claim White and Wallen, wildlife managers have their bases covered. For instance, they have plans in place to minimize future large-scale culls, to evaluate how such culling affects the genetic diversity of bison, to identify genetic subdivisions and gene flow, to determine if the two herds are converging or diverging and if culling is influencing the subpopulations:

> These analyses and uncertainties led to the implementation of several adaptive management adjustments to the Interagency Bison Management Plan designed to minimize future large-scale culls of bison, evaluate how the genetic integrity of bison may be affected by management removals (all sources combined), and assess the genetic diversity necessary to maintain a robust, wild, free-ranging population that is able to adapt to future conditions (USDI et al. 2008). In addition, the National Park Service developed a rigorous monitoring plan for Yellowstone bison that characterizes the bison inhabiting Yellowstone as a single population with significant substructure and includes randomly sampling bison from primary breeding locations during July and August to identify genetic subdivisions and estimate gene flow within the Yellowstone population (White et al. 2011a). The plan acknowledges it will be necessary to sample bison across decades to determine if existing subpopulations are converging or becoming more divergent and whether

> management actions are having a significant influence on population substructure.

The influence of management actions on population structure is plain—they are dramatically diverging—as their records show, despite White and Wallen's claimed desire for equal herd sizes. The authors state:

> Furthermore, each winter biologists use telemetry, ground observations, and aerial distribution surveys to track movements of bison and attempt to differentiate animals from each breeding herd when they approach the boundary of the park and become subject to management actions. This approach does not provide absolute certainty with respect to breeding herd membership, but has been relatively effective at allowing managers to monitor movements by bison and estimate the proportion of culls from each breeding herd. Thus, total population abundance is not the only primary factor considered in determining management actions for Yellowstone bison. As an example, the management plan for Yellowstone bison during winter 2012 clearly indicates a desire to progress toward approximately equal numbers of bison in each breeding herd and selectively cull bison from the northern herd (which is currently larger), while minimizing removals from the central herd (Geremia et al. 2012).

Importantly, what is not explained is how management selectively culls from the northern herd and minimizes culls from the central herd to achieve approximately equal numbers in the two herds. White and Wallen quote from Halber et al. about the harm of mindless culling:

> Halbert et al. (2012:9) conclude that "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." The authors further suggest that current management will ". . . erode the genetic distinctiveness between the 2 groups" (Halbert et al. 2012, p. 9).

But White and Wallen ask whether preserving the genetic distinctiveness of the herds is really the job of the National Park Service:

> We agree that bison removals should be carefully managed to prevent unintended consequences and have referenced documents in this response that indicate such management is occurring with frequent assessments of progress toward desired conditions. However, we question whether the National Park

> Service should actively manage to preserve the genetic distinctiveness of each herd because history indicates humans likely facilitated the creation and maintenance of this population substructure.

Instead, let nature take its course, White and Wallen propose:

> Rather, we recommend that the National Park Service continue to allow ecological processes such as natural selection, migration, and dispersal to prevail and influence how population and genetic substructure is maintained in the future rather than actively managing to perpetuate an artificially created substructure. The existing population and genetic substructure may be sustained over time through natural selection or it may not. Regardless, we submit that it is the conservation of the ecological processes that is important, not the preservation of a population or genetic substructure that may or may not have been created and/or facilitated by humans.

Recommending "ecological processes such as natural selection, migration, and dispersal to prevail and influence how population and genetic substructure is maintained in the future," yet preventing natural selection, migration and dispersal by recommending and carrying out large-scale culling is breathtakingly nonsensical.

White and Wallen pontificate, praising the very subspecies they are setting up to destroy:

> 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.

Human intrusion into the distribution and habitat of bison can dramatically influence evolutionary processes, White and Wallen point out:

> 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).

White and Wallen then reach the denouement of their letter, concluding:

> 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.

In short, White and Wallen recommend that bison management allow wildness and natural selection to operate so that the species can retain adaptive capabilities. This of course means that nature should be doing the selecting, not humans. If humans do the selection, it is artificial selection.

Systematically and annually killing in large numbers only the migratory of a wild species, such as bison that enter Gardiner Basin in the winter, is artificial selection. Any biologist would confirm this. It selects against migratory behavior and leaves behind a breeding stock of non-migratory animals. The more migratory herd is the central herd. This herd occupies Hayden Valley during the breeding season. Some stay in that region, while others migrate north in the winter and return to it in the spring. Because the IBMP does not test animals prior to culling with regard to either brucellosis or mitochrondrial disease, no one knows which animals are being allowed to live and carry on either genetic weaknesses or strengths. *What is known is that migration is a fitness trait. Selecting against it destroys fitness*.

Regarding the difference between natural and artificial selection, R. A. Richards observes in "Darwin and the inefficacy of artificial selection":

> But natural selection must not only be able to produce new species, it must be able to produce, via divergence from common ancestry, all the species that have ever existed. This means that the process in nature must be unlimited. Artificial selection, by virtue of its opposition to fitness, is a dead-end process. As processes, artificial and natural selection differ in kind (Richards, 1997, p. 95).

Culling can put a species into an ecological trap from which there may be no escape. As mentioned, in the case of Yellowstone's bison, by culling only the migratory, wildlife managers are promoting a potentially maladaptive behavior—non-migration, that is, staying put, even in the face of environmental changes that if not escaped can cause total destruction of the remaining herd, such as by winter kill, that is, starvation.

White and Wallen's conclusion that "managers should be promoting the conservation of wildness and natural selection to retain adaptive capabilities" means letting nature select. Not retaining "population substructures that were likely created or exacerbated by human actions" would entail not continuing to modify subpopulations by human actions, such as lethal removals.

White and Wallen do not specifically identify what actions comprise "actively managing to perpetuate an artificially created substructure" of wild bison in the park. What is advocated in both the 2014 and 2015 petitions is to allow ecological processes such as natural selection to work, as opposed to the artificial selection in the form of culling now ongoing at the park. Logically, then, in the minds of White and Wallen, "actively managing to perpetuate an artificially created substructure" would be to not disallow culling, as though culling was a part of Mother Nature herself. That, of course, is more nonsense.

Following their letter to the editor written in 2012, what course of action did these two wildlife biologists recommend to IBMP?

Large-scale culling.

Lethal removals of the migratory animals has not only continued but has increased in magnitude under the leadership of White and Wallen. Recent culling goals, sometimes not fully met, have ranged from 900 to 1,300 animals annually—numbers set with the help of White and Wallen. As mentioned, in 2017 the goal of 1,300 was met, falling mostly on the central herd, that now numbers 847. For 2018 the lethal removal goal is 1,250 animals.

The only conclusion one can come to, given this disjuncture, is that these wildlife managers do not understand natural selection and evolutionary adaptation, that is, they do not know what they are talking about, when in the name of allowing "ecological processes" to work, they recommend large-scale culling. Either that, or they are trying to hoodwink the public, using scientific language as a cover for maintaining the culling status quo.

II. Halbert et al.'s rebuttal

In the same issue of the *Journal of Heredity* that carried the above criticism by White and Wallen of the Halbert et al.'s study "Genetic Population Substructure in Bison at Yellowstone National Park" was a rebuttal by the authors of the Halbert et al. study titled "Yellowstone bison genetics: Let us move forward." Both the criticism of the study and the rebuttal were letters-to-the-editor, published in the September-October issue several months after the study. Following is Halbert et al.'s rebuttal, interspersed with my comments:

> **Yellowstone bison genetics: Let us move forward**
>
> White and Wallen (2012) disagree with the conclusions and suggestions made in our recent assessment of population structure among Yellowstone National Park (YNP) bison based on 46 autosomal microsatellite loci in 661 animals (Halbert et al. 2012).
>
> First, they suggest that "the existing genetic substructure (that we observed) was artificially created." Specifically, they suggest that the substructure observed between the northern and central populations is the result of human activities, both historical and recent. In fact, the genetic composition of all known existing bison herds was created by, or has been influenced by, anthropogenic activities, although this obviously does not reduce the value of these herds for genetic conservation (Dratch and Gogan 2010). As perspective, many, if not most, species of conservation concern have been influenced by human actions and as a result currently exist as isolated populations. However, it is quite difficult to distinguish between genetic differences caused by human actions and important ancestral variation contained in separate populations without data from early time periods. Therefore, to not lose genetic variation that may be significant or indicative of important genetic variation, the generally acceptable management approach is to attempt to retain this variation based on the observed population genetic subdivision (Hedrick et al. 1986).

Petitioner's comment: Further, the artificial introduction of the northern herd has not substantially changed the separate status of both herds, as the Halbert study confirmed. Also, the ongoing, annual artificial selection of bison that favors the non-migratory and removes the migratory members from the breeding pool can significantly alter the sex and age composition of the herds, as well as their effective population size, exposing the last wild herd to loss of genetic diversity.

- The letter continues:

> Potential support for the opinion of White and Wallen (2012) about the large contribution of human actions to the observed genetic differentiation in YNP bison could come from genetic evaluation of bison samples from just before the relocation efforts of 1935–1936 (Cahalane 1944) or from the end of the period of intensive livestock-like management in the 1950s (Meagher 1973). However, if the observed differences were created by human-influenced

events before the 1950s, then one would predict that in the last half century since then, natural exchange between the subpopulations would have greatly reduced or eliminated this genetic signal of differentiation. Regardless of the level of human influence on the observed levels of population differentiation, we must collectively move forward as good stewards of this natural resource with the best available scientific information. As such, it is paramount that we consider the long-term effects of current human interventions (bison "management") on patterns of genetic diversity.

> Second, White and Wallen (2012) state that the low level of gene flow (based on FST) we reported is no longer present because of recent higher population numbers. They suggest that radiocollared bison movement data from 2002 to 2011 and a genetics study (nuclear microsatellites) of fecal samples from 99 different animals for 17 of our loci from 2006 and 2008 support a recent higher rate of gene flow between the two subpopulations. However, the details of the movement study and the genetic study are unpublished. We encourage White and Wallen to submit these for peer-review publication so the research can be more fully evaluated and used to inform additional research.

Petitioner's comment: In personal communication from Wallen to me, he clarified this matter, as noted earlier above, saying:

> Our argument was that we started seeing radio marked females emigrating to the northern herd and Natalie and Jim noted that female emigration was nearly non existent . . . We don't dispute what their data set represents. We only wanted to show that there is more to the story than they had data to share (R. Wallen, personal communication, August 12, 2017).

A peer review study would probably reveal what Wallen and his colleagues have already found, as referenced above in "Managing the Abundance of Yellowstone Bison, Winter 2014." The authors stated in 2013: "Despite this decrease in numbers, about 2% (0-10%) of bison from the central herd have emigrated into the northern herd each year" (Geremia et al., 2013). This represents a limited opportunity for gene flow between the two herds.

- The letter continues:

> Estimates of population structure based on maternally inherited mitochondrial DNA from Gardipee (2007) showed very high differentiation between groups. Further, we examined sex-biased gene flow using her data and found gene flow values that were consistent with estimates from our nuclear data. The unpublished radiocollared bison movement data White and Wallen (2012) report found no movement between the groups for female bison until the years

2006 to 2007. In other words, the lower FST that they report for 2006 surprisingly measures lower differentiation before this documentation of movement between groups. To evaluate the potential effect of recent higher gene flow, let us assume that FST declined from 0.032 (our estimated value) to 0.017 (the average of their two values) in one generation from around 2000 to 2007. Using expression (1) in Halbert et al. (2012), then the rate of gene flow would have had to be 27.1% each way between the two groups. This seems unrealistically high.

Furthermore, the substantial evidence of cryptic population structure reported by Halbert et al. (2012) should give pause to observational studies linking YNP bison to particular breeding ranges or subpopulations. That is, while radiocollared bison movement data are immensely useful in understanding patterns of movement (e.g., Olexa and Gogan 2007), empirical genetic data are needed to establish the subpopulation origin of individuals: movement of individuals is not equal to gene flow. Furthermore, even if higher gene flow is occurring today, unidentified loci, differentiated due to selection, may be still present among the YNP subpopulations.

Petitioner's comment: In my opinion, from all appearances, White and Wallen are on a campaign to meld the northern herd with the central herd. By doing this, the uniqueness of the central herd would disappear and there would be no need to protect this herd from extinction. Without protection, extinction is sure. This would solve the conflict going on at Yellowstone, for with the migratory central herd gone, the need for culling would greatly diminish and White and Wallen would be the poster boys of the cattle industry, who would like nothing better than the eradication of migratory wild bison that they consider intrusive on their grazing land.

- The Halbert et al. rebuttal continues:

Finally, White and Wallen (2012) suggest that conservation of ecological processes is more important than genomic conservation. Here, it is critical to keep in mind that ecological processes alone do not define populations. Ecological processes can, however, shape the genetic architecture of a population. That is, a bison population is not defined by whether it migrates or has predators, but rather is determined by the genetic composition of the population and exchange of gene flow with other populations, even if cryptic in nature. Increasingly, ecological processes themselves are highly influenced by anthropogenic activities. For instance, the movement patterns of YNP bison have been continually influenced by humans (hunters, private land owners, government employees) since before YNP even became a park (Meagher 1973). To conclude that ecological processes are somehow more important to

> population conservation than genomic content is ill conceived, as both warrant consideration in the management of YNP bison.

Petitioner's comment: According to the Environmental Protection Agency's document "Considering Ecological Processes in Environmental Impact Assessments":

> ecological processes such as natural disturbance, hydrology, nutrient cycling, biotic interactions, population dynamics, and evolution determine the species composition, habitat structure, and ecological health of every site and landscape. Only through the conservation of ecological processes will it be possible to (1) represent all native ecosystems within the landscape and (2) maintain complete, unfragmented environmental gradients among ecosystems (Considering Ecological Processes).

Ecological processes are something to conserve. They do not include culling, for culling is human intrusion, which is artificial. Further, hypothetically, if there is indeed now a higher gene flow between the two herds, it could be attributed to the imbalance in population numbers created by the continued annual disproportionate culling of the two herds, resulting in a northern population almost five times greater than the central herd, creating the opportunity for genetic swamping, also called genetic pollution or genetic contamination. According to Marco Todesco and colleagues in their 2016 study "Hybridization and extinction":

> Hybridization may drive rare taxa to extinction through genetic swamping, where the rare form is replaced by hybrids, or by demographic swamping, where population growth rates are reduced due to the wasteful production of maladaptive hybrids (Todesco, 2016).

Genetic swamping is also discussed in this chapter under subheading "C." and in chapter 1, "The greatest threat: Human interference," second volume of this petition. The central herd is rapidly headed toward its complete swamping by the northern herd, meaning it is at risk of being replaced by the more maladaptive non-migratory herd. This is a concern in that recent genetic studies have confirmed that two separate clades exist in the park, one with wood bison genetics, associated with the central herd, and the other with plains bison genetics, associated with the northern herd (see chapter 10 below "Yellowstone proves plains and wood bison are separate subspecies").

- The letter continues:

> We submit that a cautious approach be used for conservation of the YNP bison in light our evidence that significant genetic differences exist between

subpopulations. To be clear, we are not proposing that the management goals for YNP bison should include the preservation of the FST value or specific alleles reported by Halbert et al. (2012). We suggest that there be continuing annual documentation of genetic variation in YNP using as large samples as possible and the most current and comprehensive genetic approaches to document both female and male gene flow and recommend that future management of YNP bison strive to minimally interfere with the distribution of genetic diversity among YNP subpopulations. While culling of bison around YNP without regard for the potential impact on genetic substructure has occurred since the mid-1980s (Plumb et al. 2009; White et al. 2011), a "minimally interfering" strategy acknowledges that genetic diversity is nonrandomly distributed in this population and aspires to develop culling strategies that are sensitive to the size of each subpopulation. The appropriate use of the best-available scientific information is the best foundation for development of management policies moving forward for this irreplaceable natural resource.

Petitioner's comment: The "cautious approach" certainly would not recommend the culling of 1,250 wild bison, as is presently the case, when only 847 central bison are left, when it is preponderantly the central herd that is migratory and when it is only the migratory that are culled by the IBMP.

C. *Yellowstone bison—conserving an American icon in modern society:* a close reading of chapter 8

Another insight into Yellowstone National Park's perspective of bison management may be gained from the text *Yellowstone bison: conserving an American icon in modern society*, published in 2015. Because of its importance, and for comparative purposes with the last letter under study, the short chapter 8 "Adaptive Capabilities & Genetics" by Wallen and White will be quoted in full. In many respects it is another version of their letter to the editor in 2012, but it contains some important differences. The Petitioner's observations will follow each paragraph, with each paragraph numbered by the Petitioner.

The authors recount the genetic history of bison in Yellowstone:

(1) Yellowstone bison went through a population bottleneck (i.e., a drastic reduction in numbers) in the late 1800s that was caused by human exploitation. There were less than 25 indigenous bison in central Yellowstone by 1902 and they persisted at relatively low numbers (less than 500 bison) for many generations. Populations that begin with, or are reduced to, a small number of animals contain less genetic variation than populations with a larger

number. Thereafter, chance losses of genetic variation may continue due to inadequate gene flow with other populations, and over time, reduce the abilities of animals to adapt to new environmental challenges. However, Yellowstone bison do not show the effects of inbreeding and have retained significant amounts of genetic variation. The high genetic diversity observed in Yellowstone bison despite their being nearly extirpated may be explained, at least in part, by the human creation of a bison herd in northern Yellowstone during 1902 from unrelated bison with somewhat different genetic make-ups that eventually interbred with the indigenous herd in central Yellowstone.

Petitioner's comment: Paragraph 1. claims that part of the high genetic variation of Yellowstone's bison, despite the bottleneck that would favor inbreeding, was the introduction of the captive plains bison into the park that eventually interbred with some of the indigenous herd. However, interbreeding of the two herds is minimal, as shown in this petiton. The statement is an acknowledgement by the National Park Service that there are two herds in Yellowstone: introduced and indigenous.

Further, by stating: "Populations that begin with, or are reduced to, a small number of animals contain less genetic variation than populations with a larger number," yet allowing reductions by the IBMP of the indigenous herd from a population high of 3,531 bison in 2006 to a low of 847 in 2017, demonstrates a flagrant disregard for the preservation of genetic variation advocated by White and Wallen and the inadequacy of existing regulatory mechanisms, such as adaptive management policies, which in the hands of Yellowstone's biologists are maladaptive.

- The chapter continues:

  (2) Bison from the central and northern regions of Yellowstone are genetically distinguishable, which likely reflects, in part, the population bottleneck caused by nearly extirpating Yellowstone bison in the late 19th century, the creation of another breeding herd in northern Yellowstone from bison of unrelated breeding ancestry, and human stewardship thereafter. These genetic differences were maintained over much of the last century by strong female philopatry (i.e., fidelity) to breeding areas, with most females returning to the same area each year. As a result, there was little gene flow between bison from the central and northern regions of the park. However, observations of radio-collared female bison indicate that in the most recent generation female groups are emigrating between central and northern Yellowstone and contributing to gene flow that could decrease genetic differences between bison in these regions.

Petitioner's comment: Paragraph 2. establishes that the two herds, even though interbreeding has occurred, are genetically distinct and therefore discrete, with little gene flow between the two herds. However, they claim recent field observations call the continued separation of the two herds into question.

If this is indeed the case, it may be due to genetic "swamping" caused by intensive culling practices by the IBMP, leading to a decline of fitness. According to Fred Allendorf, writing in "Genetic effects of harvest on wild animal populations":

> Exploitation can also increase gene flow or hybridization among subpopulations and potentially swamp local adaptations. Overexploitation could reduce the density of local subpopulations and allow for more immigration from nearby subpopulations less affected by exploitation. This could bring about the genetic swamping of the remnants of exploited subpopulations and thereby reduce fitness (Allendorf, 2008).

- The chapter continues:

> (3) Some scientists have argued that the National Park Service should actively manage to preserve the genetic distinctiveness of bison in central and northern Yellowstone. The conservation of genetic diversity is extremely important, but it is arguable whether the preservation of a population or genetic substructure that was created and facilitated in large part by humans should be the goal. Alternatively, ecological processes such as natural selection, migration, and dispersal could be allowed to prevail and influence how the population and genetic substructure is maintained into the future. Bison from central Yellowstone began dispersing to northern Yellowstone in the 1980s and these dispersal movements have continued to increase with bison abundance. Gene flow between breeding herds could lessen some potential effects of population substructure and non-random culling on the loss of genetic diversity. Thus, current management actions attempt to preserve bison migration to essential winter range areas within and adjacent to Yellowstone National Park and bison dispersal between central and northern Yellowstone. The current population distribution and genetic substructure may or may not be sustained over time through ecological and evolutionary processes. The bison will determine that.

Petitioner's comment: Paragraph 3. concludes that wild bison will determine their population distribution and genetic substructure. Indeed, this is true, but only *if* left alone, that is, *if* allowed to take part in "ecological processes such as natural selection, migration, and dispersal." However, they presently are *not* left alone. Culling has been disproportionately biased against the indigenous central herd, creating a potential for genetic swamping. This is not a "minimally interfering" strategy as advocated by Halbert and her A&M University colleagues. Both herds have had their migrations truncated by the culling activities of the IBMP, which, by its actions is defeating natural selection and instead is subjecting the herds to artificial selection. Yes, gene flow between breeding herds could lessen some potential effects of culling on the loss of genetic diversity, but such gene flow can not make up for genes permanently lost by culling. Irreversible gene loss, genes that are the result of millions of years of adaptive evolution, plus the higher probability in small populations of loss of genetic diversity due to genetic drift, is much more probable with the kind of large-scale culling routinely carried out in Yellowstone.

- The chapter continues:

  (4) To preserve genetic variation over decades and centuries, the bison conservation initiative by the U.S. Department of the Interior and the North American conservation strategy for bison by the International Union for the Conservation of Nature recommended that population (or breeding herd) sizes should be at least 1,000 bison, with approximately equal sex ratios to enable competition between breeding bulls. Furthermore, a wild bison population was defined as one with sufficient numbers to prevent the loss of genetic variation, low levels of cattle hybridization, and exposure to some forces of natural selection, including competition for breeding opportunities. Currently, Yellowstone bison comprise the only population of plains bison that has achieved these goals, with more than 1,000 bison in both central and northern Yellowstone, moderate to high variation in male reproductive success, and no evidence of hybridization with cattle.

Petitioner's comment: Paragraph 4. claims that more than 1,000 bison are in each of the two herds. No longer is that the case. Yellowstone's wildlife managers have watched as the central herd has plummeted in numbers due to lethal removals, sometimes above 1,000 animals a year, abdicating their responsibility to preserve the balance in numbers they verbally extol. Instead, they have called for and gotten increased culling numbers, creating further disproportionate lethal removals, with herd sizes akilter: in 2017 about 4,000 in the northern herd and about 850 in the central herd, a differential of almost 5 to 1.

- The chapter concludes:

  (5) Intensive management actions near the boundary of Yellowstone National Park to reduce the risk of brucellosis transmission to cattle outside the park could potentially result in a substantial loss of genetic diversity and affect population substructure. Sporadic culls of more than 1,000 bison in some winters to maintain separation between bison and cattle has removed a disproportionately large number of females and reduced population growth. Therefore, in 2008 managers made several adjustments to the Interagency Bison Management Plan to minimize future large-scale culls of bison, evaluate

> how the genetic integrity of bison may be affected by management removals, and assess the genetic diversity necessary to maintain a robust, wild, wide-ranging population that is able to adapt to future conditions. Given the importance of male reproductive success and population size on the loss of genetic variation, we recommend managing for at least 3,000 to 3,500 total bison over decades, while minimizing selective culling and preserving opportunities for bison migration and dispersal.

Petitioner's comment: Paragraph 5, written in 2015, recommending adjustments to correct the destructive effects of large-scale culling, has proven to be just talk. As mentioned, in 2017 a total of 1,300 wild bison were culled. The central herd has been decimated. Who is kidding whom? Making statements that sound good does not produce sound management if not carried out. What it demonstrates is a disregard for accepted policies of wildlife management, which are parroted by White and Wallen, but not followed.

5

Cracking the nut: the government's position against listing

On March 2, 2015 I submitted a petition to the Fish and Wildlife Service under the provisions of the Endangered Species Act to list wild bison as endangered or threatened. Several months prior to that, November 14, 2014, the Buffalo Field Campaign and the Western Watersheds Project submitted a similar petition. On January 12, 2016, the Fish and Wildlife Service rejected in one combined 90-day finding both requests made by the separate petitions to list Yellowstone's wild bison. On Mach 8, 2016 I wrote a letter to the FWS asking to clarify why the rejection had been made, receiving an answer dated April 19, 2016 from the assistant regional director of the FWS's Mountain-Prairie Region. An examination of the FWS's 90-day finding and FWS's letter of explanation shows that its justifications for not listing wild bison are in error.

A. FWS's reasons for denial

In its 90-day finding of January 12, 2016 under the heading "Hunting and culling" the FWS stated:

> The first petition argues hunting and the annual winter cull are negatively impacting the YNP bison population by decreasing its genetic viability, selecting for genetic traits that will decrease its fitness, and altering its sex ratio (Halbert 2003, p. 133, first petition + Halbert *et al*. 2012, p. 9, both petitions). The second petition argues culling is negatively impacting the YNP bison in similar ways, but argues hunting of YNP bison should continue

because "wild bison have coexisted with human populations hunting them for millennia," and YNP bison "survival would be enhanced by hunting."

YNP bison leave through the north and western boundaries of YNP during winter while seeking lower elevation areas where food is more abundant. This migration can lead to interaction with domestic cattle grazing in areas adjacent to YNP and the spread of brucellosis from YNP bison to cattle. Brucellosis and disease management are discussed further under Factor C. The State of Montana allows hunting of YNP bison typically between November and February in the Gardiner Basin area just north of YNP (MFWP 2013, unpaginated). If population size goals based on conservation needs are not reached after the hunting season, the IBMP implements a cull using the Stevens Creek Capture Facility. Hunting in the State of Montana and culling by the IBMP are coordinated and implemented together to regulate the population and potential threats claimed by the petitioners apply to both activities. Therefore, hunting and culling are evaluated together as they relate to overutilization. Hunting bison is considered a recreational use of the animals. Culling though, may be considered a scientific use since it is controls the spread of wildlife disease and is meant to maintain the YNP bison population size at conservation goals, while remaining within the management capabilities of YNP.

Petitioner's comment: As pointed out in my 2015 petition, as well as in this 2018 petition, culling wild bison does not prevent the spread of brucellosis out of the park because elk also have the disease, yet are allowed to leave the park and mingle with cattle on the park's borders. Further, a 2015 study has shown that the transmission of brucellosis among bison is not mitigated by culling bison (Hobbs, 2015).

- The 90-day finding continues:

The petitions claim genetic viability may be degraded by a loss of unique genetic qualities (particularly the ability to migrate) through disproportionate culling of migratory animals. The first petition states "culling migratory bison could reduce the overall health and resilience of the Yellowstone bison by favoring less migratory bison, which may also select for a mitochondrial gene defect that decreases their fitness . . ." Both petitions cites Pringle's (2011, entire, both petitions) findings, which suggest bison are predicted "significantly impaired in aerobic capacity, disrupting highly evolved cold tolerance, winter feeding behaviors, escape from predators and competition for breeding" (Pringle 2011, p. 1, both petitions). However, these impairments have not been connected to specific defects in the bison mitochondrial genome and Pringle's assertions are predicated on assumptions that bison mitochondrial defects are caused by not the same, but similar mutations observed in humans and dogs (Pringle 2011, p. 1, both petitions). Only one bison from YNP analyzed in Pringle's study had haplotypes that contain the possibly deleterious mutations (Pringle 2011, p. 14, both petitions). Further, these defects are thought to have arisen from the initial population bottleneck that reduced the North American bison population to 25 animals in YNP (Boyd and Gates 2006, p. 1, first petition). Therefore, any deleterious genetic effects of the bottleneck would have occurred at that time and would not necessarily be exacerbated by present culling management regimes.

Petitioner's comment: To clarify what was being said by the FWS, I wrote Pringle, noting that I had quoted his study "Widespread Mitochondrial Disease in North American Bison" in a petition I submitted to the FWS in 2015 to list Yellowstone's wild bison, providing him a copy of the 90-day finding. Pringle is an expert on vertebrate comparative genomics. He received his undergraduate degree in 1966 from Harvard, completed graduate work in molecular biology at the University of California San Diego, and received a Ph.D. in mathematics at the University of Oregon. He was a college professor at Gettysburg College in Pennsylvania, taught biochemical genetics at the University of Texas Medical School and currently directs the Sperling Biomedical Foundation based in Eugene, Oregon (Declaration of Dr. Tomas Pringle, 2011).

I asked him two questions, which are embedded in his reply below and which I have italicized. His October 22, 2016 reply follows:

> This sounds like a brief written by a cattleman's lawyer on behalf of FWS, not a geneticist or FWS biologist much less any kind of scientist. The issue here is cattlemen not wanting to share public land grazing allotments with another (vastly more popular) large herbivore and overall racist suppression of Native American culture. It has nothing whatsoever to do with brucellosis, an imported European cattle disease that has gotten into elk and various other North American species. It has nothing to do with MT's status as 'brucellosis-free' state as they imported a diseased cow from TX and nothing of economic consequence happened to EITHER state.
>
> Further, this has nothing whatsoever to do with proper management of the YNP bison herd. I challenge the whole concept that bison or any other native species needs genetic or any other kind of 'management' (unless it be halting trophy rack hunting). No one proposes a cull of a native species in a national park for the species' benefit — this is all about two cowardly controversy-avoiding agencies kowtowing to the local cattle industry, even though almost all of the adjacent FS allotments were retired by NWF years ago.
>
> *1. What does the FWS mean by stating "Only one bison from YNP analyzed in Pringle's study had haplotypes that contain the possibly deleterious mutations*

(Pringle 2011, p. 14, both petitions)"? I thought a number of bison had mitochondrial disease. How many bison were included in the study?

Lots, as I recall. I haven't revisited this paper since it was posted in 2011 but for sure I included ALL data on ALL bison with fully or partially sequenced mitochondrial genomes. I would NEVER make an issue out of a single bison because that could merely be an individual animal with a founder mutation just as we see all the time in human genetic disorders. So if you look at the text, it will clearly state how many bison had the mutation in question. It would be a huge job to update the paper to Oct 2016, lots more data exists now including the whole nuclear genome.

As we all know, dogs, cats, horses, cows, mice, etc. are widely used model species for a great many human genetic disorders, e.g. a mouse with cystic fibrosis or breast cancer etc. So it is no great leap — especially since the protein coding genes of the mitochondria have the same well-studied functions within aerobic electron transport in all VERTEBRATES not just placental mammals — to conclude that an amino acid change that is clearly classified as deleterious by widely applied criteria will be deleterious regardless of what species of VERTEBRATE it occurs in or is transferred to, e.g. lamprey eel or bison. In this case, we know all too well what the role the affected protein has in energy metabolism. We know all too well what happens in humans, mice and other mammals when the primary electron transport chain for producing ATP is disrupted. Yeast would do ok here, they have other options. Mammals do not.

Protein-coding got lost in the lawyer's comments: this is a huge escalation up from a mere genetic marker. I wouldn't have bothered with just a random mitochondrial base pair change as these are near-impossible to evaluate phenotypically. To the contrary, this is an irreplaceable protein with implausible secondary compensation. The protein has been damaged by an inherited mutation in the bison who carry it. If the protein were no longer able to carry out its function at all, it would be lethal. So it is just sub-optimal, very sub-optimal by the same criteria used to classify amino acid changes in the other 6000 mammalian genes having known disease mutation issues.

2. The FWS states: "Further, these defects are thought to have arisen from the initial population bottleneck that reduced the North American bison population to 25 animals in YNP (Boyd and Gates 2006, p. 1, first petition). Therefore, any deleterious genetic effects of the bottleneck would have occurred at that time and would not necessarily be exacerbated by present culling management regimes." Isn't that statement forgetting that the different herds vary widely in disease load? Moreover, by saying something is "not *necessarily exacerbated," one can also say that something is not "not necessarily exacerbated" also, so what is the point?*

I've read this 3-4 times and concluded it is just word salad, someone with minimal familiarity with population biology throwing out lay speculation (which we call "just-so stories" after Rudyard Kipling). I have no idea what the point is. Just change the disease to cystic fibrosis and two populations of humans, one of which carries a mutant allele.

My profile is now available at ResearchGate, the linked-in for scientists. My peer-reviewed genetics papers have been cited 5,610 times by other researchers in other peer-reviewed journals. This puts me in the 85% percentile of living scientists. [Some editing needed, some misattributions but no substantive changes.] (www.researchgate.net/profile/Thomas_Pringle).

I did a very careful job on this bison paper just as a public service. I was not paid and had no idea in advance that anything of interest would emerge from it. This is a very difficult area in genetics because of numerous bizarre characteristics of mitochondrial inheritance. Based on publication histories, I would say no one employed by either NPS or the USFWS is remotely qualified to either independently research this issue or evaluate academic aspects of my paper. It is an advanced topic requiring decades of prior specialized research experience (Thomas Pringle, personal communication, October 22, 2016).

- The 90-day finding continues:

Lastly, the second petition posits that "the genetic diversity of wild bison is not being maintained by the IBMP's actions of lethally removing migratory bison, but instead the herds' genetic composition is being altered by the artificial selection of bison with non-migratory and domestic animal traits." However, the second petition does not cite sources to support these claims and there is no evidence at this time that indicates culling animals migrating from YNP will eliminate a genetic basis for the migratory behavior. In addition, continual migration each year suggests this behavior persists.

Petitioner's comment: That "the second petition does not cite sources to support these claims" is untrue. The following quoted passages are directly from the 2015 petition and cite sources of what has been posited.

Dale F. Lott in "American bison: A natural history," writing on the long-term genetic effects of artificial selection, also called selective breeding, noted, as quoted in the petition:

> But what of the bison's long-term future? In the long run a species adapts by tapping its ultimate resource—its gene pool. The gene pool contains not just the species' reality but also its future possibilities. It limits not just what challenges a species can handle today, but its range of possible adjustment to future changes.
>
> Many genes are in only some individuals. Therefore, the more individuals, the bigger the gene pool. Several million bison would have a very large gene pool, but reduce that population to several hundred and it's become very likely that a lot of genes have fallen by the wayside on the road to extinction . . . the surviving populations have been divided into even smaller populations in parks and refuges. The size of a species gene pool sets a limit on future adaptation. But very small populations raise another specter: inbreeding. Today's plains bison-Bison bison-mingled with millions of their own kind drifting across a wide and unbroken sea of grass. Suddenly they were reduced to scattered handfuls confined to tiny islands a few miles across that more or less matched their original habitat. It's a scenario sure to chill the blood of a genetically oriented conservation biologist. Deleterious genes that would have been diluted to near-insignificance in a gene pool contributed to and drawn from by millions could suddenly be concentrated and vigorously expressed in a gene pool drawn from fewer than a dozen animals.
>
> From widely outbred to severely inbred in one or two generations—the worst possible case of the infamous genetic bottleneck. It all adds up to a gloomy forecast for the American bison . . . (Lott, 2002, pp. 192-194).

As stated in the 2015 petition:

> According to Lott, the great enemy of wildness is selective breeding:
>
> > Sometimes when I talk about wild bison someone points out that all of today's plains bison descend from animals that spent at least some time enclosed in a fence. Therefore, some argue, all of today's bison are domestic and there are no wild bison to preserve. That claim reflects a misunderstanding of what domestication is. It's not being confined—if it were, every animal in most zoos would be domesticated. They're not. Even those that take food from our hands are tamed—habituated to humans—not domesticated. 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, 2002, p. 197-200).
>
> One of the traits not wanted by the Montana Department of Livestock is the wild bison's migratory behavior. The wild herd crossing Yellowstone

National Park's border is deemed a nuisance and the rationale for lethal control (Horsley, 2015, pp. 276-277).

In the 2015 petition, I also cited a study on exploitative selection, which is just another name for the process of artificial selection:

> Fred W. Allendorf, regents professor of biology at the University of Montana and professorial research fellow at Victoria University of Wellington, New Zealand, in collaboration with other researchers, studied the outcome of what they term "exploitative selection" in "Genetic effects of harvest on wild animal populations." (Recall that Allendorf is the author of a genetics text that Wallen suggested Davis reference in his 2007-finding regarding various points made in my original 1999 petition.) The authors noted:
>
> > Virtually all species have separate local breeding groups (subpopulations) that are somewhat reproductively isolated. Harvest of wild populations can perturb genetic subdivision among populations within a species and reduce overall productivity. The primary problem is that harvesting a group of individuals that is a mixture of several subpopulations can result in the extirpation of one or more subpopulations. This will not be recognized unless the subpopulations are identified separately and individuals from population mixtures are assigned to subpopulations.
>
> A phenotype is any observable characteristic or trait of an organism, such as its morphology, development, biochemical or physiological properties, behavior, and products of behavior (like a bird's nest). Phenotypes result from the expression of an organism's genes as well as the influence of environmental factors and the interactions between the two. The researchers noted that a population's genetics should be monitored in order to devise recovery programs that would minimize phenotypic changes detrimental to survival. [Allendorf et al. stated:]
>
> > There is ample evidence that exploitative selection is at least partially responsible for phenotypic changes over time observed in exploited populations. However, determining the role such changes have played in the decline in harvested populations is much more difficult. This issue is analogous to the controversy in conservation biology about the causal role of genetics in extinction. Extinction, or population decline, is always the result of a variety of interacting biological and environmental factors. Attempts to identify a single cause (e.g. loss of genetic variation or genetic change brought about by exploitative selection) in the decline of wild populations are doomed to fail. A more prudent course is to assume that harvest will result in exploitative selection, develop management and

recovery programs that will minimize potential harmful effects of genetic changes due to harvest and then to monitor for molecular genetic changes as well as key life-history traits (Allendorf, 2008).

Migration is a phenotype. Capacity to reproduce is a phenotype. Aggressive behavior is a phenotype. When by artificial or exploitative selection, as opposed to natural selection, one kills bison that are genetically programmed to migrate and that have the sufficiently aggressive behavior to seek out better winter habitat, then there is the potential to select out the very traits necessary for survival in the wild, namely, the ability to change habitat under stress.

Could the governmental culling programs be doing this?

As mentioned above, older experienced females are often the leaders (Meagher, 1989). It is these bison that lead other members of their herd to forage areas outside the park, primarily the Gardiner Basin. When they are killed at the border, their knowledge is destroyed and thus this migratory instinct, coupled with learned behavior, is selected out and abolished from the gene pool (Horsley, 2015, pp. 277-278).

In the 2015 petition I wrote:

Ken Cole, writing for *The Wildlife News*, made the following observation in "Greater Yellowstone Bison show signs of inbreeding: Government slaughter could irreparably harm bison species":

In recent years, while conducting repeated culling—where greater than half of the Yellowstone herd could be killed either by slaughter or winter kill—government managers never studied how their actions affected the genetics of the bison. For example, prior to the winter of 2007/2008 the population was estimated to be 5,500. That winter 1,631 buffalo were killed by the government and hunting but an additional 1,500 died from starvation due to the harsh winter that they were unable to escape because their habitat has been so curtailed by the policy of Montana and its greedy livestock industry. This left only 2,300 bison, or less than half of the bison herd, the following spring and possibly irreparably harmed the remaining genetic diversity of the herd.

A prime reason for the potential for irreparable genetic harm is that the culling process developed by the government does not take into account the genetic composition of the various herds. Removal is based [on] only one initiating factor, migration.

Scientists do not know what members of what herds are being killed at the borders by park removals, that is, shootings and shipments to slaughterhouses, according to a study published in the *Journal of Wildlife Management* and funded by the National Park Service and National Science Foundation, involving investigators Julie A. Fuller and Robert A. Garrott, both from the Department of Ecology, Montana State University, and P. J. White, supervisory wildlife biologist, Yellowstone National Park. It appears scientists are not even sure in what direction the bison "dominos" are falling. They speculate that:

> Density-related emigration from the central herd to the northern range may be fueling bison emigration onto private and public lands where large-scale removals occur, exacerbating the brucellosis controversy for natural resource managers.

However, they point out that "removals at the northwestern boundary can no longer be reliably assigned to the northern herd. Long-term studies of marked animals from both herds should be initiated to elucidate the extent and factors influencing these movements (Fuller et al, 2007).

Park managers therefore do not know what genetic traits they are increasing or decreasing—including genetic strengths and genetic weaknesses—by these bison removals. Playing with bison genetics like dice, park managers under the interagency leadership are running a crapshoot. It is a gamble that responsible wildlife managers cannot afford to take (Horsley, 2016, p. 279).

Recall that the Fish and Wildlife Service stated that:

> However, the second petition does not cite sources to support these claims and there is no evidence at this time that indicates culling animals migrating from YNP will eliminate a genetic basis for the migratory behavior.

Do the above cited sources not count? For the Secretary of the Interior, acting through the U.S. Fish and Wildlife Service, to not recognize or to discount in the 90-day finding relevant citations provided in my 2015 petition is unfair and improper.

As pointed out in past petitions and throughout this present petition, just because a species is migrating despite the annual removal of the great majority of animals that migrate, does not mean that at some point that migratory trait or behavior will not be eliminated. To deny this denies the mechanism of artificial selection. Further, the petitioner cited numerous instances of the effects of selective culling and the effects of hindered migration in other species, which in personal communication to the Petitioner were termed "inappropriate surrogate comparisons."

For the FWS in its 90-day finding to claim “there is no evidence at this time that indicates culling animals migrating from YNP will eliminate a genetic basis for the migratory behavior” and that “In addition, continual migration each year suggests this behavior persists” leaves the Petitioner only one proof acceptable to the FWS: that IBMP’s culling has stopped the expression of the migratory instinct in Yellowstone’s wild bison—the very event that the Petitioner is trying to avoid through the species’ protection by the EPA.

The 90-day finding cited a study on the park’s carrying capacity and the need for culling titled “Carrying capacity, migration, and dispersal in Yellowstone bison,” led by Glenn E. Plumb and including P.J. White and Rick L. Wallen, all park biologists. The authors laid out the study’s objective:

> We synthesized available information to address two central questions in this debate: (1) has the Yellowstone bison population surpassed numbers that can be supported by the forage base in the park; and (2) why do some bison move outside the park during winter, even when numbers are below food-limited carrying capacity?

Plumb et al. found that while there is sufficient forage in the park for the wild bison population, culling is still necessary:

> While evidence indicates the Yellowstone bison population has not exceeded the park’s food-limited carrying capacity of approximately 6200, it also appears that the interactive effects of severe winters with population levels greater than 4700 bison could induce large-scale movements of bison to lower-elevation winter range outside YNP (Geremia et al., 2009). Such large movements jeopardize brucellosis risk management objectives by overwhelming manager’s abilities to maintain separation between bison and livestock. Thus, we propose that a Yellowstone bison population that varies on a decadal scale between 2500 and 4500 animals should satisfy the collective long-term interests of stakeholders, as a balance between the park’s forage base, conservation of the genetic integrity of the bison population, protection of their migratory tendencies, brucellosis risk management, and other societal constraints.

To justify culling, Plumb et al. equates lethal removals to “dispersal sinks.” Based on the Plumb et al. study, the Fish and Wildlife Service evaluators consider culling to be a natural component of the ecosystem and that the IBMP in this regard functions as Mother Nature, herself. This finding is in error.

- The 90-day finding continues:

> In addition, permanent movement out of YNP (i.e. dispersal) is thought to have naturally occurred in the absence of management regimes (Plumb *et al*. 2009, p. 2383, both petitions). Therefore, winter culling may actually be serving as a surrogate for a dispersal sink (permanent movement out of the population) that would occur as a natural part of the ecosystem process.

Petitioner's comment: As noted in the 2015 petition, Plumb et al. fundamentally misunderstands what a dispersal sink is. It is not "permanent movement out of the population," but instead temporary, initiated for the survival of the species. Michael Clinchy and researchers in "Dispersal sinks and handling effects: interpreting the role of immigration in common brushtail possum populations, define "dispersal sink":

> A "dispersal sink" . . . may be defined as any habitat in which, in the absence of immigration, the resident population is expected to decline to extinction, . . . because local births are insufficient to compensate for local deaths . . . Dispersal sinks are cited in the literature on metapopulation dynamics as a case in which immigration is clearly important in "rescuing" populations from extinction. Dispersal sinks are assumed to occur in suboptimal habitat, whereas "source" populations . . . from which immigrants derive, are assumed to occur in optimal habitat.

Apparently, the FWS evaluators did not read the portion of the 2015 petition below which supports a correct understanding of what a dispersal sink is, for they did not acknowledge this passage or rebut it:

> It is intuitively obvious that culling is not natural and to try to pawn off on the public that it is natural is an example of scientific hubris. Dispersal sinks lead to extinction within the dispersal area when there are fewer births than deaths and when no immigration from outside makes up for the losses. Plumb identified IBMP's brucellosis control management, i.e., lethal removal, with a dispersal sink. When a spatial area is emptied routinely by killing its inhabitants, such a dispersal sink guarantees extinction of its occupants, for dead bison cannot multiply.
>
> Douglas W. Morris, professor of evolutionary and conservation ecology at Lakehead University, writing in the American Naturalist "On the evolutionary stability of dispersal sink habitats," argues that a dispersal sink without migration back to the source (in the case at hand, YNP), is not evolutionarily stable. He states:

> A recurring theme in the literature of population regulation is that surplus reproduction in high-quality "source" habitats is exported to low-quality "sink" habitats. Two recent innovative papers by Pulliam (1988) and Pulliam and Danielson (1991) have shown that equilibrium densities in both kinds of habitats can be maintained by an evolutionary stable strategy (ESS) of habitat selection. Yet the basic idea that populations exist indefinitely in habitats in which mortality exceeds recruitment seems counter to other evolutionary models that argue convincingly for habitat specialization. I show that emigration to sink habitats is likely to be an ESS only if there is reverse migration back to the source (Morris, 1991).

Gardiner Basin, which is the site of the Stephens Creek capture facility that serves as a stockade from which to ship bison to slaughterhouses, is the so-called "dispersal sink." Definitionally, permanent removal of a population from such a site—that is, where deaths exceed births—assures extinction. Historically, Gardiner Basin did not function as a place of no return, but as a sub-optimal, temporary refuge during the winter to assure survival. With greening up in the spring the herds returned to the optimal habitat, Yellowstone's higher altitude grasslands.

What is a "natural component of the ecosystem" is carrying capacity. But Plumb et al. justify culling because some day the park's bison *could* exceed carrying capacity—in other words, kill bison before they limit themselves by exceeding the forage base. This is absurd wildlife management for if a species exceeds its nutritional source it will die—a process that is a "natural component of the ecosystem." Further, to cull bison because they spread brucellosis is also absurd when elk also spread the disease, but are not culled. This leaves us with the real reason for culling: "other societal constraints," that is, the interest ranchers have in keeping the forage base of the park's outlying wildlife habitats all to themselves and their cow-calf operations.

- The 90-day finding stated:

> Finally, the first petition suggests animals from the Central/Western herd are being hunted at a disproportionately high rate compared to their Northern counterparts, which "threatens the genetic viability of the Yellowstone bison and could result in the loss of unique genetic qualities, maternal lineages, and the loss of overall genetic diversity." Halbert *et al*. (2012, p. 8, both petitions) indicate that the YNP bison consists of two subpopulations that are genetically distinct, but not isolated. The relatively large genetic variation among YNP bison may be attributed to the maintenance of distinct subpopulations and the comparatively large effective population size of the YNP population (Halbert *et al*. 2012, p. 9, both petitions). Therefore, the first petition claims that the two herds (subpopulations) should be managed in light of their unique genetic

qualities. The IBMP sets annual population size goals for the two herds separately so that neither herd is reduced to such an extent that it may be at risk of losing important genetic qualities (Geremia *et al*. 2014, second petition). The first petition cites Hendrick (2009, p. 419, first petition) on the importance of maintaining an effective population size of 1000 animals (or less with substantial genetic exchange between smaller subpopulations) and that the YNP herd meets this standard. To date, there is no evidence that culling has impacted the long-term genetic viability or persistence of the YNP bison population (White *et al*. 2011, p. 1328, both petitions).

Petitioner's comment: Because of the FWS's refusal to protect Yellowstone's bison herds, culling continues to hinder and alter migration and disproportionately reduce herd sizes. The northern herd has substantially decreased its yearly migration since 2008, when a high percentage of the population (composed of migratory animals) was culled, and the central herd, while continuing to migrate, is suffering a steep population decline due to culling only migratory bison. Instead of being equal in size, the ratio now is five northern herd bison for each central herd bison, with the central herd well below the effective population size of 1000 animals.

- The 90-day finding states:

However, White and Wallen (2012, p. 751, second petition) assert that the observed population substructure and genetic differentiation was "substantially influenced by a human-induced bottleneck" and as a result, "there is evidence that the existing genetic substructure was artificially created." Since individuals from other herds were used to supplement the YNP bison in 1902, estimates suggest only approximately 30-40% of the YNP bison genetic makeup derive from the original 25 survivors (Hendrick 2009, p. 417, first petition). Thus, maintenance of subpopulation genetic differentiation and overall genetic diversity may not be crucial for preserving genes from the survivors of the historic bottleneck. Lastly, White and Wallen (2012, p. 752, second petition) conclude that the National Park Service should allow ecological processes to "influence how population and genetic substructure is maintained in the future rather than actively managing to perpetuate an artificially created substructure . . . it is the conservation of the ecological processes that is important, not the preservation of a population or genetic substructure that may or may not have been created and/or facilitated by humans."

In summary, we find that the information provided in the petitions does not present substantial scientific or commercial information indicating listing of the YNP bison may be warranted due to Factor B [overutilization for commercial, recreational, scientific, or educational purposes].

Petitioner's comment: Just as Plumb et al. misunderstand the term "dispersal sink," White and Wallen misunderstand the term "ecological processes." Just as Plumb et al. equate a dispersal sink with culling, White and Wallen equate "ecological processes" with culling—and prohibiting culling as "actively managing to perpetuate an artificially created substructure." That the National Park Service should allow ecological processes to "influence how population and genetic substructure is maintained," but interpret this as compatible with the lethal removal of large segments of a population expressing migratory behavior or traits is irrational.

What is disappointing is that the FWS swallowed White and Wallen's warped reasoning hook, line and sinker.

B. Petitioner's letter questioning finding

When the 2015 petition was denied, to better understand why, I wrote the person listed as a contact, Mark Sattelberg, FWS field supervisor. After several exchanges, I submitted the following email (with embedded questions in italics) March 8, 2016:

> Below please find questions concerning the December 31, 2015 "90-Day Finding on Two Petitions to List a Distinct Population Segment of Bison in its United States Yellowstone National Park Range as Threatened or Endangered under the Endangered Species Act."
>
> The FWS says in its finding that:
>
>> The petitions state concerns regarding the restriction of movement into historical range outside YNP boundaries. However, given the current stable-to-increasing population status of the YNP bison herd, we do not find substantial information that restriction of range is likely a limiting factor for the continued existence of YNP bison.
>
> Abundance of bison in general is not the issue, but instead the abundance of wild bison. The continued existence of YNP bison depends on their continued existence as wild animals, not merely a "stable-to-increasing population," which could merely be a stable-to-increasing population of primarily non-migratory bison. A key trait of wildness is the adaptive migratory trait.
>
> *Over the long term, how can the FWS conclude that this trait will be preserved by persistently eliminating it annually through its culls of migratory animals*

only? What studies can the FWS point to that indicate that over the long term destroying only migratory animals will preserve this trait in the YNP herd?

The 90-day finding found that the wild Yellowstone bison are a discrete population segment (DPS). A DPS is defined as markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors. One of those behaviors is the trait of migration, which is unique to this subspecies.

The FWS states:

> Lastly, the second petition posits that "the genetic diversity of wild bison is not being maintained by the IBMP's actions of lethally removing migratory bison, but instead the herds' genetic composition is being altered by the artificial selection of bison with non-migratory and domestic animal traits." However, the second petition does not cite sources to support these claims and there is no evidence at this time that indicates culling animals migrating from YNP will eliminate a genetic basis for the migratory behavior. In addition, continual migration each year suggests this behavior persists.

The FWS's only support that such culling is not harming the Yellowstone bison's migratory behavior is its observation that "continual migration each year suggests this behavior persists."

So, will only the cessation of that continual migration prove to the FWS that such large-scale culling of migratory-only bison endangered that trait?

Further, the FWS claims:

> To date, there is no evidence that culling has impacted the long-term genetic viability or persistence of the YNP bison population (White et al. 2011, p. 1328, both petitions).

But the same White et al. study states:

> 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. Longterm bison conservation would likely benefit from management practices that maintain more population stability and productivity.

How does the FWS square its summation of the White et al. study with what White et al. also says in that same study about large-scale culls?

Moreover, that study concluded:

> Yellowstone bison provide the wild state and adaptive capabilities needed for restoration but, to date, the brucellosis issue has prevented their use in restoration efforts . . .

Does the FWS believe it is following good wildlife management practices when it is putting wild bison's wild state and adaptive capabilities at risk—qualities valuable for herd restorations—through its denial of protection under the ESA? Can the FWS categorically state that it is not putting those capabilities at risk by allowing the large-scale culls by the IBMP to continue?

To demonstrate that the persistent selection of wild bison for the non-migratory trait via large-scale culls will eventually leave only non-migratory bison in existence—thereby producing a herd lacking a major quality that makes wild bison wild and capable of survival—can only be done by analogy with other species that have had their migratory behavior altered. Absolute proof could only be shown when wild bison stop migrating, which is what the petition is trying to prevent.

Does not the FWS want to act before it is too late? Do not the examples of altered migration for other species—which I have cited throughout the petition extensively—suggest just the opposite, that is, their migration may not persist? For instance, whooping cranes, when isolated in captivity, lose the ability to migrate when released. The lead animals of migrating Arctic caribou are not killed by indigenous hunters for fear it will stop them from migrating in the future. Migration entails learned behavior. Wipe out the leaders that know the migratory route and you wipe out migration.

Does not the example of the whooping crane count? Does not the wisdom of indigenous hunters count? Does not the FWS find them instructive?

Historically, the European bison, the wisent, was exterminated in the wilds, with only a few left in zoos in the early 1900s. The species was later reintroduced to the Caucasus Mountains. From the high elevations of the region they annually migrated to the foothill forest where the snow was less abundant. However, poachers using helicopters decimated the herd, which eventually changed its behavior. Now the herd migrates to the wind-blown, snow-free mountain tops for survival.

In my petition of March 2, 2015 I wrote:

> The poachers who brought the restored Caucasian bison to the brink of extermination are equivalent to the interagency collaborators operating

> under the acronym IBMP. Terrorized (like the Yellowstone bison) by helicopters, driven from their migratory habitat (like the Yellowstone bison), they now survive on the snow-free mountain tops of the Caucasus region. If their migratory habits can be changed by lethal removal means, how can one justify similar actions brought against the migrating Yellowstone bison as harmless, as did the FWS evaluating my first petition?
>
> Hopefully, Georg Wilhelm Friedrich Hegel will be proven wrong when he wrote in *The Philosophy of History* that "What experience and history teaches us is that people and governments have never learned anything from history, or acted on principles deduced from it" (Hegel, 1956, p. 7).

Apparently, Hegel was right, for the FWS in its current 90-day finding states exactly the same defense of the IBMP's lethal removal of wild bison that it made with regard to my first petition, that is, since they are still migrating, no harm is being done. This is incredibly short-sighted.

Unlike the Caucasian bison, Yellowstone's wild bison have no other place to go but Gardiner Basin when winter gets severe. I wrote in my recent petition:

> A habitat that cannot be occupied—such as the Gardiner Basin, because the wild bison seeking to occupy it via migration are killed before they get there—is an arena where those migrating fail to produce offspring. Animals that fail to produce offspring fail to pass on their migratory genes. This has the potential for profound genetic and behavioral consequences.
>
> Associated with the trait of migration is aggressiveness. Domestic animals are less aggressive because that trait has been selected out artificially. Livestock owners want tame animals they can manage. Domestic animals are also less intelligent than their wild ancestors. Not only is the trait of migration being selected out, but concurrently there is a high potential that by IBMP's culling, a cascade of other traits, in particular wild traits, are being lost as well. Only time will tell the effect of weeding out these traits.

Does the FWS believe that taking such a chance is responsible wildlife management?

Is there such a thing as a migratory gene? A 2011 study of the Blackcap warbler titled "Identification of a gene associated with avian migratory behaviour," headed by Jakob C. Mueller, Department of Behavioral Ecology and Evolutionary Genetics, Max Planck Institute of Ornithology, claims there is.

The evolutionary importance of genes controlling migratory behavior can be seen in drosophila larvae vis-à-vis survival of the fittest. Fruit flies have a particular gene that controls foraging behavior. It governs whether a maggot will be a sitter or a rover, whether it will stay put or migrate to another nutritional source, say another rotten spot on an apple. Depending on the environment, either one or the other will survive better, ensuring the survival of that species. This behavior is also essential for bison and shows the importance of having viable populations of *both* migratory and non-migratory bison.

None of these supporting pieces of evidence provided by my petition were mentioned in FWS's finding.

Do these analogs, studies and observations, all of which are cited in my recently rejected petition, often at some length, not count? That wild bison are still migrating despite the killing of the vast majority of migratory bison suggests to the FWS that their migratory habit will persist. Does FWS's conclusion trump what other findings indicate for other species, that is, that the migratory trait can be eliminated or significantly altered by environmental influences?

The 90-day finding states:

> Thus, maintenance of subpopulation genetic differentiation and overall genetic diversity may not be crucial for preserving genes from the survivors of the historic bottleneck. Lastly, White and Wallen (2012, p. 752, second petition) conclude that the National Park Service should allow ecological processes to "influence how population and genetic substructure is maintained in the future rather than actively managing to perpetuate an artificially created substructure . . . it is the conservation of the ecological processes that is important, not the preservation of a population or genetic substructure that may or may not have been created and /or facilitated by humans."

This passage is all too typical of the doubletalk that emanates from the FWS, as well as the IBMP. Does not the FWS see the hypocrisy of this statement?

Is not the National Park Service, which is a participant in the Interagency Bison Management Plan, by its lethal removal management practices actively creating an artificial substructure within the park's wild bison population by promoting an imbalance between migratory and non-migratory animals *through its culling of only migratory bison? Is this not artificially altering ecological processes, instead of conserving them?*

But of course, the FWS would have us believe that the IBMP is Mother Nature herself. It would have the public think that the slaughter being directed by this interagency against the park's bison via the Stephens Creek capture facility in Gardiner Basin mimics a natural process called a "dispersal sink."

The FWS states in the 90-day finding:

> In addition, permanent movement out of YNP (i.e. dispersal) is thought to have naturally occurred in the absence of management regimes (Plumb et al. 2009, p. 2383, both petitions). Therefore, winter culling may actually be serving as a surrogate for a dispersal sink (permanent movement out of the population) that would occur as a natural part of the ecosystem process.

This is misrepresentation. Plumb as a co-author never defines a dispersal sink as "permanent movement out of the population." Instead he says in "Carrying capacity, migration, and dispersal in Yellowstone bison" that:

> Dispersal is defined as movement from one spatial unit to another, without return (at least in the short term . . .).

The parenthetical statement "at least in the short term," is critically important. For bison in the Gardiner Basin that "short term" is winter. After that, all would return except for one factor: the Stephens Creek capture facility and other government culling activities. They do not return because they are killed. This is not how an evolutionarily stable dispersal sink functions. As pointed out in my petition, in order for a dispersal sink to be evolutionarily stable, animals *must return* from the source from which they dispersed. If they do not, they will become extinct, for a dispersal sink is a suboptimal habitat where, over the long term, births will not exceed deaths.

Is not the IBMP, by not allowing bison to return to their source from the Gardiner Basin dispersal sink, assuring eventual extinction of wild bison?

The 90-day finding states:

> Our standard for substantial scientific or commercial information within the Code of Federal Regulations (CFR) with regard to a 90-day petition finding is "that amount of information that would lead a reasonable

> person to believe that the measure proposed in the petition may be warranted" (50 CFR 424.14(b)).

It further states:

> The second petition discusses the ecological impacts of stocking nonnative fish, such as lake trout, in YNP waters, however, the petitioner and sources cited do not provide information regarding the potential impacts of non-native fish stocking on YNP bison. Therefore, we do not find the petitioners present substantial information that non-native species may be a threat to the YNP bison such that listing may be warranted.

This finding is either the result of an incredible misreading of my petition, or critical passages have not been read at all by the FWS evaluators.

Would not a reasonable person evaluate the entire petition, instead of just an isolated part?

Introduction of non-native trout into Yellowstone Lake was an *example* of how invasive species can harm an ecosystem and in my petition was never directly related to harming wild bison. Instead, I made extensive references to *cattle* as being an invasive species whose presence in critical bison habitat functions to harm bison because of the lethal removal activities of the IBMP in its attempt to protect domestic livestock grazing on the perimeters of the park.

Why was this information concerning cattle as an invasive species affecting the survival of wild bison not evaluated?

But the lack of evaluation of the information contained in my petition does not stop here.

Bison are culled because of the fear that brucellosis will spread from bison in the park to cattle grazing outside the park.

The FWS states in its finding:

> To avoid contact between YNP bison and cattle, which increases the risk of transmission of brucellosis, the YNP bison are removed from areas used for cattle grazing via hazing back into YNP, followed by, when necessary, capture, testing, and slaughter or release of captured bison, depending on brucellosis test results (USDI and USDA 2000, p. 6, first petition).

Later it states:

> The first concern stated in the petitions with regards to culling as disease management is its limitation on YNP bison range and population size. However, the petitions do not provide evidence suggesting IBMP activities may be a threat to the species such that the species may warrant listing. Since the conception of IBMP in 2000, the YNP bison population size has remained within the recommended 2,500-4,500 range, with the exception of 2005 and 2007 years when numbers exceeded 4,500 (Plumb et al. 2009, p. 2385, both petitions; National Park Service 2013, pp. 8, 14, first petition). Disease management is often an important aspect of wildlife management and stable-to-increasing population trends do not indicate IBMP disease management is limiting the YNP bison population.

First, as initially pointed out, a stable-to-increasing population of bison is not the issue. It is the wild quality. Secondly, for disease management to be worth its name it must manage a disease. If it does not, it is not worth carrying out, obviously. As I pointed out in the petition, IBMP's culling activity does not significantly impact the brucellosis threat emanating from the park. In the petition, I provided information demonstrating that elk, shown recently to be more of a threat as a brucellosis vector than bison, were allowed to migrate and mingle with cattle, while bison were not.

How does this make epidemiological sense? How does allowing one infected species out of the park, but not another, control or manage the disease? Why, given these facts, did not FWS agree with the petition that cattle, instead of bison, should be removed from the ecosystem as the only rational epidemiological solution to containing the spread of brucellosis from the park to domestic animals?

Further, I document numerous times that captivity and close proximity create an environment that promotes brucellosis. Not allowing bison to migrate concentrates bison, as does feeding elk on feed grounds. Allowing bison to migrate and occupy their historical habitat would promote dispersal and thus has the potential to reduce the prevalence of brucellosis.

Why was this position not evaluated by the FWS in its finding? And lastly, why was my claim that mountain bison may still inhabit the park and deserve protection under the provisions of the ESA not evaluated? I provided extensive information to support that claim.

C. FWS's answer to petitioner's questions

I received an answer dated April 19, 2016 from the assistant regional director of the FWS's Mountain-Prairie Region. It stated:

> Thank you for your email inquiry of March 8, 2016, to Mark Sattelberg concerning our December 31, 2015, 90-day finding on bison in Yellowstone National Park. Mark forwarded your email to our Regional Office in Denver for response. This is our reply to your March 8 email. Our 2015 90-day finding was in response to two petitions, including your petition submitted March 2, 2015. We believe our finding adequately addressed concerns raised in the two petitions.
>
> We appreciate your interest regarding the bison population in Yellowstone National Park. The primary concern voiced in your email appears to be the potential impact winter culling may have on the "wildness" of Yellowstone bison as expressed by their migratory behavior. This issue was addressed in detail in our 2015 90-day finding.
>
> One thing we considered at great length is your concern over the preservation of the "wildness" trait (as expressed through migratory behavior) in the context of the purpose of the Endangered Species Act (Act) in conserving species (as defined in the Act). The Act is not designed to conserve behaviors/traits. The Act states that, to the maximum extent practicable, the Service will make a finding as to whether the petition presents substantial information indicating that the petitioned action is warranted. In the case of a petition to list a species, we consider whether there is substantial information that a species may be in danger of extinction throughout all or a significant portion of its range or likely to become endangered within the foreseeable future throughout all or a significant portion of its range; in other words, whether the species may meet the definitions of endangered or threatened. It could indirectly preserve traits if we have evidence that lack of that trait is somehow affecting the species to the point that it meets the definition of threatened or endangered. Then we could list the species based on whatever stressor is causing the lack of that trait that is proven to be crucial to its continued existence. This is where substantive information is lacking. Distribution, abundance, and trends of the bison population in Yellowstone National Park do not support a conclusion that this population is endangered, either now or in the foreseeable future.
>
> We also considered your concern that culling will artificially select for bison that do not migrate, and that Yellowstone bison will somehow be less "wild"

because of it. However, as our finding stated, they still do migrate, numbers overall are stable to increasing, and there is evidence that migration is a learned behavior. We agreed that plains bison (Bison bison bison) can best retain their full wildness in large populations experiencing minimal human influences and exposed to the same natural factors that historically impacted bison herds. Unfortunately, today's developed landscapes often limit opportunities to conserve bison under completely natural conditions. Interestingly, winter migration out of Yellowstone National Park by bison did not begin in substantial numbers until the severe winter of 1975/76 (Meagher 1989). Therefore, it may be a learned behavior.

The assumption that culling bison will eventually lead to the proposed migratory trait being artificially selected out of the herd *may* be possible. However, the petition provides only speculation and inappropriate surrogate comparisons that this will happen in Yellowstone bison, tenuously leading to a population decline in Yellowstone bison, which, in turn, will cause the Yellowstone bison to meet the definitions of threatened or endangered. Yellowstone bison are a highly managed population that shows no evidence of trending towards threatened or endangered now or in the future.

In our 2015 finding, we agreed that culling has not eliminated brucellosis in Yellowstone bison. The Interagency Bison Management Plan notes that within the Park, the National Park Service has management jurisdiction; when bison leave the Park, the State of Montana has management authority. Other agencies with roles under the Management Plan include the U.S. Forest Service and Animal and Plant Health Inspection Service. The intention of the Management Plan is not to eradicate brucellosis in Yellowstone wildlife, but to control its spread to livestock, which it has done. Management practices to improve the nutritional condition of Yellowstone bison and thereby improve their immune response to infection and increase the effectiveness of vaccines are underway and may help to address concerns related to brucellosis (see Treanor 2012 and Treanor et al. 2015).

Your email also asserted that mountain bison (aka wood bison; *Bison bison athabascae*) may inhabit the Park. There is contentious debate regarding both genus and subspecies designations for bison. However, if we assume that the subspecies designations for plains and wood bison are correct, the dividing line between historical ranges for the two subspecies is considerably north of Yellowstone National Park, running generally east-west through the central portions of British Columbia, Alberta, and Saskatchewan. We addressed plains bison in our 2015 90-day finding. We recognize that an article by Meagher (1973) spoke of a population of mountain bison originally present in the Park,

> but we are not aware of additional articles by Meagher or others that support this possibility.
>
> Even though we maintain that a 12-month status review of the Yellowstone bison is not warranted, we believe that understanding and support for bison conservation continues to grow, and with it an improvement in bison management leading to increased conservation of this iconic species. Thank you again for your interest in Yellowstone bison.
>
> Sincerely,
>
> Assistant Regional Director
>
> (Assistant regional director of the FWS's Mountain-Prairie Region, personal communication, April 18, 2016).

What conclusion can one come from this reply? That the Fish and Wildlife Service is willing to gamble with the possibility that culling will eliminate wild bison's migratory behavior. As it states, "The assumption that culling bison will eventually lead to the proposed migratory trait being artificially selected out of the herd *may* be possible."

Wild bison are not being allowed to adapt to their environment. If they try, they are killed. There is no way out of the park for these migratory animals. They are boxed in. They can not escape when Mother Nature warns them that now is the time to disperse to lower levels of the park for forage so as to escape starvation.

Regardless of whether bison are on one side of the park's northern boundary (demarked by the stone arch in the background, Figure 17) or on the other, when they migrate to Gardiner Basin in the winter for survival, the IBMP has the authority to dispatch them and has done so to thousands. Killing Zone 1, site of the Stephens Creek capture facility, is inside the park, killing Zone 2 is just outside.

The bison shown in Figure 17 below were most likely killed because they occupied this grassland during the winter to gain forage. In the background is the Roosevelt Arch at the park's north entrance near Gardiner, Montana. The top of the arch is inscribed with a quote from the Organic Act of 1872, the legislation which created Yellowstone. It reads "For the Benefit and Enjoyment of the People."

At the commemoration of the arch, Theodore Roosevelt praised "the Yellowstone Park" as "something absolutely unique in the world . . . Nowhere else in any civilized country is there to be found such a tract of veritable wonderland made accessible to all visitors, where at the same time not only the scenery of the wilderness, but the wild creatures of the Park are scrupulously preserved." (Roosevelt Arch at Yellowstone's North Entrance, 2016).

Figure 17. WILD BISON IN KILLING ZONE. ***Photo from IBMP's 2015 Annual Report.***

But being in sight of the arch now triggers the lethal removal of wild bison. Their wildness is terminated here by the elimination of those still wild enough to migrate for survival, for the Fish and Wildlife Service does not deem the trait of migration worthy of preservation when it come to Yellowstone's wild bison. So far, it will not protect that trait, that behavior, but instead allows the destruction of bison that express it. According to the FWS, “The Act is not designed to conserve behaviors/traits.” This is an incorrect reading of the act.

6

Protection depends on right use of species concepts

Species are the end points of evolution. They are distinct from each other. But what makes them distinct? Numerous species concepts exist to help sort that out. Two important ones are the biological species concept and the phylogenetic species concept. Reproductive isolation, the failure of populations to interbreed or to form viable or fertile hybrids, is the centerpiece of the biological species concept. According to Harvard biologist Ernst Mayr:

> Species are groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups. As can be seen from these definitions, it is necessary in the cases of interrupted distribution to leave it to the judgment of the individual systematist, whether or not he considers two particular forms as “potentially capable” of interbreeding—in other words, whether he considers them subspecies or species (Mayr, 1942, p. 120).

On the other hand monophyly, the shared descent of a common ancestor, is the centerpiece of the phylogenetic species concept. Oxford’s *A dictionary of biology* defines this concept of a species as:

> an irreducible group whose members are descended from a common ancestor and who all possess a combination of certain defining, or derived, traits (see apomorphy) (Martin, 2015).

It has been established that two breeding herds of wild bison inhabit Yellowstone National Park. One herd, the central herd, migrates and is endemic. The other herd, the northern herd, is more resident and was introduced. Part of the reason the Fish and Wildlife Service has not listed Yellowstone's wild bison as endangered is because it does not consider migration a trait that should be protected.

Recall that in personal communication with me in response to my questions to clarify this matter, the FWS stated concerning the purpose of the Endangered Species Act (see chapter 5 C. for full letter, this first volume):

> One thing we considered at great length is your concern over the preservation of the "wildness" trait (as expressed through migratory behavior) in the context of the purpose of the Endangered Species Act (Act) in conserving species (as defined in the Act). The Act is not designed to conserve behaviors/traits.

This was an eye-opener. A great proportion of my 2015 petition was devoted to showing how various traits and behaviors of wild bison were being put into jeopardy by the culling actions of the IBMP. If these traits in and of themselves did not count, and would only count if—and only if—there was an associated decline in numbers of bison, if one only looks at the total population and not the subpopulations, rejection of my petition becomes more probable.

However, the FWS's claim that the "Act is not designed to conserve behaviors/traits" is not a statement based on fact, but rather is an opinion and defeats the intent of the ESA to protect endangered species. It stems from an overly restrictive and outdated interpretation of the definition of "species" in the Endangered Species Act.

According to Anna L. George and Richard L. Mayden, writing in "Species Concepts and the Endangered Species Act," *Natural Resources Journal*, Spring 2005:

> There is no single accepted definition of a "species" in the natural sciences, nor does the Endangered Species Act (ESA) offer one. Instead, prolonged debate over species concepts has allowed various stakeholders to embrace and defend particular definitions based upon personal agendas that may be at odds with the objectives of the ESA.

Further, the authors state:

> Using outdated concepts to identify biodiversity is not only distasteful to conservation biologists and taxonomists, but also contrary to the ESA itself—both substantively and procedurally (George, 2005).

Zoologist Kevin De Queiroz, National Museum of Natural History, Smithsonian Institution, noted there are at least 24 species concepts advocated by different groups of biologists, including the biological, ecological, evolutionary, cohesion, phylogenetic, monophyletic, genealogical and phenetic concepts. The meaning of species chosen by an investigator or evaluator can dramatically affect a decision reached vis-à-vis a petition for listing or how to conserve a species (De Queiroz, 2007).

According to the FWS, the rejection of my petition in part hinged on the meaning of "species" as defined in the Endangered Species Act. This, however, involves a misinterpretation of the act's definition of species by the federal government, evident in a public advisory that states: "Under the Act, a 'species' is defined as any species or subspecies of fish, wildlife, or plant, or any 'distinct population segment' (DPS) of any species of vertebrate fish or wildlife which interbreeds when mature (Public Advisory: Information to Consider When Submitting a Petition under the Endangered Species Act, 2017). This is in error. Under "Definitions" the act actually says:

> The term "species" includes any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature.

As stated in the act, the definition of species *includes* a distinct population segment that interbreeds when mature, that is, the biological species concept. But it is important to understand, the act does not state the biological species concept is the only meaning. What is stated by the act is merely an example of what species means. Under the section in the act termed "Definitions," the section states numerous words or phrases used in the act "mean" this or that. However, with regard to the definition of species, it does not say what it "means," but instead states what it "includes," namely the biological species concept. According to evolutionary biologist Leigh Van Valen:

> The usual concept of species can be stated as follows (Mayr, 1970): "Species are groups of interbreeding natural populations that are reproductively isolated from other such groups." This concept is grandly called "the biological species concept." But that is an arbitrary appropriation of a term with a more general and earlier meaning. I will instead use the term "reproductive species concept" (Van Valen, 1976).

From this perspective, a biological species is a group of individuals that can breed together, but can not breed with other groups. A new species is formed when an existing species splits due to reproductive isolation. Once a species lives in two different areas, the geographical isolation makes breeding between the groups reduce or stop. Each group develops features which make breeding between them work less well. Eventually, each group becomes a separate biological species, because the two species do not reproduce with each other even when they are together (Biological Species Concept, 2016; Mayr, 1982, p. 273).

But this definition has some difficulties. For instance, how does one define an asexual species? Hydras, a type of freshwater animal related to jellyfish, reproduce asexually by developing small, genetically identical polyps that protrude from the parent. These polyps break off from the parent to form a new organism in a process called "budding." Budding does not involve interbreeding.

Another problem: since field studies are rarely done to confirm that individuals in the wild are mating and producing young, the only tenable verification of interbreeding is numbers of individuals in a group. If the numbers are stable or increasing, all is supposedly well, regardless of evolving behavior or traits. Only when the numbers are decreasing is a link with behavior or traits sought, for a decline shows the possibility that the species is endangered or threatened by some cause. The biological species concept hinges on the ability to reproduce, making the defining feature for speciation a *process*, instead of a trait or behavior, thereby setting the stage for discounting the importance of conserving a trait or behavior.

And yet another problem: in the context of Yellowstone National Park how can the FWS legitimately apply this definition as a reason to not intervene via its power to protect a species when one considers that the IBMP by its lethal removal of migratory bison is by definition doing what will create a new species, that is, physically isolating over time two groups of animals, migratory bison and non-migratory (resident) bison? The IBMP is making the park equivalent to an island. In effect, all those that attempt to get off of it die and can not interbreed, leaving the variant, the non-migratory wild bison, the only type left. Result? A maladaptive species—the opposite of what Mother Nature would do.

Theoretically, come a very harsh winter, this new species, because they no longer possess members that can migrate, could all perish, trapped in high elevations because of the loss of the genetic trait of migration. This possibility has been termed "speculation" by the FWS. But is it not also speculation by the FWS that this will not happen? Yet the agency responsible for carrying out the Endangered Species Act is comfortable with speculating extinction will *not* happen despite an extensive culling environment that *could* make it happen—and thus adopts a Pollyanna attitude and does not protect migratory wild bison.

Limiting the definition of a species to mean *only* the inability of members of two groups to reproduce is not a good taxonomic standard for speciation, especially in terms of conserving species that may look substantially the same, but have subgroups with variant morphologies, such as different beak sizes, viz. Darwin's finches, or those that behave differently, such as the Yellowstone bison.

Hypothetically, limiting the meaning of species to the biological species concept only, bison in the park could evolve into creatures that sit on logs and powder their noses, but as long as they look like bison, they still would be considered bison despite changes in behavior. Why? Because the only thing that counts regarding existence as a species is if the mature members of that species are interbreeding.

Conservation of varieties, rather than just species, is important when that variety can save the entire species from extinction at some evolutionary point in time. What is needed is a more realistic and practical definition—and it need not be an either/or situation, but can be a definition in addition to the biological species concept. To conserve a species, it may sometimes be necessary to conserve a variety of a species, for the meaning of species is blurred. Charles Darwin noted:

> Hereafter, we shall be compelled to acknowledge that the only distinction between species and well-marked varieties is, that the latter are known, or believed, to be connected at the present day by intermediate gradations, whereas species were formerly thus connected (Darwin 1859, p. 485).

A more accurate picture of a species can be painted using several definitions, depending on what needs to be elucidated to make taxonomic distinctions for better conservation. One candidate for evaluating the taxonomic status of Yellowstone bison could be the ecological species concept. Zoologist Mark Ridley, Oxford University, in the textbook *Evolution* defines the concept:

> The ecological species concept is a concept of species in which a species is a set of organisms adapted to a particular set of resources, called a niche, in the environment. According to this concept, populations form the discrete phenetic clusters that we recognize as species because the ecological and evolutionary processes controlling how resources are divided up tend to produce those clusters. Ecological research, particularly with closely related species living in the same area, has abundantly demonstrated that the differences between species in form and behavior are often related to differences in the ecological resources the species exploit (Ridley, 2003).

This perspective has application to Yellowstone's wild bison because they have a unique relationship with the environment. Unlike most bison in the nation, they do not migrate horizontally across the plains, but instead altitudinally. They are dependent for long-term survival as a herd on Gardiner Basin which functions as a "dispersal sink." This defining characteristic of Yellowstone bison is illustrated by Figure 11, which shows the historical, pre-settlement range of the subspecies.

By limiting movement in the ecosystem on which wild bison depend for survival, IBMP (with the sanction of the FWS), is setting the stage for a cascade into extinction by killing in the fall and winter all bison that migrate into the ecological niche of Gardiner Basin. In the event of an extraordinary winter, disease, predation and winter-kill could destroy all those animals that stayed behind in the park. If the potential genetic saviors—the migratory herd—are eliminated by the IBMP, the net result would be extinction of that entire subspecies at Yellowstone. The government's targeted culling denies the park's bison herds of the expression of the very trait and behavior that defines who they are as a subspecies.

But according to the FWS in its 2015 finding, since the bison population is stable and not decreasing, it is no big deal if they destroy the migratory members of the herd. Why does the FWS think this? As mentioned, because the FWS administrative staff is blind to the need of a diversity of traits and behaviors among wild bison subgroups—in particular the migratory and the non-migratory herds—and does not count as significant the migratory herd, a herd that is forced to decline every year by means of large-scale lethal removals by the IBMP. In short, by such lethal removals, the herd is denied the niche that makes them a distinct population segment. The herd is not allowed to adapt.

What is particularly troubling is, because the preponderance of the migratory herd is the central herd, culling is disproportionately reducing that herd, the endemic herd, which is now a fifth of the size of the less migratory herd, the northern herd, the introduced herd. Both herds used to be equal in size.

Recall, the phylogenetic species concept views a species as a "group whose members are descended from a common ancestor and who all possess a combination of certain defining, or derived, traits." The term phylogenetic comes from "phylogenesis," Greek from the terms phyle/phylon (meaning "tribe, race,") and genetikos (meaning "birth"). In phylogenetic terms, a trait is called an apomorphy. Phylogenetics traces an organism's evolutionary origin, its common ancestors, its tribe of birth, by noting similarities of traits, often those traits being evident as genetic units. The more similar the genetic structures, such as DNA, the closer the relationship of one organism to another as far as classification goes. In this definition of species, *traits and behavior count.*

The incapacity for two groups of animals to interbreed may not be the defining attribute of speciation. This may be too simplistic. Not interbreeding could be viewed as an apomorphy, a trait-derived behavior whereby one group of animals becomes unattractive to members of a splinter group, such as a divergence in song among birds that become isolated from one another. This would create distinct species because the two bird groups, when put together after a sufficient period of time, do not recognize the mating call of another, and thus do not mate.

Finches that inhabit the Galapagos Islands, collectively known as Darwin's finches, display a great diversity in beak form and function. They are thought to have evolved from a parent flock that was blown by strong winds from South America to these islands in the Pacific. Over time these birds came to inhabit island after island in a chain of islands. Field studies have shown that beaks evolve by natural selection in response to variation in local ecological conditions.

For instance, evolutionary change in beak depth in the population of ground finches (*Geospiza fortis*) on the island of Daphne Major were studied by Princeton University biologists Rosemary and Peter Grant. They found:

> Birds with small beaks and small body size suffered selective mortality in 1977, during a severe drought . . . The larger members of the medium ground

> finch population survived on a diet of large, hard seeds, which increasingly dominated the food supply as a result of an initial preferential consumption of small seeds. Smaller birds, lacking the mechanical power to crack the large seeds of *Tribulus cistoides* [a low-growing flowering plant] and *Opuntia echios* [a prickly pear], died at a higher rate than large birds. An evolutionary response to directional natural selection followed in the next generation . . . because beak size variation is highly heritable.

On the other hand,

> Natural selection in the opposite direction, with small birds surviving disproportionately, occurred 8 years later. The island experienced a major, prolonged El Niño event from November 1982 to August 1983. The abundant rain and high temperatures transformed the vegetation and food supply of the finches, and they bred for 8 months as opposed to the usual 1 or 2 months. Vines and other plants multiplied and spread, smothering the low-growing *Tribulus* plants and *Opuntia* cactus bushes. The seed supply became dominated by small seeds, and seeds of *Tribulus* and *Opuntia* became scarce. When the island entered the next drying-out episode during the drought of 1985, the supply of seeds fell, and so did the numbers of finches from high points in the productive years of 1983 and 1984. Large birds died at the highest rate; hence, the medium ground finches that were small, with relatively pointed beaks, were selectively favored.

What the Grants believed they were observing was the beginning stages of the formation of a separate species. The authors noted:

> Speciation begins with the divergence of a population and is completed when two populations that have diverged on different islands establish coexistence with little or no interbreeding . . . We obtained insight into the initial process of divergence on Daphne Major, thanks to a highly fortuitous circumstance: the founding of a new population (Grant, 2003).

What could cause the cessation of interbreeding? A 2004 study by biologists Jeffrey Podos, University of Massachusetts, and Stephen Nowicki, Duke University, suggests that as a consequence of beak evolution, changes occurred in the structure of finch vocal signals, since beaks play a functional role in song production in songbirds. Because song plays a significant role in finch mating dynamics, the study hypothesizes that the functional link between beaks and song may have contributed to the process of speciation and adaptive radiation in these birds. The large-beaked variety now sang a different tune. Its mating call became unattractive to the small-beaked variety and were not selected as mating partners. Interbreeding ceased and speciation began (Podos, 2004).

The lack of two related groups of animals to interbreed is the end result of evolutionary divergence. In the case of conserving a species, if it gets that far, it may be too late, for the species from which the other diverged may have become extinct.

Variation protects a species from extinction. In the case of the ground finches, variation in beak sizes protected the species from environmental changes in drought and wet seasons. But what would happen if a prolonged drought left only large-beaked finches, and then a prolonged wet season occurred? With no smaller-beaked birds, that finch species would perish.

Variations, apomorphies, traits, behaviors, that is, various aspects of genetic diversity, whether in the form of a subpopulation, subspecies or species, protect a collection of organisms from extinction because such entities enable the organism to adapt to its environment. How to identify their presence and sort them out as belonging to certain groups becomes critically important in conservations of species by allowing investigators to know what to protect.

Phylogenetic is especially useful in this regard. When taxonomy is based on phylogeny, organisms are classed together according to their common evolutionary ancestry. If organisms share many features, that is are homologous, it indicates they are closely related and have a relatively recent common ancestor.

Two methods of determining the evolutionary relationships between organisms are molecular similarity and cladistic analysis. Classifying organisms based on molecular similarity involves comparing the sequence differences in either nucleic acids, such as DNA, or proteins. Highly related organisms are expected to have many sequence similarities, while more distantly related ones have fewer similarities.

A group of organisms believed to have evolved from a common ancestor is called a clade and is by definition monophyletic. The relationship between different organisms can be visualized by what is called a phylogenetic tree or cladogram, tree-like diagrams. Roughly speaking, such a tree shows when an organism or collection of genes diverged into separate paths due to a mutation, producing a bifurcating pattern of divergence, that is, the tree of life.

The tips of the tree represent species or genes, also termed clades, and the nodes or points of branching on the tree represent the common ancestors of those descendants. A tree, however, is a hypothesis about the relationships among the organisms or genes and new data can change the tree’s configuration. A phylogenetic tree or cladogram can look like the diagram in Figure 18 below.

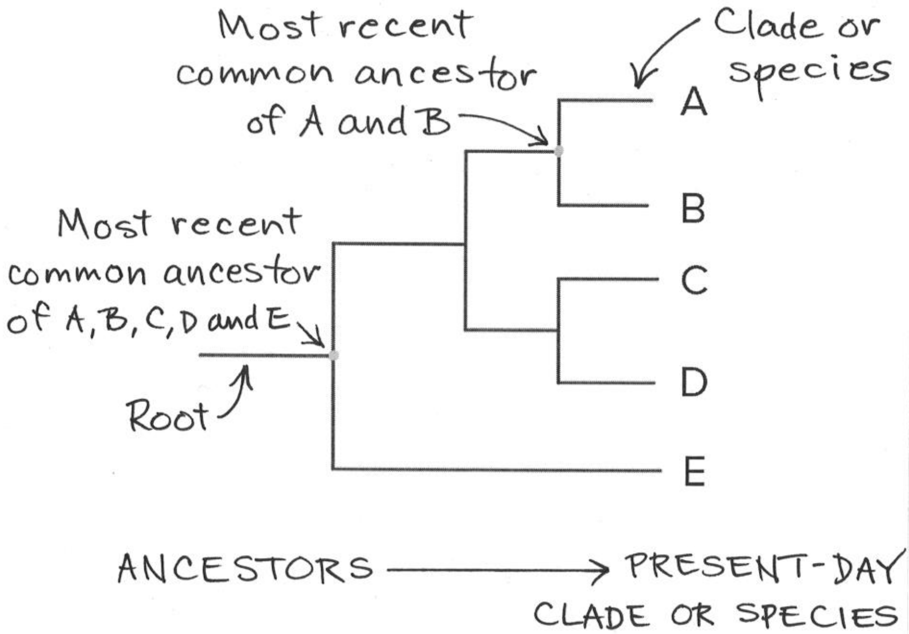


Figure 18. PHYLOGENETIC TREE, with species or genes indicated as letters A, B, C, D, E, showing most common ancestors and present-day clade or species.

A useful tool for looking at maternal ancestry is mitochondrial DNA, which is inherited from the mother alone and stays the same over generations. A haplotype is a group of genes within an organism that was inherited together from a single parent. The word "haplotype" is derived from the word "haploid," which describes cells with only one set of chromosomes, and from the word "genotype," which refers to the genetic makeup of an organism. The lineage of a species can be traced through its genetic makeup and diagrammed by means of phylogenetic trees and clades.

In 1937 geneticist and evolutionary biologist Theodosius Dobzhansky stated in *Genetics and the origin of species:*

> biological classification is simultaneously a man-made system of pigeonholes devised for the pragmatic purpose of recording observations in a convenient manner and an acknowledgment of the fact of organic discontinuity . . . genetics has so profound a bearing on the problem of the mechanisms of evolution that any evolution theory which disregards the established genetic principles is faulty at its source (Dobzhansky, 1982, pp. 4, 5, 8).

To disregard traits, which arise from genetic structure, in the evaluation and classification of a species is not using the best available science. However, phylogenetics should not replace the biological species concept—they go hand in hand. As noted in “Phylogenetics and the origin of species” by John C. Avise and Kurt Wollenberg, “Historical descent and reproductivity ties are related aspects of phylogeny and jointly illuminate biotic discontinuity.” The authors observed that:

> Thus, at microevolutionary scales, concepts of phylogeny cannot be divorced from those of population genetics and demography. As a sundering agent at the level of populations and species, extrinsic and intrinsic barriers to interbreeding are keynote evolutionary agents motivating genealogical partitions at the level of allelic lineages.

However, Avise and Wollenberg noted:

> to cleanse from species concepts all references to reproductive isolation would be to leave an unduly sterile epistemological foundation for the origin and maintenance of the biotic discontinuities so evident to Dobzhansky 60 years ago (Avise et al., 1997).

In an attempt to unify and synthesize the various species concepts, Stephen J. O’Brien and Ernst Mayr, writing in “Bureaucratic Mischief: Recognizing Endangered Species and Subspecies,” state:

> The U.S. Endangered Species Act of 1973 was designed to identify and protect plant and animal species whose number and habitat had become sufficiently depleted to critically threaten their survival. The Act as amended specifically affords protection to three categories of biological taxa: species, subspecies, and populations. The operational definition of these terms, inadequate taxonomy, and the periodic occurrence of hybridization between species and subspecies have led to confusion, conflict, and, we believe, certain misinterpretations of the Act by well-intentioned government officials.
>
> The listing of certain species as endangered has encouraged an increase in investigation of these taxa, notably in molecular genetics and field ecology (1). In some cases the molecular genetic results contradicted previous ideas about species integrity or taxonomic distinctions that were based on phenotypic (morphological) descriptions.

O’Brien et al. note that one of the basic species concepts is the Biological Species Concept as proposed by Mayr:

> In 1940, Mayr (6) proposed the Biological Species Concept (BSC) that defined a species as “groups of actually or potentially interbreeding populations that are reproductively isolated from other such groups.” Reproductive isolation, the primary component of the BSC, refers to the heritable tendency of distinct

> species to avoid gene flow or interbreeding even when they are brought into physical contact in nature. In clarifying this concept Mayr (6) noted that most species occupy distinct ecological niches and that this ecological distinctiveness is the keystone of evolution. Although various alternative species concepts and criticisms (7, 8) have appeared, the BSC has emerged as a biological paradigm with its major components affirmed (8).

The authors point out that between two species, hybrids or hybrid zones "do not disintegrate the genetic integrity of the species" and hybridization between subspecies can produce gene flow:

> A major strength of the BSC is that it reflects the occurrence in natural situations of the irreversible process of speciation. It emphasizes reproductive isolation as the sole discriminator of species as whole entities, but acknowledges the occasional production of hybrid individuals or even hybrid zones (9, 10). Further, the BSC acknowledges the existence of appreciable genetic diversity within species that is often partitioned geographically (or temporally) by population subdivision into subspecies, ordinarily under conditions of allopatry (reproductive barriers are geographic). The distinction however is that natural occurrences of hybrid individuals or hybrid zones between recognizable species do not disintegrate the genetic integrity of the species, while hybridizations between subspecies produce gene flow and genetic mixing. Reproductive isolation in nature provides an effective protective device against genetic disintegration of the species genotype (6, 8).

The authors posit that a subpopulation can be defined as a subspecies if the population shares a unique geographic range, a group of evolved phenotypic characters and a common evolutionary legacy:

> The subspecies category has been defined as "a geographically defined aggregate of local populations which differ taxonomically from other subdivisions of the species" (6). A valuable recent modification (11) urged that the evidence for BSC subspecies designation should come from the concordant distribution of multiple, independent, genetically based traits. In an attempt to provide formal criteria for subspecies classification we offer the following guidelines: Members of a subspecies share a unique geographic range or habitat, a group of phylogenetically concordant phenotypic characters, and a unique natural history relative to other subdivisions of the species. Because they are below the species level, different subspecies are reproductively compatible. They will normally be allopatric and they will exhibit recognizable phylogenetic partitioning, because of the time-dependent accumulation of genetic difference in the absence of gene flow. Most

subspecies will be monophyletic, however they may also derive from ancestral subspecies hybridization (12).

According to O'Brien and Mayr, allopatric (geographically separate) subspecies have three basic fates: go extinct, become a new subspecies or become a new species. That subspecies carry adaptive capabilities argues for protecting them against extinction. They state:

> In our view an allopatric subspecies has four possible fates; it may: (i) go extinct; (ii) exchange genes with another subspecies and become a new "mixed" subspecies; (iii) by genetic drift, selection, subdivision, or other demographic processes change its genetic character over time to become one or more new subspecies; and (iv) if effectively isolated, become a new species by acquiring genetic isolating mechanisms. It is not possible to know which subspecies will become new species, but they all have this potential. Moreover, as the time of allopatry increases, the probability of genetic differentiation increases, and included within these differentiative changes are ecologically relevant adaptations. The possibility that a subspecies carries such adaptations coupled with the potential to become a unique new species are compelling reasons for affording them protection against extinction.

At present, park management is making the park an island of extinction by killing off all those wild bison that try to escape it, rapidly changing their evolutionary descent, a descent that has the likelihood of ending in extinction if not discontinued.

7

The failure of "adaptive management" at Yellowstone National Park: Just lip service

Yellowstone's wild bison central herd is on the brink of extinction due to years of large-scale culling. The culling continues for one reason only: bad wildlife management. Such management operates with a bias toward cattle industry interests, instead of protecting the public's interest in wildlife. It is a bias so strong that no one speaks up even in the face of impending extinction of one of America's most iconic of mammals: the wild bison herd of Yellowstone National Park. It is not supposed to be this way. Management is governed here by a policy instituted by the Department of the Interior called "adaptive management," which in short is making decisions based on learning from experience, then modifying future actions for a better outcome. Yellowstone's biologists, however, are not learning and are not adapting, but instead are recommending actions that will lead to what they are supposed to prevent—the species' nonexistence.

For the winter of 2017-2018 biologists are recommending the culling of up to 1,250 wild bison, a number that outnumbers the present population of the central herd, namely, 847 animals, driven down to that figure by the massive culling that reduced the central herd almost 50 percent from the prior year. If that recommendation is met, it could completely destroy the central herd. Such culling removes only migratory animals, those entering Gardiner Basin. The preponderantly migratory bison are those from the central herd. Biologists are recommending the lethal removal of more northern herd animals than central, but as in prior years, have no way of knowing what animals are from what herd. If they did, they would not have removed almost 50 percent of the central herd in 2016-2017, while leaving the northern herd essentially untouched, resulting in the opposite of what they recommended. Yellowstone biologists make promises they know they cannot keep.

And it is all because of 300 cows. At an expenditure of $3 million annually—sometimes culling over a thousand bison that enter Gardiner Basin in one year in the name of preventing the spread of brucellosis to cattle, while allowing elk that have the disease to migrate into the very herds they are supposedly protecting—wildlife management here is a sham, especially when one considers that almost all cattle are gone in the winter from Gardiner Basin when the culling is conducted, especially when one considers that migration north out of Gardiner Basin is prohibited by barriers at Yankee Jim and especially when one considers that fewer than 300 cattle graze here after winter for the purpose of fattening, most of them trucked in (see chapter 13, this petition, first volume). Dividing $3 million by 300, cost to the public is $10,000 a head annually to finance disease control by culling bison, which does not control the disease. The biologists in charge of the management of wild bison know better. They know that managing the disease in bison, but not in elk, will not work.

Commenting on a study titled "Genomics Reveals Historic and Contemporary Transmission Dynamics of a Bacterial Disease among Wildlife and Livestock," published in *Nature Communications*, lead wildlife biologist for the park's bison program Rick Wallen noted:

> Any attempt to control the rate of spread in wildlife must be evaluated at the ecosystem scale and include an effective strategy to address infection in elk across the greater Yellowstone area. Focus on bison alone, as was suggested in the past, will not meet the disease eradication objective and conserve wildlife (Laustsen, 2016).

But no one at Yellowstone National Park takes remedial action, not even the person making the above warning, the person in charge of protecting the park's bison, and not even in the face of warnings by himself and his colleagues of the negative effect of continuing current culling practices. Yellowstone National Park, when it comes to bison management, is out of control. It is at such a critical juncture that the Petitioner, as noted above, requests an emergency listing be granted for the park's wild bison prior to the next scheduled culling at Gardiner Basin, as well as elsewhere, due to a failure to adhere to policies of adaptive management that state a goal of the park biologists is to keep the herd sizes equal.

Recall in "Yellowstone Bison—Should We Preserve Artificial Population Substructure or Rely on Ecological Processes?" park biologists White and Wallen state:

> Thus, total population abundance is not the only primary factor considered in determining management actions for Yellowstone bison. As an example, the management plan for Yellowstone bison during winter 2012 clearly indicates a

> desire to progress toward approximately equal numbers of bison in each breeding herd and selectively cull bison from the northern herd (which is currently larger), while minimizing removals from the central herd (Geremia et al. 2012).
>
> Halbert et al. (2012:9) conclude that "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." The authors further suggest that current management will ". . . erode the genetic distinctiveness between the 2 groups" (Halbert et al. 2012, p. 9). We agree that bison removals should be carefully managed to prevent unintended consequences and have referenced documents in this response that indicate such management is occurring with frequent assessments of progress toward desired conditions.

They know what to do, but will not do it. Park biologists Chris Geremia and Doug Blanton, as well as White and Wallen in "Managing the Abundance of Yellowstone Bison, Winter 2014," recommend keeping both herds above 1,000 animals, stating:

> Pursuant to the Interagency Bison Management Plan, Yellowstone bison are managed towards an end-of-the-winter guideline of 3,000 animals. Managers at Yellowstone National Park also want to maintain more than 1,000 bison in the central and northern breeding herds . . .

They warn, however, that large-scale lethal removals at the northern management area, i.e., Gardiner Basin, could decrease the central herd below 1,000 animals:

> One alternative for improving management effects on northern herd conditions would be to increase the total number of bison removed in the northern management area. However, such an approach would also increase our chances of decreasing the central herd below 1,000 bison. Also, as winter severity increases, the chances of bison from the central herd moving to the northern management area where they may be inadvertently removed also increases. Therefore, there is the potential to remove hundreds of central herd bison in the northern management area if winter is severe (Geremia, 2013).

Despite these goals and despite these warnings, these very same wildlife managers have recommended large scale removals year after year that, as mentioned, have resulted in the reduction of the central herd in 2017 to about 850 animals, while the northern herd has increased to about 4,000 animals.

Further, the *Record of Decision* that established the Interagency Bison Management Plan in 2000, whose central tenet is to prevent wild bison migration out of the park by limiting their number to 3,000 animals—ostensibly the population size that triggers migration—states as an adaptive management policy:

> Given these and other unknowns, the National Park Service is committed to conducting additional research on genetics in bison. If the additional information suggests the management practices of the Joint Management Plan adversely affect genetic diversity, the NPS will review management actions and recommend adjustments (Record of Decision, 2000, p. 51).

However, experience has shown that bison will migrate out of the park at any population level, given a severe winter, that the central herd is the most migratory, exposing it to disproportionate culling and that such culling is reducing the central herd to such low levels of population as to expose it to the loss of genetic diversity and extinction.

Yet, despite such information, IBMP's harmful culling practices continue. Park biologists and the IBMP do not learn from experience and do not adapt. Because of the inability to adhere to the adaptive management policies recommended, the existing regulatory mechanisms are inadequate in the operation of the park with regard to the prevention of the extinction of wild bison there, necessitating the intervention of the Fish and Wildlife Service in listing both herds as endangered or threatened. Because extinction could occur the winter of 2017-2018 due to the low level of the central herd, an emergency listing is requested.

Yellowstone's biologists and wildlife managers talk the talk but they do not walk the walk. They know all the right words to say, but do not act on what they say should be done to conserve the park's wild bison. And when they do act, it is to recommend large-scale culling that disproportionately targets the native wild bison herd that inhabits the park's central valleys. In one decade Yellowstone's iconic central herd has been decimated to the brink of extinction at the hands of state and federal government agents, licensed hunters and American Indian tribes. As mentioned, the herd has plunged from a high of 3,500 animals to a historic low. And all the while, Yellowstone's biologists and wildlife managers let it happen. In fact, they took part in the decline and encouraged it.

Supposedly, this is all being done in accord with the Department of the Interior's policy of "Adaptive Management." In the words of Yellowstone biologists Geremia, White and Wallen in "Population Dynamics and Adaptive Management of Yellowstone Bison, Yellowstone National Park":

> Adaptive management is a structured decision-making approach for improving resource management by systematic learning from management actions and outcomes. It involves the exploration of alternatives for meeting objectives;

> prediction of outcomes from alternatives using current understanding; implementation of at least one alternative; monitoring of outcomes; and using results to update knowledge and adjust actions. Adaptive management provides a framework for decision-making in the face of uncertainty and a formal process for reducing uncertainty to improve management and outcomes over time.

In other words, it means picking a plan to meet an objective, carrying out that plan, assessing the outcome, making another plan based on predicting an alternative for a better outcome, carrying out that action and so on, hopefully engaging in a process that through fine-tuning achieves a better result to meet the objective at hand. The authors continue with defining adaptive management:

> Model development is a component of the structured decision-making process that brings together data and uncertainty through testable hypotheses representing our understanding of the system and effects of management alternatives. Uncertainty arises from our lack of understanding of the ecological process, measurement error, environmental variability, and our lack of complete control over management actions.

The basic problem in ecological research is to understand processes that we cannot observe based on quantities that we can observe (Hobbs et al., 2015). Models help researchers do that. They are a simplification of reality, like maps, but usually using mathematical models and often involving computer processing. The models are often in the form of research studies that collect and analyze evidence to predict the outcome of a hypothesis, then based on findings, implementing a course of action. This process is then repeated based on new evidence generated by implementation of the recommended action, with the process repeated indefinitely until a goal is met. According to the authors:

> The hierarchical Bayesian state-space [i.e., mathematical] modeling approach can be used to build complicated models that are suitable for incorporating these sources of uncertainty and comparing forecasted outcomes of a system under management. These approaches support adaptive management by incorporating new data as it becomes available and revising future predictions as outcomes of management are monitored.

To help understand future ecological outcomes of actions that affect the environment (such as culling), predictions are made based on past observations. These predictions often use Bayesian probability analysis, based on Bayes' Theorem. A simple explanation of that mathematical law is given by John Horgan, January issue of *Scientific American* titled "Bayes's Theorem: What's the Big Deal?":

Named after its inventor, the 18th-century Presbyterian minister Thomas Bayes, Bayes' theorem is a method for calculating the validity of beliefs (hypotheses, claims, propositions) based on the best available evidence (observations, data, information). Here's the most dumbed-down description: Initial belief plus new evidence = new and improved belief (Horgan, 2016).

The actual theorem (also called Bayes' rule or Bayes' law) is an equation that looks like this:

$$P(A \mid B) = \frac{P(B \mid A)P(A)}{P(B)}$$

Figure 19. BAYES' THEOREM.

and reads: the probability that an event A occurs given that another event B has already occurred is equal to the probability that the event B occurs given that A has already occurred multiplied by the probability of occurrence of event A and divided by the probability of occurrence of event B. Often the equation uses differential calculus and is computer processed.

Geremia, White and Wallen continue their explanation of adaptive management, describing the Bayesian probabilistic or "state-space approach" they use. "State-space" means the set of all possible states of a dynamical or changing system, such as the total number of bison. The authors explain:

> In the state-space approach, we begin by estimating the initial conditions of the bison population. This includes the number of bison in age and sex stages which can be summed to identify total herd and population sizes. Next, we predict the bison population during the next year based on survival, birth, and winter removals. These quantities, which are referred to as states are assumed to be unobserved, meaning we never know their exact value. As the year passes, we collect data on the bison population through aerial counting, completing age and sex composition surveys, and monitoring collared animals. These data are compared to model predictions made before the data were collected to refine estimation. These data are imperfect, because we cannot count or track every single individual. Therefore, even after data are collected, we still do not know the exact values of the states of interest.

To fine-tune the predictions over time, say annually, iteration is used, which involves repetition of the Bayesian process as applied to the result of the previous application so as to obtain successively closer approximations to the solution of the problem, say how many bison to cull the next year. The authors explain:

> We repeat this process of forecasting the state of the bison population during the next year and collecting data to check and improve our predictions. Over time, predictions improve because repeating these comparisons each year improves our understanding of the system (Geremia et al., 2015).

This sort of analysis has been used successfully to estimate the correct level for harvesting waterfowl. For instance, according to "Adaptive Management: The U.S. Department of the Interior Applications Guide" by Williams, B. K., and E. D. Brown:

> Adaptive harvest management was developed to deal with uncertainties in the regulation of sport waterfowl hunting in North America. Each year, a proposed policy for waterfowl hunting regulations is derived by dynamic optimization methods. After regulatory decisions based on this policy are made, model-specific predictions for subsequent breeding population size are compared with monitoring data as they become available, to produce new model credibility weights with Bayes' rule. The process is adaptive in the sense that the harvest policy "evolves" over time to account for new knowledge generated by the comparison of predicted and observed population sizes. The change in harvest policy from 1995 to 2007, resulting from changing model weights, is a striking example of the efficacy of adaptive management as it is actually implemented.

But Williams et al. note that success can be elusive:

> A key concern is the recognition and measurement of success. An adaptive management project is viewed as successful if progress is made toward achieving management goals through the use of a learning-based (adaptive) decision process. Evaluation of an adaptive management project should involve a comparative assessment that considers the costs of adaptive management above and beyond those that would be incurred in any case. Impediments to the success of adaptive management include, e.g., institutional resistance to acknowledging uncertainty, risk aversion by many managers, myopic management, lack of stakeholder engagement, and other factors (Williams, 2012).

In the hands of Yellowstone's wildlife managers, adaptive management is a striking failure, if for no other reason, its administration has the potential of driving into extinction the very species it manages. According Williams et al., "Adaptive management focuses on learning and adapting, through partnerships of managers, scientists, and other stakeholders who learn together how to create and maintain sustainable resource systems" (Williams, 2012). It is the regulatory mechanism that governs the management of Yellowstone wildlife, most notably, Yellowstone's bison. But in Yellowstone, resistance to learning, risk aversion and shortsighted management prevail. Yellowstone's biologists are not learning from experience and if they are learning, are disregarding what they have learned, drawing wrong conclusions.

For instance, the cap of 3,000 animals set for the maximum number of wild bison allowed in the park, as codified in the Interagency Bison Management Plan for the population size that triggers migration and thus correspondingly triggers culling actions, is the result of a study by Norman F. Cheville et al. in "Brucellosis in the Greater Yellowstone Area." This study used a regression analysis model to explore the relationship between variables, such as level of bison population, temperature and snow. The study stated:

> The final issue addresses relationships at populations above the 3,000 threshold. One might expect the response to winter conditions to be strongest in large populations. Given bison populations of more than 3,000, does winter severity influence the number of bison moving out of the park? Regression analysis of bison populations on various indexes of winter severity in years when there were more than 3,000 bison show that SNOW and snow index are strongly related to bison moving out of YNP . . . No other winter-severity variable is close to significance, nor does stepwise regression result in an improved fit.
>
> Of the two measures of winter severity available, TEMPERATURE and SNOW, only SNOW proves to be important statistically in explaining bison movements. Figure II-4 shows that for populations over 3,000, the number of bison moving out of YNP increases rapidly with increasing SNOW (on average, 68 bison for each inch of SNOW). Furthermore, on the average, no bison moved outside YNP when SNOW was 17 in. or less. That average fails to capture the fact that historically some bison have moved outside the park even when the population was low (Meagher 1973). Nevertheless, 17 in. of SNOW is a useful benchmark for increased probability that bison will move out of YNP and, if not controlled, potentially come into contact with cattle (Cheville et al., 1998).

But what is the point of such studies if probability does not match reality? What is the point if in fact bison migrate out of the park in any weather conditions—as they do? What is the point if the disease is spread by two vectors but only one vector is controlled—which is the case? Science involving Yellowstone is often not science, but puffery. While scientific studies are the basis of regulating management of wildlife in Yellowstone, such studies are often incorrectly applied to justify mismanagement, especially those reliant on probability analysis. Studies have found that culling at Yellowstone is no more effective than not culling in reducing the spread of brucellosis out of the park

(Hobbs et al., 2015). But what actions are taken based on such studies? Continued large-scale culling.

Further, culling bison not only *does* not protect cattle from the spread of brucellosis but *can* not under present disease management, because as mentioned, brucellosis is not only prevalent in park bison, but in park elk as well. If both species can transmit the disease to cattle, but one species is allowed to mingle with those very same cattle being protected from contact by another species, disease transmission still occurs and the spread of disease is not controlled. According to National Academies of Sciences' "Revisiting Brucellosis in the Greater Yellowstone Area":

> The only remaining U.S. reservoir of *B. abortus* infection is in the Greater Yellowstone Area (GYA), where wildlife transmitted cases spill over into domestic cattle and domestic bison. Yet this spillover is now occurring with increasing frequency, raising the possibility of brucellosis reoccurrence outside the GYA . . . Much has changed in the 19 years since the previous report. There is now clear evidence that transmission of B. abortus to domestic livestock in the GYA has come from infected elk, not bison, posing greater challenges for control of transmission to domestic species. This is coupled with significant changes in land use around the GYA, and the increasing value that the public places on our wild lands and the wildlife they support (Revisiting Brucellosis in the Greater Yellowstone Area, 2017).

If adaptive management is supposed to adapt, why are disease control efforts still aimed at one vector, but not another? How is this learning and updating for better results? How is this disease control? How is this cost-effective? At a $3 million-a-year expenditure by the IBMP to supposedly protect from brucellosis no more than 300 cattle grazing in Gardiner Basin, it is costing the public $10,000 per head annually (see chapter 13, this petition, first volume). However, killing large numbers of wild bison inside the park for the benefit of ranchers does not effectively control the spread of brucellosis and does not benefit ranchers. Grazing cattle near a habitat where brucellosis is prevalent is not in the best interests of the cattle industry in Montana or nationally. Such biohazardous exposure in fact puts state and national brucellosis-control efforts in jeopardy.

The annual round-up of bison for shipment to slaughterhouses is mere showmanship and subsidizes the beneficiary: private, commercial interests. This is in violation of the Yellowstone National Park Protection Act of 1872 that established the park. It "provided against the wanton destruction of the fish and game found within said park, and against their capture or destruction for the purposes of merchandise or profit."

According to the *Record of Decision* that established the Interagency Bison Management Plan as a bison-only culling agency in 2000, "The management of bison under this plan will include actions to protect private property; actions to reduce the risk of transmission of brucellosis from bison to cattle; and, actions to maintain a viable, free-ranging population of Yellowstone bison." In practice, interagency members protect cattle from the transmission of brucellosis by bison, but *not* by elk. They claim they maintain a viable, free-ranging population of Yellowstone bison, but kill all bison that attempt to roam freely out of the park.

In reality, the park as well as the national forests bordering the park are being managed like a cattle ranch when it comes to its iconic ungulates, wild bison. The meadows just outside the park boundary in Gallatin National Forest function as feed lots for the fattening of cattle. In the fall, these domestic animals are rounded up and shipped off to slaughter. Migrating wild bison are also rounded up in the fall like cattle and driven into the Stephens Creek capture facility in Gardiner Basin, a grassland just inside the park that functions as a stockyard. Like cattle, they too are shipped off to slaughter.

While this is being done, sometimes over a thousand elk have been observed in Gardiner Basin on a winter day. They watch as convoys of livestock trailers haul wild bison away to a slaughterhouse. Ranchers and biologists pretend they are controlling brucellosis this way, but it is only wishful thinking. Not only are they deceiving others, but they are deceiving themselves.

Managing an ecosystem like a ranch turns it into a ranch. All domestic animals were once wild, like the aurochs, the wild and now extinct ancestor of cattle. Selective breeding of wild animals domesticates by allowing only those with desired traits to mate. The IBMP is systematically removing from the breeding population only migratory bison, leaving behind in the reproductive pool a growing population of the non-migratory, also called residents, those that stay put in the park. Statistically, such non-migratory animals are more prevalent in the northern herd, a population that is dramatically growing, while the population of the central herd, the more migratory, is plummeting.

This divergence of herd populations is covered up by the government referring to the two discrete herds as one herd for management purposes.

To add insult to injury, the National Park Service says this is all necessary to prevent a "mass migration" of wild bison into the state of Montana, when just a few miles down the migratory corridor historically used by bison for exiting the park in winter is Yankee Jim Canyon, a natural and made-made barrier to the bison moving further north. While several recent actions by wildlife managers and other officials have had a positive impact, such as allowing bison year-round access to Hebgen Lake and the decision to curtail vaccination, the result of the preponderance of poor mangement is the potential extinction of Yellowstone's wild bison.

Despite the public outcry against this highly controversial bison culling program carried out under the Interagency Bison Management Plan, it continues by using science and mathematical simulation models to bluff. It continues despite the long opposition to it by such conservation groups as the Buffalo Field Campaign, the Western Watershed Project and Earth Justice, to name a few. It continues despite IBMP's inability to address the Government Accountability Office's 2008 criticism of the interagency's twin goals, which are mutually exclusive under the present plan. The GAO stated:

> The plan has two broadly stated goals: to "maintain a wild, free-ranging population of bison and address the risk of brucellosis transmission." The plan, however, contains no clearly defined, measurable objectives as to how these goals will be achieved, and the partner agencies have no common view of the objectives (Yellowstone Bison, 2008).

The IBMP still has no plan in place to carry out its objectives that does not entail eventual wild bison extinction. Because of its existing inadequate regulator mechanisms, including its misapplication of the concept of adaptive management, the Fish and Wildlife Service should list both herds for protection.

Flawed wildlife management decisions by governmental bodies can potentially lead to extinction of the species mismanaged, for they can put that species into an ecological trap from which there may be no escaping. Martin A. Schlaepfer, an ecology and evolutionary biologist at Cornell University, in a 2002 review article co-authored by biologists M.C. Runge and P.W. Sherman titled "Ecological and evolutionary traps" noted:

> Organisms often rely on environmental cues to make behavioral and life-history decisions. However, in environments that have been altered suddenly by humans, formerly reliable cues might no longer be associated with adaptive outcomes. In such cases, organisms can become "trapped" by their evolutionary responses to the cues and experience reduced survival or reproduction. Ecological traps occur when organisms make poor habitat choices based on cues that correlated formerly with habitat quality. Ecological traps are part of a broader phenomenon, evolutionary traps, involving a dissociation between cues that organisms use to make any behavioral or life-history decision and outcomes normally associated with that decision. A trap can lead to extinction if a population falls below a critical size threshold before adaptation to the novel environment occurs. Conservation and management protocols must be designed in light of, rather than in spite of, the behavioral mechanisms and evolutionary history of populations and species to avoid "trapping" them.

Examples of ecological traps are asphalt roads that look like lakes to mayflies because of the way the roads reflect light. The female mayflies because of this reflective quality lay their eggs on the roads, destroying the eggs. Or take a certain beetle. Landfills or roadsides with bottles and broken glass appear to male beetles as female beetles. They attempt to mate with these shards, but of course produce no young. These species have made maladaptive decisions to their environment that reduce the species' productivity (Schlaepfer, 2002).

In the case of wild bison, herds have been migrating down the mountains in Yellowstone for millennia. Such seasonal movement worked for their survival. But now the environment has turned into an ecological trap whereby the cues to leave the high ranges—such as high snow levels, low temperatures and ice that crusts over their forage—no longer serve to protect them but instead doom them. The authors' conclusion that, "In such cases, organisms can become 'trapped' by their evolutionary responses to the cues and experience reduced survival or reproduction" accurately describes what is happening to the park's wild bison except for one element: they do not become figuratively "trapped" by their environment but are, indeed, literally trapped by means of the Stephens Creek capture facility operated on park land by government personnel.

In this case there is an easy fix—stop trapping them. Stop making the Yellowstone bison "a highly managed population." Nature thrives on *not* being managed. Instead, keep human intrusion out. It is human despoliation and the introduction of invasive species such as cattle that should be managed.

Adaptive management in the hands of Yellowstone's wildlife managers is a failure because it adapts wild bison to the needs of cattle, rather than to the needs of the wild bison populations the park is supposed to protect. With scientific studies designed to provide a rationale to keep wild bison off the turf on which private cattle graze—the majority of which is a national forest, i.e., public land—protection is a sham. According to the *Record of Decision* that established the Interagency Bison Management Plan, as noted, herd size triggers lethal removal:

> The population target for the whole herd is 3,000 bison. If the late-winter/early-spring bison population is above the 3,000 target, specific management actions may be undertaken at the Stephens Creek capture facility or outside the Park in the western boundary area to reduce its size (Record of Decison, 2000, p. 16).

The 3,000 figure has been established as the park's maximum for wild bison because this is the number of bison that has been found to trigger migration onto adjacent national forest and private grasslands where cattle graze. The *Record of Decision* states:

> As an additional risk management measure, the agencies would maintain a population target for the whole herd of 3,000 bison. This is the number above which the NAS (1998) report indicates bison are most likely to respond to heavy snow or ice by attempting to migrate to the lower elevation lands outside the park in the western and northern boundary areas (Record of Decision, 2000, p. 20).

Coincidentally, a herd size of 3,000 is supposedly also the number that has been determined to be a minimum viable population, that is, the minimum population size needed for a species to survive in the wild. Would this not lead an unsuspecting reader of these numbers to the conclusion that IBMP's culling program that reduces park bison down to 3,000 is not harming bison? It is a wrong conclusion, however. Science is again being used to deceive so as to promote commercial interests. Let us look at the science.

On examining the scientific literature, we find the simulation studies used to support these two identical numbers are flawed. National Park Service biologists, led by P.J. White, in "Management of Yellowstone bison and brucellosis transmission risk: Implications for conservation and restoration," state:

> recent demographic and genetic analyses suggest that an average of more than 3000 bison total on a decadal scale is likely needed to maintain a demographically robust and resilient population that retains its adaptive capabilities with relatively high genetic diversity (Gross et al., 2006; Freese et al., 2007; Plumb et al., 2009; Pérez-Figueroa et al., 2010).

As seen from the above quote, the White et al. study cites four other studies to back up its claims. However, as an analysis in this petition's second volume of all four studies demonstrates:

> While these studies are interesting and make several valuable points, with regard to the population size needed to preserve the genetic diversity of the wild bison in Yellowstone, they are useless as a guide for the genetic and behavioral conservation of the herd. In the simulation models cited, all culling scenarios are on a *random* basis. The culling at Yellowstone National Park, however, is not random but deterministic, selecting out bison for lethal removal only those bison that are exercising their migratory instincts. No population level of wild bison in the park will assure the preservation of genetic diversity if the IBMP's policy of artificially selecting out only migratory animals continues (this petition, second volume, chapter 25, "Wildlife managers' pseudoscientific flimflam").

There are two reasons for this:

- Selection by humans is non-random and artificial;
- Selecting against a trait is not random; hence, the study does not represent the true state being observed by claiming a random basis.

With regard to the number 3,000 as the trigger point of migration which brings bison near cattle, this is a mathematically-derived prediction (see discussion, second volume, chapter 32 "Comment on alternatives for revision of IBMP, Cheville et al., *Brucellosis in the Greater Yellowstone Area*). In reality, historically, bison will move out of the park at almost any population number. According to Rick Wallen, Yellowstone's wildlife biologist:

> Bison move about on the landscape and leave the area that we designate as Yellowstone National Park for a couple of reasons. Population abundance alone could drive them to pioneer new areas, but, on top of that, bison will move anytime there's heavy snowfall winters. Even at really low population abundance, you should expect a lot of animals to leave the national park (Herbert, 2015).

And incredibly, as mentioned earlier above and in the 2015 90-day finding, reducing wild bison down to 3,000 by large-scale culling is justified by the Fish and Wildlife Service as mimicking Mother Nature herself. FWS states in its 2015 finding that:

> winter culling may actually be serving as a surrogate for a dispersal sink (permanent movement out of the population) that would occur as a natural part of the ecosystem process (this petiton, second volume, Appendix D).

This finding is a misinterpretation of flawed studies that together cascade into misrepresentation of the facts (see this petition, second volume: "The Plumb study," chapter 25, "Wildlife managers' pseudoscientific flimflam"). It results in a direct endorsement of a process leading to extinction. A dispersal sink where movement of a species out of it is permanent, or where deaths exceed births, is an environment where that species becomes extinct. Applying such flawed studies to justify the culling practices of the IBMP and using flawed reasoning to interpret those studies distorts the truth so necessary for a correct evaluation of the issue.

The truth is further degraded by the Fish and Wildlife Service's methodology in evaluating petitions on listing wild bison, sustaining and supporting the park's failed adaptive management decisions and actions. The FWS is looking at the probability of extinction through the lens of the biological species concept only, where species is defined as those members of a class that interbreed and where long-term survival status is measured by the total number of a subspecies that exist, with that number in this case being the combined populations of both the central herd and the northern herd. Migration under this methodology essentially has no meaning as long as the herd is above a certain total population level. But nature assures survival by providing genetic variations for a species within a population, such as the migratory trait, especially necessary in case of catastrophes. Nature plans ahead by providing a species a variety of genes by which to adapt to environmental changes. The FWS is blind to that need.

By its failure to employ other species concepts, like the ecological and phylogenetic species concepts—concepts that place importance on the adaptive evolution of a species to its ecological niche and to the need for variation in traits and behavior—the FWS is unable to evaluate the truth about the long-term survival status of Yellowstone's wild bison subspecies. Without the IBMP knowing and acting on the truth, its culling practices have a high potential to continue to erode the park's wild bison genetics to the point of extinction. The FWS has allowed the systematic elimination over decades of an essential adaptive trait—migration—a trait necessary for the survival of the total population of wild bison, as well as both the central and northern herds individually.

Bison in the Yellowstone area evolved in behavior in response to the landscape, seasonally migrating from high altitudes to lower altitudes such as Gardiner Basin to assure winter survival. Members of the Yellowstone herd adapted their behavior to the Yellowstone niche. That adaptive behavior is being prohibited by the IBMP. Far from being irrelevant, traits and behaviors are critically important in assessing endangerment of species. Here is why.

Artificial selection is the intentional reproduction of individuals in a population that have traits desired by domesticators. It is human-directed evolution. Long before Darwin, farmers and breeders were using the idea of selection to cause major changes in the features of their plants and animals over the course of decades. They allowed only the plants and animals with desirable characteristics to reproduce, causing the evolution of farm stock and crops. For instance, broccoli evolved from wild mustard by suppressing the development of flowers. Cattle evolved by capturing the fierce wild aurochs and allowing only the most docile to mate. This process is called artificial selection because people, instead of nature, select which organisms get to reproduce (Artificial selection, 2017). The end result is domestication.

It is self-evident that if the trait of migration in a herd composed of migratory and non-migratory (also called resident) animals is eliminated by killing all those animals that migrate, only the non-migratory will be left to reproduce.

No reasonable person can deny that wild bison are being exposed to artificial selection through the culling activities of the IBMP, for by killing only those animals that have the undesirable trait of migration—a sub-group—it is biasing the breeding pool toward a population composed more of what is wanted: non-migratory animals. No reasonable person can deny that this will produce an effect—a more non-migratory, docile, domestic herd. If the more migratory herd is the central herd, then culling migratory animals will disproportionately diminish the central herd. As noted previously, Darwin pointed out:

> as the favoured forms increase in number, so, generally, will the less favoured decrease and become rare. Rarity . . . is the precursor to extinction. We can see that any form which is represented by few individuals will run a good chance of utter extinction, during great fluctuations in the nature or the seasons, or from a temporary increase in the number of its enemies . . . We have seen that the species which are most numerous in individuals have the best chance of

> producing favourable variations within any given period (Darwin, 1859, p. 109).

The mortality of wild bison is impacted by a number of forces: humans, in the form of federal and state agencies, hunters, predators, disease, in-breeding and severe weather and other endangerments, many of which happen randomly and can not be predicted with precision. As a population declines from such forces, it can at some point go extinct. The number of animals above which extinction in the wild is unlikely despite these forces is called the minimum viable population (MVP). Or put another way:

> A minimum viable population size (MVP) can be defined as the smallest size required for a population or species to have a predetermined probability of persistence for a given length of time (Shaffer, 1981) (Reed et al., 2003).

According to the *Record of Decision*, the document outlining the Interagency Bison Management Plan in 2000:

> The estimation of a minimum viable bison population size involve[s] not only genetic factors but also demographic and environmental factors such as sex ratio, reproductive success of males and females, fluctuations in population size, and random chance or catastrophe. These factors differ for different species, hence, no universal estimate of a minimum viable bison population exists. Given these and other unknowns, the National Park Service is committed to conducting additional research on genetics in bison. If the additional information suggests the management practices of the Joint Management Plan adversely affect genetic diversity, the NPS will review management actions and recommend adjustments. Considering the information currently available, the agencies believe they are providing for the conservation of Yellowstone bison genetics by balancing a spring bison population limit of about 3,000 animals with other management objectives (Record of Decision, 2000, p. 51).

As noted, the Fish and Wildlife Service has argued in its findings on petitions seeking the listing of wild bison that the population of this species is not declining, but in fact is stable, and even increasing, and is therefore not in danger of extinction. By its agreement with the culling practices of the IBMP, the FWS supports the hypothesis that 3,000 animals—the number stipulated in the *Record of Decision* for the maximum number allowed to inhabit the park—is a minimum viable population.

But what is the thinking of others concerning the number that would constitute a minimum viable population for a species? In "Minimum viable population size: A meta-analysis of 30 years of published estimates," an Australian team reviewed the scientific literature regarding studies on the concept of MVP. The authors "sourced 529 relevant articles published between January 1974 and December 2005, describing up to 2202 species and a minimum of 1444." The authors, consisting of Lochran W. Traill and Barry W. Brook, Research Institute for Climate Change and Sustainability, School of Earth and Environmental Sciences, University of Adelaide, and Corey J.A. Bradshaw, School for Environmental Research, Institute of Advanced Studies, Charles Darwin University, Darwin, Northern Territory, concluded:

> By implementing a unique standardization procedure to make reported MVPs comparable, we were able to derive a cross-species frequency distribution of MVP with a median of 4169 individuals . . . (p. 159).

For mammals the standardized MVP was determined to be 3,876 animals (Traill et al., 2007).

In another study, empirical data suggests that an MVP of approximately 3,000 animals is too low to assure persistence of a species. An Australian and United States team in "Estimates of minimum viable population sizes for vertebrates and factors influencing those estimates" wrote:

> Extinction records from national parks in the western USA (Newmark, 1987; Soule, 1987) shed some light on what is likely to constitute a minimum viable population size. Of 69 populations of lagomorphs (rabbits and hares), the 9 populations (13%) that went extinct had median population sizes of 3276. The parks were established about 75 years prior to the study and, therefore, would represent 40–50 generations for a lagomorph. Thus, 3000 animals do not appear to be sufficient to ward off extinction during these time frames.

The team consisted of David H. Reed, Julian J. O'Grady and Richard Frankham, Key Centre for Biodiversity and Bioresources, Department of Biological Sciences, Macquarie University, Australia; Barry W. Brook, Key Centre for Tropical Wildlife Management, Northern Territory University, Darwin, Australia, and Jonathan D. Ballou, Department of Conservation Biology, Conservation and Research Center, National Zoological Park, Smithsonian Institution, Washington, DC.

Instead, an MVP of 7,000 animals was deemed needed to prevent extinction. The study also stated that the figure was applicable for all vertebrates. The authors noted:

> It has long been believed that there is no single value for population size that may be applied to all populations to ensure persistence (Gilpin and Soule´, 1986; IUCN 1994). However, recent evidence calls this into question. In this study, no differences in MVP were found due to taxon, [such as a species,

> family, or class] trophic level [the position an organism occupies in a food chain], or global latitude.

A reason for the higher MVP is the duration of most studies. The authors noted:

> Short-term studies consistently underestimate the true variances for demographic parameters in populations. Thus, the lack of long-term studies for endangered species leads to widespread underestimation of extinction risk. The results of our simulations suggest that conservation programs, for wild populations, need to be designed to conserve habitat capable of supporting approximately 7000 adult vertebrates in order to ensure long-term persistence (Reed, 2003).

Coincidentally, this number (7,000) is about the level that has been identified as the carrying capacity of the park for bison. In 2015 a call was made by the National Park Service and the State of Montana for public comment on a proposed revision of the Interagency Bison Management Plan as published in the Federal Register titled "Environmental Impact Statement for a Management Plan for Yellowstone-Area Bison." The upper limit suggested as an alternative for the park's wild bison abundance was 7,500 animals, identified as the "food-limited carrying capacity" of the park for bison (Environmental Impact Statement for a Management Plan for Yellowstone-Area Bison, 2015). As mentioned, the total bison populations as of 2017, after culling almost 1,300 bison, were 4,816, with about 3,969 in the northern herd and 847 in the central herd, representing a decrease of 12 percent for the two herds combined and almost a 50 percent reduction for the central herd. Small herd size is associated with less capacity for allelic variation and heterozygosity, that is, genetic diversity.

As of the submission of this petition, the revision of the IBMP has remained stalled.

Like all wildlife populations, Yellowstone's wild bison experience genetic drift, but unlike most wildlife populations, wild bison are subject to artificial selection via IBMP's culling program. This compounding of genetic influences can have profound consequences. Artificial, non-random lethal removal of animals from a population that selects out a certain trait, such as migratory behavior, exponentially increased the chance for the loss of allelic variation and heterozygosity. This deleterious effect is compounded again by reducing the herd to a smaller population, increasing the potential for genetic drift.

This results in systematically stripping away the protective advantage of the migratory trait—not by chance, not by natural selection, but on purpose by state and federal government agencies. The government by its large-scale culling practices is exposing the herd to large population reductions on a routine basis. Non-random selection directed by humans, such as culling, is artificial selection. Come a random event that further reduces the variability of the herd's genetic trait of migration through genetic drift, coupled with IBMP's non-random selections against that variation, wild bison are being progressively set up for extinction. Come a severe environmental change that needs to be escaped, such as deep, ice-encrusted snow and cold weather—with the herds' adaptivity compromised by the loss of a trait that was once heterozygous—the park-bound wild bison will not express the missing trait, i.e. migratory behavior, with massive winterkill the possible result.

Geography predisposes the herds to separately evolved behaviors. In a study of the area in "Predicting Bison Migration out of Yellowstone National Park Using Bayesian Models," by Chris Geremia, P.J. White, Rick L. Wallen and others, the authors note:

> 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. [7,900 feet] 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 [14 inches] and temperatures reaching -42 C [-44 F.]. The northern herd occupies the comparatively drier and warmer northern portion of Yellowstone. Elevation decreases from 2,200–1,600 m. [7,200-2,200 feet] over approximately 90 km [56 miles] between Cooke City and Gardiner, Montana with mean snow water equivalents decreasing from 30 to 2 cm. [12 inches to 1 inch] along the east-west elevation gradient. 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. 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., 2011).

Because winters are generally harsher in the vicinity of the central herd as compared to the northern herd habitat, the central herd would likely be more migratory.

Evaluating the ability of wild bison's ability to survive in the GYE readily falls into error if the herds are lumped into one population. This perspective does not reflect reality and for this reason conclusions based on the assumption that the herd is homogenous are prone to error. In "Spatial Population Structure of Yellowstone Bison," Edward M. Olexa and Peter J. P. Gogan, writing in the July 2007 issue of *The Journal of Wildlife Management*, studied the spatial and temporal movements of bison in Yellowstone National Park by observing the radio locations of the animals. The authors stated:

> We documented spatial separation of Yellowstone bison into 2 segments, the northern and central herds, during all periods . . . We did not observe exchange between the 2 segments during the peak rut and it varied during the extended rut (2.15–3.23%). We estimated a winter exchange of 4.85–7.77%. The outcome and effectiveness of management actions directed at Yellowstone bison may be affected by spatial segregation and herd affinity within the population.

The authors concluded:

> Reductions based on total population size, but not applied to the entire population, may adversely affect one herd while having little effect on the other (Olexa, 2007).

Underscoring the importance of measuring the status of wild bison by analyzing subpopulations, is the study by Halbert et al. published 2012 in the *Journal of Heredity* titled "Genetic Population Substructure in Bison at Yellowstone National Park." The researchers stated:

> 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 longterm 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.

Such subdivisions may contain a third subpopulation, wood bison, also known as mountain bison. The authors note:

> A third distinctive herd in the Pelican Valley was previously proposed based on historical observations (Meagher 1973). Only 2 live capture samples from bison in the Pelican Valley were available for this study . . . and the possibility

> of a third genetic cluster cannot be completely discounted at this time. Direct sampling and genetic analysis of larger numbers of bison from the Pelican Valley would be useful in evaluating this possibility.

Although more research needs to be done on this referenced third group, most likely it is not a separate, isolated remnant herd, but instead is represented in the genetic structure of the central herd population. Researchers with Texas A&M University have discovered a clade associated with the present-day central herd that contains genes of wood bison, as reported in "Mitochondrial Genome Analysis Reveals Historical Lineages in Yellowstone Bison" (see chapter 10 "Yellowstone proves plains and wood bison are separate subspecies," this petition, first volume).

Culling has severely disrupted migratory behavior. In the past, of the two major subpopulations, those that were culled near West Yellowstone were almost all from the central herd, while those culled in Gardiner Basin were both from the central and northern herds. According to the study:

> As with the live capture group, most of the winter cull bison were assigned to 1 of the 2 identified clusters (546/596 = 91.6%). Bison sampled near West Yellowstone appear to be nearly exclusively from the Central subpopulation (cluster 2). This observation was consistent across all 6 years in which samples were obtained (Figure 3B).
>
> Winter cull samples were obtained from bison near Gardiner in only 2 years of the study (1997, 2003), and the distribution of cluster assignments was strikingly different between these years. Most of the bison sampled near Gardiner in 1997 appear to be from the Northern subpopulation (68.1% assigned to cluster 1) and those sampled in 2003 appear to be primarily from the Central subpopulation (87.8% assigned to cluster 2). These findings are consistent with observations that the entire northern herd moved toward the Gardiner boundary during the winter of 1996–1997 (Taper et al. 2000) but not 2002–2003 (Geremia et al. 2009) (Halbert et al., 2012).

In 1996-1997, the entire northern herd consisted of 860 bison. After culling, the herd count was 455, an almost 50 percent reduction. Since then, the herd has grown steadily, indicating that it has developed behavior that enables reproduction, namely, non-migration. It is this behavior that ensures the survival of the fittest by escaping the IBMP culling operation in the north at Gardiner Basin. Today the northern herd is almost 10 times its size in 1996, namely, 4,000 bison.

On the other hand, the population of the central herd in 1996-1997 was 2,724. As the herd does not have the option to not migrate (except for a few that stay behind around the thermal pools), because of the more harsh winters in the central valleys of the park and because the herd has no where else to go but north in severe winters (Hebgen Basin west of the park has a climate similar to the interior central valleys), they migrate to Gardiner Basin, where almost all reaching the basin are culled. As mentioned, that herd now totals 847 bison, over a threefold reduction since 1996.

This sharp diminishment in population size has put the central herd into a genetic bottleneck, which can reduce the variation in its gene pool. Thereafter, a smaller population, with a correspondingly smaller genetic diversity, remains to pass on genes to future generations of offspring through sexual reproduction. The resultant lower population reduces the effective population size, increasing the probability of genetic drift. Successive culls can plunge the population into extinction.

What do studies that look at the effective population size say about the Yellowstone wild bison herds? Of particular note is the 2012 computer simulations for various population levels by Andres Perez-Figueroa and co-authored by park biologists White, Wallen and others titled "Conserving genomic variability in large mammals: Effect of population fluctuations and variance in male reproductive success on variability in Yellowstone bison." The investigators factored in not only the potential effects of genetic drift, but also culling and hunting. The authors described the parameters of the study:

> 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. We built an individual-based computer simulation model to examine how actual culling and hunting strategies influence the effective population size (Ne) and allelic diversity in Yellowstone bison over 200 years (28 generations). The Ne for simulated populations ranged from 746 in stable populations of size 2000 up to 1165 in fluctuating populations whose census size fluctuates between 3000 and 3500 individuals.

The results purported that fluctuations in population size as caused by culling and hunting do not necessarily increase the loss of genetic variation:

> Simulations suggested that 93% of allelic diversity, for loci with five alleles will be maintained over 200 years if the population census size remains well above 2000 bison (and if variance in male reproductive success is high). However for loci with 20 alleles, only 83% of allelic diversity will be maintained over 200 years. Removal of only juveniles (calves and yearlings) resulted in longer generation intervals which led to higher maintenance of allelic diversity (96%) after 200 years compared to the culling of adults (94%) when the mean census size was 3250 (for loci with five alleles). These simulations suggest that fluctuations in population census size do not

> necessarily accelerate the loss of genetic variation, at least for the relatively large census size and growing populations such as in Yellowstone bison.

The study concluded:

> Finally, our simulations suggest that the conservation of high allelic diversity (>95%) at loci with many alleles (P5) will require the maintenance of a populations size greater than ~3250 (mean Nc) and removal of mainly or only juveniles.

The study is defective at a basic level. Output of *in-silico* simulations of genetic data is dependent on the demographic parameters used, such as population size. For the output data to be meaningful, it must reflect the reality of the demography being studied. In this case, it is the breeding populations of the park, since genetic diversity is controlled by mating. Since two separate breeding populations exist in the park, two different sets of parameters must be run to determine if fluctuations in population census size accelerate the loss of genetic variation, that is, parameters for the population of the central herd and also the northern herd. Combining the two different breeding herds as one parameter will produce output data that is in error, that is, it will not show the truth of the situation peculiar to Yellowstone's bison populations.

As mentioned, the census population of the northern herd is 4,000 animals, while the central herd is 847. Since the central herd is significantly below the recommended level of 3,250 animals, the central herd is at risk in maintaining high allelic diversity.

The study turned out to be a death warrant for the central herd, which has been allowed to sink to a small population status. Using faulty simulation methodology, it gave backing for the continued large-scale culling by the IBMP of both herds based on their status as a combined unit. Further, a key recommendation was not followed, i.e., lethally removing mostly calves.

The recommendation to limit culling to juvenile bison was not followed even though three of the study's team members are affiliated with the Interagency Bison Management Plan (two of whom are with the National Park Service, an IBMP member) and despite the NPS's commitment to adjust its management of bison due to new information. Recall that the *Record of Decision* states:

> Given these and other unknowns, the National Park Service is committed to conducting additional research on genetics in bison. If the additional information suggests the management practices of the Joint Management Plan adversely affect genetic diversity, the NPS will review management actions and recommend adjustments (Record of Decision, 2000, p. 51).

The 2012 Perez-Figueroa et al. study recommended limiting culling to calves as a means of preserving allelic diversity (AD), that is, the number of single gene types—another way to measure genetic diversity. The authors stated:

> Culling of only juveniles gave the longest generation intervals (9.5 years), which translated into the highest maintenance of AD (up to 96.1% . . .) suggesting that juvenile removal would be relatively effective for maintaining genetic variation. The culling of only younger individuals preserves the older age cohorts and increases the generation interval which, in turn, slows the loss of variation over time. Our results suggest that such enhancement would occur in small as well as large herds (>2000 animals) and is more pronounced for conservation of AD than for He.

Table 3. Age and gender composition of culls and harvests of Yellowstone wild bison, plus percents of total (*table by Petitioner from Table 1*).

Time span	Total	Male	Female	Calves	Unknown
1985-2011	7070	2197 (31%)	2527 (36%)	1028 (15%)	1318 (18%)
2012-2016	2191	783 (38%)	908 (41%)	489 (22%)	11 (.5%)
1985-2016	9261	2980 (32%)	3435 (37%)	1517 (16%)	1329 (14%)

The study recommending limiting culling to mostly juveniles was received for publication by *Biological Conservation* March 7, 2011, meaning that action to modify the culling could have been made by 2012. Those recommendations to preserve genetic diversity were never carried out. Interestingly, the removal of mainly calves from a bison herd in the wild is what wolves do via predation.

From 1985 through 2011, 15 percent of the animals culled were calves. From 2012 (date of the Perez-Figueroa study) through 2016, 22 percent were calves and all told, from 1985 through 2016, 16 percent were calves—essentially no change**.**

However, wildlife managers' continued high culling recommendations were given a green light by a key finding of the 2012 Perez-Figueroa simulation study, namely, that "These simulations suggest that fluctuations in population census size do not necessarily accelerate the loss of genetic variation, at least for the relatively large census size and growing populations such as in Yellowstone bison."

Perez-Figueroa et al. stated that the researchers used values in their simulation models that represented the Yellowstone bison's genetic structure plus birth and death rates as well as population distribution according to age. For the simulations, the herds were considered one homogenous, interbreeding herd. Specifically, the authors wrote:

> We used input values representative of Yellowstone bison to parameterize the simulation models (Appendix S1 in Online Supporting information), including microsatellite data from 48 loci, age-specific birth and death rates, and population age structure (Halbert, 2003; Fuller et al., 2007; Brodie, 2008; Geremia et al., 2009; National Park Service, unpublished data). For each demographic scenario, we ran 50 independent replicate simulations. We also considered Yellowstone bison to be one deme, which is consistent with recent genetic and field data (Fuller et al., 2007 Bruggeman et al., 2009; R.Wallen, unpublished data).

Deme, in biology, is defined as a population of organisms within which the exchange of genes is completely random; i.e., all mating combinations between individuals of opposite sexes have the same probability of occurrence. A deme usually is not a closed population but contributes individuals to neighboring populations and receives immigrants from them (Deme, 2017). The authors' claim that the Yellowstone bison groups could be considered as one deme—that is, a population of animals breeding mainly within the group—is wrong, for, as mentioned, the two herds do not mainly interbreed. There are, in fact, two distinct breeding groups—northern and central. Claiming otherwise is not consistent with other findings (the Olexa 2007 study and the Halbert 2012 study just mentioned), and is based on outdated studies and unpublished data. The "one deme" input values are not representative of the status of the Yellowstone herds.

This faulty study has supported management practices at Yellowstone that have allowed the central herd to be pushed to the verge of extinction and has significantly altered the demography of the two herds.

Earlier, I discussed White and Wallen's illogical letter to the editor of the *Journal of Heredity* titled "Yellowstone Bison—Should We Preserve Artificial Population Substructure or Rely on Ecological Processes?" In that letter, the authors stated the background for their position, which gave a thumbs-down for preserving such herds as the central herd in Yellowstone. Recall they stated:

> Halbert et al. (2012) analyzed microsatellite genotypes collected from 661 Yellowstone bison sampled during winters from 1999 to 2003 and identified 2 genetically distinct subpopulations (central, northern) based on genotypic diversity and allelic distributions. On the basis of these findings, they raised concerns about the management and long-term conservation of Yellowstone bison because of disproportionate culling of the 2 subpopulations in some winters. The data and findings of Halbert et al. (2012) are significant and useful for managers charged with conserving these iconic wildlife. However, their article provides information regarding the behavior and management of

> Yellowstone bison that does not accurately portray historic or current conditions. This response clarifies those conditions and challenges some of their apparent deductions and recommendations.

Recall they explain:

> Halbert et al. (2012, p. 1) indicate that Yellowstone bison provide an opportunity to examine a ". . . natural population substructure, which could have important implications for the long-term evolution of these populations." They assume ". . . the Yellowstone population was not subdivided before 1936" and that "these 2 subpopulations [central, northern] have differentiated in a relatively short period of approximately 8 generations [64 years]" (Halbert et al. 2012, p. 5, 7). However, these statements ignore that humans contributed to the observed population and genetic substructure in Yellowstone bison by nearly extirpating them in the late 19th century (except for approximately 23 bison that survived in central Yellowstone) and then by creating another breeding herd in northern Yellowstone at the turn of the 20th century from 21 bison of unrelated breeding descent and divergent genetic stock that were relocated from northern Montana and Texas (Meagher 1973).

Recall the duo concluded:

> 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 . . . Thus, a few bison populations in the greater Yellowstone ecosystem . . . 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 et al., 2012).

In other words, the central herd population substructures is not worth preserving and artificially selecting out the migratory trait by disproportionately killing members of the central herd above the northern herd is acceptable, despite the fact that the central herd is the only herd to have survived extirpation, despite the fact that it is the original herd and was not introduced into the park like the northern herd, despite the fact biologists have stated (as mentioned in the second volume, chapter 1 "The greatest threat: Human interference") that "Every animal which is removed from the breeding population can no longer contribute to the genetic variability of the herd" (Geist, 2008), despite the fact that "some behaviors or traits, including the propensity to migrate, could be lost with the killed bison" (Robins, 2008), despite the fact that James Derr, a professor of genetics at Texas A&M, said "it is important to not reduce the bison population levels any further and risk the elimination of these disease resistant genes" and that "we should know the genetic makeup of bison before management decisions are made which may compromise the future of bison genetic health," despite the fact that Joe Templeton, Texas A&M University, Department of Veterinary Pathobiology, said "The so-called random shooting at the Montana borders is actually eliminating or depleting entire maternal lineages," that "this action will cause an irreversible crippling of the gene pool," and that "Continued removal of genetic lineages will change the genetic makeup of the herd, thus it will not represent the animal of 1910 or earlier," stating that "It would be a travesty to have people look back and say we were 'idiots' for not understanding the gene pool" (Geist, 2008).

White and Wallen claim they have good intentions with regard to subpopulations. As they note in their letter to the editor of the *Journal of Heredity*:

> Although the 2 subpopulations have been disproportionately culled in some years, biologists have clearly warned of possible demographic effects if large culls were continued over time (White et al. 2011b). Biologists have also acknowledged that it is not clear how large-scale culling might influence the genotype diversity and allelic distributions of the subpopulations over time (White et al. 2011b).

As mentioned, to heed these warnings, they claim "adaptive management adjustments" have been made:

> These analyses and uncertainties led to the implementation of several adaptive management adjustments to the Interagency Bison Management Plan designed to minimize future large-scale culls of bison, evaluate how the genetic integrity of bison may be affected by management removals (all sources combined), and assess the genetic diversity necessary to maintain a robust, wild, free-ranging population that is able to adapt to future conditions (USDI et al. 2008).

And they claim "rigorous monitoring" is now being done:

> In addition, the National Park Service developed a rigorous monitoring plan for Yellowstone bison that characterizes the bison inhabiting Yellowstone as a single population with significant substructure and includes randomly sampling bison from primary breeding locations during July and August to identify genetic subdivisions and estimate gene flow within the Yellowstone population (White et al. 2011a).

Monitoring, they assert, may take decades to determine the status of each herd and the effect of culling.

> The plan acknowledges it will be necessary to sample bison across decades to determine if existing subpopulations are converging or becoming more divergent and whether management actions are having a significant influence on population substructure.

They claim sophisticated tracking methods are used to determine what animals are from what herd as they approach a culling facility at the park's boundary:

> Furthermore, each winter biologists use telemetry, ground observations, and aerial distribution surveys to track movements of bison and attempt to differentiate animals from each breeding herd when they approach the boundary of the park and become subject to management actions.

However, these methods are not totally reliable, the authors note:

> This approach does not provide absolute certainty with respect to breeding herd membership, but has been relatively effective at allowing managers to monitor movements by bison and estimate the proportion of culls from each breeding herd.

Recall they point out culling decisions are not based just on total population abundance alone, but also on equalizing the size of the separate herds:

> Thus, total population abundance is not the only primary factor considered in determining management actions for Yellowstone bison. As an example, the management plan for Yellowstone bison during winter 2012 clearly indicates a desire to progress toward approximately equal numbers of bison in each breeding herd and selectively cull bison from the northern herd (which is currently larger), while minimizing removals from the central herd (Geremia et al. 2012).

But what does this all mean in practice? Anything? Or is it all talk? Curious how this intent was being carried out and after reading an update by White and Wallen on the lethal removal goals for the winter of 2016-2017, I wrote Wallen the following email April 3, 2017:

> The Interagency Bison Management Plan's "Status Report on the Yellowstone Bison Population, August 2016" posted on the web by you, Chris Geremia and P.J. White August 17, 2016, included the following culling recommendations for winter 2016-2017:
>
> > Focus population management reductions on the northern herd. Under severe weather conditions, we anticipate a large migration of bison into

> the northern management area that could exceed 2,000 animals. A mass migration could challenge our ability to meet shared goals of maintaining low transmission risk of brucellosis among bison and livestock. Also, breeding herds larger than 3,000 animals have been associated with high grazing intensities on summer ranges that may not be sustainable over time. There are currently nearly 4,000 animals in the northern herd and we recommend reducing the northern herd towards 3,000 animals.

I have several questions about these guidelines and the culling outcome this past winter:

1. How many bison were lethally removed during winter 2016-2017, both by hunting and by shipping to slaughter from the Stephens Creek capture facility?

2. How many of those animals lethally removed were from the Northern herd and how many from the Central herd?

3. For those animals that enter Zones 1 or 2 at Gardiner Basin, how does the IBMP determine what bison are from what herd prior to the act of culling?

4. How many elk during winter 2016-2017, which also have the potential of carrying brucellosis, migrated to the same region from which bison are culled, essentially Zones 1 and 2, Gardiner Basin?

5. Would elk that inhabit the same region as the Northern and Central bison herds be culled if their herd densities were determined a.) to be too high to be sustainable or b.) that they posed a threat of brucellosis transmission to cattle?

Wallen responded the next day, April 4, 2017:

> We did a summary of the work we conducted at our Stephens Creek bison facility and posted it on the world wide web at our interagency site for sharing such information. [at] http://ibmp.info/Library/ StatusReports/20170316_ YELLbison_MgmtReport.pdf
>
> There is no way to answer your 2nd question. We conduct aerial surveys during the summer months to count bison throughout the park and that is the time we can judge how each breeding group in the park may have been affected by the previous winters management actions.

> We have a monitoring program in which we track a representative sample of bison from each breeding group using radio telemetry methods. Through the years of monitoring we know that a portion of the central range bison migrate to the northern range and mingle with the northern range residents.
>
> The northern range wildlife working group collaborate to conduct a northern range elk count each winter. The polygons in which that group counts and records their elk data does not match the bison management zones you refer to so the answer to your 4th question can not be provide with precision. However, I am sure the number is more than a couple of thousand.
>
> Your last question is really one that you should ask the state of Montana. The National Park Service changed policy in 1968 to eliminate elk culling within the park. Thank you for your interest in wild Bison.

On April 13, 2017 I again queried Wallen:

> With the culling and harvest for last winter totaling about 1,200 wild bison, with the population of the central herd totaling about 1,200 and with the inability to determine to what extent each breeding group has been affected by the previous winter's management actions, how do you know if the entire central herd has not been wiped out by such actions?

Wallen answered May 3, 2017:

> Mr. Horsley, thank you for your interest in the conservation of Yellowstone bison. This population represents the most important conservation herd of bison in all of the United States. Some would even argue for all of North America. The population is large in size to protect the genetic and evolutionary traits that allow populations to respond to changes in their environment, the population is still responding to all of the drivers that shaped the species for thousands of years (predators, competition with other species, harsh environmental climates) and they have a relatively large landscape to continue to interact upon.
>
> I saw your question in which you were concerned that the entire central herd of Yellowstone bison may have been removed during the past winter operations period in which we culled 786 bison and the tribal and state hunters harvested over 400 bison outside the park on both the north and west boundaries. The answer to your question is in my 4 April reply to your original inquiry. I noted that a portion of the central herd is known to migrate to the northern range during the winter. We know that from monitoring a set of radio marked individuals within that herd unit. By monitoring those radio marked

> bison we know that since a portion of those animals are still alive, we predict that the winter operations actions did not remove every single central herd animal. Additionally, throughout this past winter we observed a portion of the central range bison occupying the interior ranges of the Hayden Valley and the Firehole Geyser Basin. This portion of the central herd followed a long standing tradition of remaining on interior ranges until early spring when they migrate to the Gallatin National Forest near the Horse Butte Peninsula.
>
> Additionally, I noted that we conduct periodic flights to document distribution of the bison and also conduct a count in the summer to estimate abundance of bison occupying the breeding areas during June, July and sometimes in August. This summer aerial survey is when we will be able to estimate the effects that our past winter operations actions had upon each sub population unit of the Yellowstone bison.
>
> The park is now open for vehicular travel through out most of the areas where bison are distributed. Please come visit Yellowstone and observe how widespread the Yellowstone bison are found upon the National Park landscape. In recent years the state of Montana has evaluated the advantages of having wild bison occupy areas outside the National Park as an attraction for the tourist industry and to protect a very small portion of our natural heritage the way the National Park Service does within Yellowstone National Park. Montana now allows some bison on some habitat outside the National Park year around. I appreciate your concern for the well being of the central herd of bison within and adjacent to Yellowstone National Park. I can assure you at this time there are still bison occupying the central ranges of the Park and contributing their ecological significance to the dynamic nature of greater Yellowstone.
>
> Have a most excellent day Mr. Horsley.

Stating that “By monitoring those radio marked bison we know that since a portion of those animals are still alive, we predict that the winter operations actions did not remove every single central herd animal” only confirms that Yellowstone’s biologists are in agreement with continuing management actions, such as large-scale culling, that decreases the central herd’s population to such low levels that there is the real risk of indeed of removing “every single central herd animal.” This is acknowledging that present lethal removal actions that put the central herd at risk of extinction is acceptable to these biologists. They refuse to blow the whistle to stop them.

Further, one can only conclude from Wallen’s remarks that park biologists and wildlife managers have no way to track which bison are from which herd prior to culling. Thus, the Interagency Bison Management Plan is out of control in administering its culling operations and suffers from inadequate existing regulatory mechanism in determining herd membership of bison selected for culling and in controlling disproportionate and large-scale culling. While stating the need to keep the herds balanced in number, the present policy of only considering the fluctuations of total numbers of bison in the park, as Figures 5 and 6 above show, is driving the central herd's population precipitously down a path to inevitable extinction, which could occur due to culling in early 2018.

Taking up Wallen's suggestion to contact the state of Montana regarding questions 4 and 5 above, I emailed Andrea Jones, information and education manager, Montana Fish, Wildlife & Parks, region 3, Bozeman. Her answers April 17, 2017, in italics follow my questions:

> I am forwarding an email to Rick Wallen in which he recommends that I contact the state of Montana with regard to an answer for question 5: "Would elk that inhabit the same region as the Northern and Central bison herds be culled if their herd densities were determined a.) to be too high to be sustainable or b.) that they posed a threat of brucellosis transmission to cattle?"
>
> *Much of what you're getting at in terms of Montana's management of elk in areas with brucellosis is addressed in the "Elk Management in Areas with Brucellosis 2017 Work Plan" adopted by Montana's Fish and Wildlife Commission in October 2016. Please see the attached work plan. The plan is designed essentially to limit the comingling of elk and cattle, not to limit population, so the answer to your question 5 (a) is no. As to 5 (b), As per the plan, the state may implement limited elk management removals using hunters to address the concern of comingling. In those cases not more than 25 elk may be taken in a district, and not more than 10 in a given hunt.*
>
> Also I would like your answer to question 4: "How many elk during winter 2016-2017, which also have the potential of carrying brucellosis, migrated to the same region from which bison are culled, essentially Zones 1 and 2, Gardiner Basin?"
>
> *I think Mr. Wallen gets at this in his answer and we wouldn't have anything to add. However, I am attaching the recent winter survey of the Northern Yellowstone Elk herd.*

The referenced document, the "2016-2017 Winter Count of Northern Yellowstone Elk by the Northern Yellowstone Cooperative Wildlife Working Group," was an aerial survey conducted January 15, 2017, by staff from the Montana Department of Fish, Wildlife & Parks and the National Park Service. The survey disclosed that:

> Staff counted 5,349 elk, including 573 elk (11%) inside Yellowstone National Park and 4,776 elk (89%) north of the park. Survey conditions were favorable across the region. The 2017 count was 9% higher than the 2016 survey results of 4,912 elk, and was 37% higher than the lowest count of 3,915 elk in 2013. This year's count of 5,349 was the highest since 6,037 elk were counted in 2010.

The other referenced document, "Elk Management in Areas with Brucellosis 2017 Work Plan," concerning various adopted actions, noted:

> Fundamentally these are meant to reduce the risk of brucellosis transmission from elk to cattle in a manner that maintains elk on the landscape. Given the risk of transmission in areas where elk have tested positive for exposure to brucellosis (seropositive) is associated with proximity of elk to cattle, these actions are designed to adjust local elk distribution away from cattle at small geographic scales.

Further, the document stated:

> The total elk lethally removed by EMRs [Elk Management Removals] and kill permits (see below) shall not exceed 250 elk across the entire DSA [brucellosis Designated Surveillance Area, namely, the northern portion of the Greater Yellowstone Ecosystem] and not more than 25 elk may be taken by EMRs and kill permits in individual hunting districts identified as being below management objective in the most recent FWP survey efforts. Recent elk surveys reveal not less than 24,000 elk directly observed within the DSA.

According to the document, the elk management plan is designed to "identify and minimize risky elk concentrations." It provides for hazing and the use of fencing to control elk movements, but stipulates that "Any such fencing project may be only in those areas of the DSA with a history of repeat livestock infections." Unlike the bison management plan, the elk management plan forbids lethal removals for population control, stating that "EMRs will be used to adjust elk distribution and not for population control." It states that the "DoL [Montana Department of Livestock] has no authority to prescribe wildlife management actions" (Andrea Jones, personal communication, April 17, 2017).

On April 20, 2017 I again wrote Andrea Jones:

> Thanks for your reply. An obvious question arises. If the state of Montana's elk plan is designed essentially to limit the comingling of elk and cattle, not to limit population, as a means of mitigating brucellosis transmission, then why is Montana limiting population in wild bison?

I received an answer April 25, 2017 from Sam Sheppard, MFWP regional supervisor:

> Your most recent question to my understanding is as follows.
>
> "If the state of Montana's elk plan is designed essentially to limit the comingling of elk and cattle, not to limit population, as a means of mitigating brucellosis transmission, then why is Montana limiting population in wild bison?"
>
> You also referenced Montana's elk plan is designed to limit the comingling of elk and cattle. Under the brucellosis response in elk you are correct. It should also be noted that we have and utilize the exact same tool and concept with regards to bison management under the IBMP. Montana does in fact however manage elk populations across the entire state as outlined in our statewide elk management plan which is different than the brucellosis management plan. We also utilize the same set of other tools such as response to game damage, shoulder season and kill permits for elk and deer populations throughout the state (Sam Sheppard, personal communication, April 25, 2017).

Indeed, Montana's "statewide elk management plan" "is different than the brucellosis management plan" administered by the IBMP. The lethal removals under the elk management plan are radically lower in magnitude than the bison plan. For the northern sector of the Greater Yellowstone Ecosystem, per 5,000 wild bison, lethal removals are authorized for up to 1,300 and sometimes beyond, a ratio of about one bison out of every four animals, while for elk per 24,000 animals, not more than 250 may be lethally removed, a ratio of about one elk for every 100.

Wildlife managers have failed us, the public. They have not followed their own recommendations to limit culling of bison to calves, to avoid large-scale culling and to keep the populations of the two herds the same. Further, elk get preferential treatment when it comes to their management.

Like other recommendations, the stated goal by White and Wallen of keeping herds equal in size was never put into action despite the abundant and clear evidence that the herds were diverging beginning with the massive culling of the herds in 2006 until by 2016 the northern herd at 3,627 was almost three times the size of the central herd at 1,283—and now almost five times the size.

How did this statistical somersault occur? Starting about a decade ago, the central herd has been more heavily culled than the northern herd, because the central herd is more migratory.

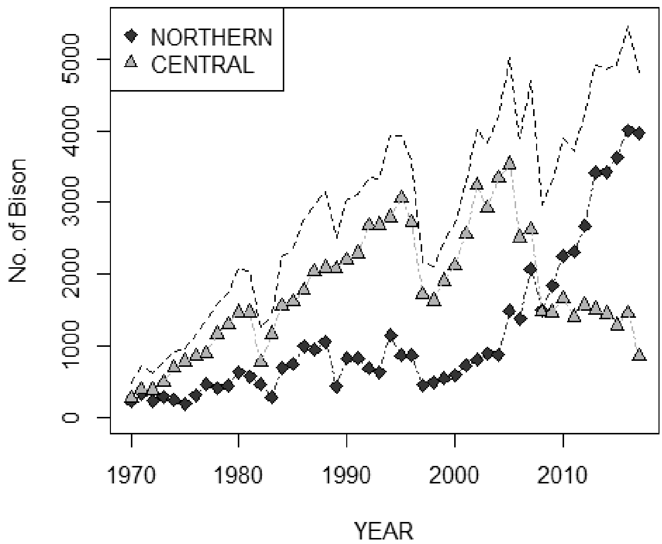
Instead of following the precepts of adaptive management and changing course, the recommendation was made to cull up to 1,500 animals, settling on a goal of 1,300 animals for the winter of 2016-2017, a goal that was met with the culling of 1,302, according to figures supplied by the Buffalo Field Campaign.

If this is adaptive management it is adaptive to only one thing: the desire of the IBMP members, in particular the Montana Department of Livestock and the National Park Service, to stop the migration of wild bison.

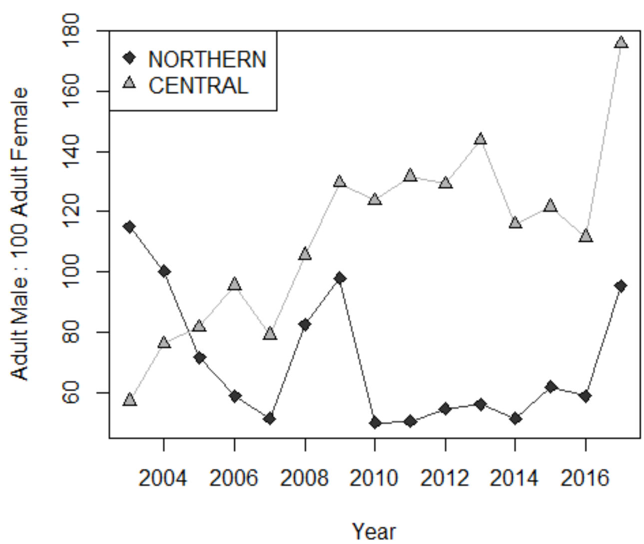
The mystery of why the Yellowstone herd is stable and at times increasing despite large-scale culling has been solved. In the artificial world created at the borders of the park, those that do not enter Zone 1, the killing fields of the Gardiner Basin, are the ones that survive. Those that stay behind, the less migratory, are those from the northern herd—the introduced herd. They are the survivors. It is the central herd, the more migratory, that is absorbing most of the destruction caused by the disproportionate culling of the IBMP. And it is this herd that is composed of the remnants of the herd that was not extirpated. The IBMP is driving into extinction America's last truly wild bison. And they do it in concert with all those who have been assigned to protect this iconic herd: officials of Yellowstone National Park; the National Park Service; Montana Fish, Wildlife and Parks; the U.S. Forest Service; the U.S. Fish and Wildlife Service, as well as various representatives of Indian tribes. The irrational or dysfunctional decision-making outcomes of this group are a result of obsessive conformity to a hidden agenda—cattle in an ecosystem at any cost: groupthink. Adaptive management in Yellowstone had been turned on its head and now stands as maladaptive mismanagement. It will go down in history as one of ecology's greatest tragedies.

When viewed against the extinction-level culling going on at the borders of Yellowstone, park biologists' claim that "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" is just talk, talk without meaning.

And when these same biologists claim that they want to keep the herds equal in size, it is even more talk. They provide the evidence of the divergence of the two herds themselves with their reports, such as the one compiled by Geremia, Wallen, and White's "Status Report on the Yellowstone Bison Population, September 2017." The report graphically represents the divergence of the herds over the years as shown by Figure 20.



Figures 20. WIDELY DIVERGING population numbers (above) are evident from the annual maximum counts of bison observed in the central and northern regions of Yellowstone National Park during June 1-August 31 from 1970-2017, as well as numbers of bison in sex categories (below) determined from summer aerial and ground surveys (Geremia et al., 2017).



Yet, given the facts, the park's biologists do not act to cure the imbalance of the two herds created solely by disproportionate culling. They know it is happening, but pay no attention to the figures they generate.

8

Bayes' law rules Yellowstone

When it comes to the conservation of wild bison and the mitigation of brucellosis in the Greater Yellowstone Ecosystem, to manage or not to manage that population is the question. A number of alternatives have been studied and implemented over the years. Have they worked to meet established goals? Can they work as presently being carried out? What, indeed, are those goals and how realistic are they? These questions have been asked in a number of studies, many analyzed in this petition.

A seminal work on this issue is by a team of researchers led by N. Thompson Hobbs, senior research scientist at the Natural Resource Ecology Laboratory and professor in the Department of Ecosystem Science and Sustainability at Colorado State University. Hobbs received support from the National Park Service (Rocky Mountains Cooperative Ecosystems Studies), the Yellowstone Park Foundation, the National Science Foundation, and the National Socio-Environmental Synthesis Center.

Hobbs' team also includes National Park Service colleagues Geremia, White, Wallen and J.J. Treanor; as well as Jack C. Rhyan, U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Veterinary Services, National Wildlife Research Center, Colorado; and Mevin B. Hooten, U.S. Geological Survey, Colorado Cooperative Fish and Wildlife Research Unit, Department of Fish, Wildlife, and Conservation Biology, and Department of Statistics, Colorado State University.

In "State-space modeling to support management of brucellosis in the Yellowstone bison population," published 2015 by *Ecological Monographs,* they outlined the need for the study:

> The proximity of bison to livestock creates risk of meaningful economic harm to human livelihoods (Bidwell 2010). Thus, brucellosis in the Yellowstone

> bison is an issue in wildlife policy of national importance (Cheville et al. 1998, Olsen 2010). Management actions are needed to mitigate the risk of disease transmission from bison to livestock (Bidwell 2010).

It is an accurate statement that the "proximity of bison to livestock creates risk of meaningful economic harm to human livelihoods." Because this proximity promotes the transmission of brucellosis from wild ungulates in the park to cattle just outside it, that risk affects the livelihoods of ranchers, members of American Indian tribes, hunters, conservationists and those serving park visitors. It is not only the "human livelihoods" of ranchers, who want fewer bison on public landscapes, but also the livelihoods of those sectors of the public who want more wild bison on the landscape. Tribal groups have questioned the need for a cap on the park's bison population and the need for lethal removals by the government. But currently, it appears that in the GYE the rights of ranchers trump the rights of tribes, which is unfair, especially when the culture of tribes has historically depended on wild bison.

It is an accurate statement that "management actions are needed to mitigate the risk of disease transmission from bison to livestock," but what needs management: bison, elk or cattle? They all can be vectors of brucellosis. Millions of dollars are at risk if the disease spills over into cattle herds state-wide and nationally.

The study is pivotal in that it has been used to support the present management of Yellowstone's wild bison herds. The study claims:

> The model we describe here is now being used by Yellowstone National Park to support management of brucellosis in bison. Model results were instrumental in informing the decision to forgo implementing a parkwide vaccination program. The low probability of success in reducing brucellosis infection and transmission through vaccination, once uncertainties were considered, was a key factor in this decision (National Park Service and Montana Fish, Wildlife and Parks 2013, National Park Service 2014). A companion state-space model is used to develop annual harvest recommendations and migration forecasts for Yellowstone bison (Geremia et al. 2011, 2014a, b). Using these models to inform adaptive management engages decision makers and stakeholders in an informed conversation, allowing them to consider the consequences of alternative actions with honest assessments of uncertainty.

Unfortunately, models used to inform adaptive management of the consequences of their actions are often ignored. For example, the Hobbs et al. study outlines the problems posed by putting domestic animals near wildlife conservation habitats. It observes:

> Managing the Yellowstone bison is emblematic of a global challenge in species conservation. A particularly important problem in conserving large mammals worldwide is created by zoonotic diseases transmitted between wildlife, livestock, and people. These diseases isolate conservation areas from the surrounding, human dominated landscape because managers and policy makers often seek to minimize contact between wildlife and the domestic animals that inhabit lands along protected-area boundaries (Newmark 2008). This problem is particularly acute when a disease has been eradicated in domestic livestock because a single transmission from wildlife to livestock can reverse years of expensive effort, harming public health and human livelihoods (Gortazar et al. 2006). As a result, there is often intense political pressure to assure that wildlife hosts are confined to protected areas, confinement that may impede the ability of wildlife to find the habitat needed to meet their seasonally changing requirements. This is the case for many species of ungulates because protected areas often fail to include their complete migratory range.

To conserve biological diversity, the Hobbs et al. study points out that effective management of large migratory ungulates, such as bison, must allow migration beyond the boundaries of protected areas, such as parks:

> Establishing protected areas has been a mainstay of efforts to conserve biological diversity worldwide. This strategy can be successful for sedentary species or species with ranges of movement that are contained within protected-area boundaries. However, the areas of landscapes used by large, migratory mammals often vastly exceed the dimensions of parks and conservation reserves, even the largest ones (Berger 2004, Bolger et al. 2008). There is growing recognition that although protected areas contribute an important component of efforts to conserve the world's biological diversity, they cannot be the sole route to conserving all species (Thirgood et al. 2004, Bolger et al. 2008, Newmark 2008, Craigie et al. 2010), particularly large, migratory species. Instead, effective conservation must work to maintain landscapes that allow migrations to occur (Berger 2004), which requires managing conflict between wildlife and people.

According to Hobbs et al., to assure conservation of wild bison, a computerized probability analysis based on Bayes' Theorem would be an ideal way to model alternatives for managing conflicts resulting from disease transmission due to migration:

> Managing the risk of transmission of disease from migratory wildlife to livestock requires a clear understanding of the process of transmission and a way to evaluate alternatives for management. However, even the best, most

comprehensive data, hard won by monitoring and research, cannot provide the understanding needed for managing that risk without a framework for modeling and forecasting. We show how a Bayesian state-space model can provide that framework for a species that is iconic for efforts to conserve large mammals in North America.

Figure 21. THOMAS BAYES. Portrait identified as Thomas Bayes (1702-1761), an English statistician, philosopher and Presbyterian minister who formulated a probability theorem that bears his name: Bayes' theorem, also known as Bayes' law or rule. Bayes' mathematical notes were edited and published after his death by Richard Price in 1763 under the title "An Essay towards solving a Problem in the Doctrine of Chances" in *Philosophical Transactions*. *(Art in the public domain.)*

The objectives of the study:

> were to enhance understanding of the role of brucellosis in shaping bison population dynamics and to provide a basis for forecasting the outcomes of alternative management actions.

In this study, Bayesian models were employed to predict what actions would be the best to take based on past and new information:

> Yellowstone National Park has embarked on a program of adaptive management of the Yellowstone bison. Adaptive management as it was originally formulated requires a model that assimilates past data to support forecasts of the future behavior of the system being managed (Walters 1986). Bayesian state-space models offer a particularly useful framework for supporting management decisions because they can exploit multiple sources of data, account for multiple sources of uncertainty, and provide honest forecasts. They provide a coherent framework for continuously updating current

> knowledge with new information, the hallmark of adaptive management. Here, we describe a Bayesian state-space model of disease transmission in the bison population of the Greater Yellowstone Ecosystem, USA, that assimilates data from multiple sources to evaluate alternatives for adaptive management.

Forty years of data were used to estimate future bison population states so as to forecast the outcome of employing various possible ways of controlling brucellosis, concluding with what the results of the study might mean for managing park bison in the future:

> We begin with a description of the data that have accrued from population monitoring and designed research studies of bison in Yellowstone during the past four decades. We then outline a Bayesian hierarchical model used to estimate parameters and population states, including future states. We use the model to forecast the effects of different alternatives for managing brucellosis to illustrate how models like ours can be used to support decisions and policy. We close by discussing the implications of our findings for managing bison in Yellowstone . . .

Just what is a "Bayesian state-space model of disease transmission"? While touched on earlier, because of its importance to its application to bison management at the park, the concept will be looked at briefly in more detail. At a basic level, in science, a model is a representation of an idea, an object, a process or a system that is used to describe and explain phenomena that cannot be experienced directly.

What can not be experienced directly in the case of the park's bison is the state in totality of each animal past, present and future, such as knowing for every member its sex, age and location, and whether it is diseased. Because such data can not be completely acquired for an entire population, samples are taken that hopefully are representative of the characteristics being analyzed. Knowing the characteristics of a sample enables the calculation of the characteristics of the entire population, such as the percentage of juveniles or adult males or females. Once that is known, the influence on such a population by altering it, such as by culling, can be calculated by means of probability analysis to predict its future state, such as a population reduction or increase of the total herd or by age groups.

As mentioned, a "state-space" is the set of all possible states of a dynamical or changing system, such as the total number of bison. This can be represented graphically in a state-space model where each coordinate is a state variable, and the values of all the state variables completely describe the state of the system. A "state–space model" predicts the future state of a system from its previous states, such as a change in a value over time. "Bayesian" refers to the use of Bayes' rule to accomplish this, using probability theory and statistics. Bayes' rule describes the probability of an event, based on prior knowledge of conditions that might be related to the event. Prior knowledge or data is often just called "priors" and the prediction generated is called “posterior probability,” that is, the statistical probability that a hypothesis is true—such as culling a certain number of bison will reduce the transmission of brucellosis by a certain percentage—calculated in the light of relevant observations.

In this study, the priors (the collected data), included:

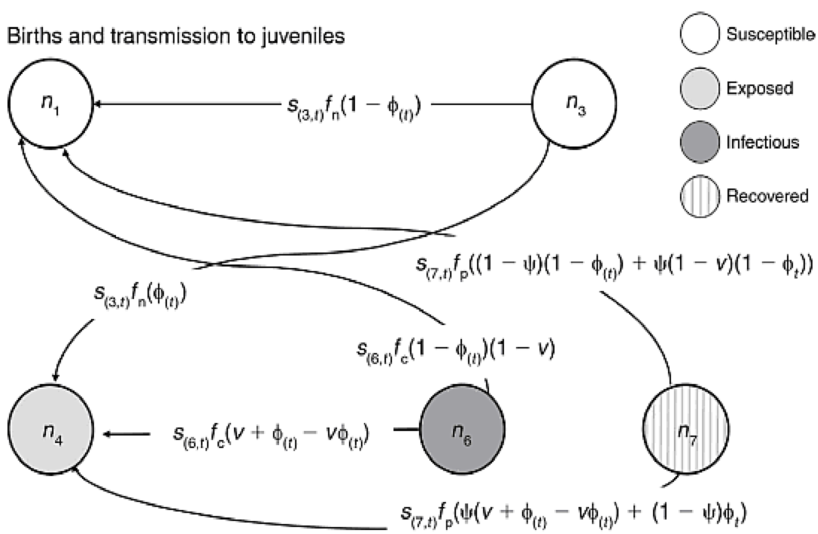
> (1) aerial counts, (2) aerial classifications of juveniles and adults, (3) ground classification of adult and yearling males, yearling females, and adult females, (4) seroprevalence of juvenile, yearling, and adult females, (5) a capture history of disease status of yearling and adult females, (6) observations of the number of animals annually removed from the population, and (7) the age, sex, and serology of removals.

The probability calculations associated with Bayesian statistics are complex. Using Bayesian analysis has garnered those ecologists who employ it an almost magical quality as they pull answers from their Bayesian hats. For illustrative purposes, here is an example of a probability equation concerning infection in Yellowstone bison contained in the Hobbs et al. paper:

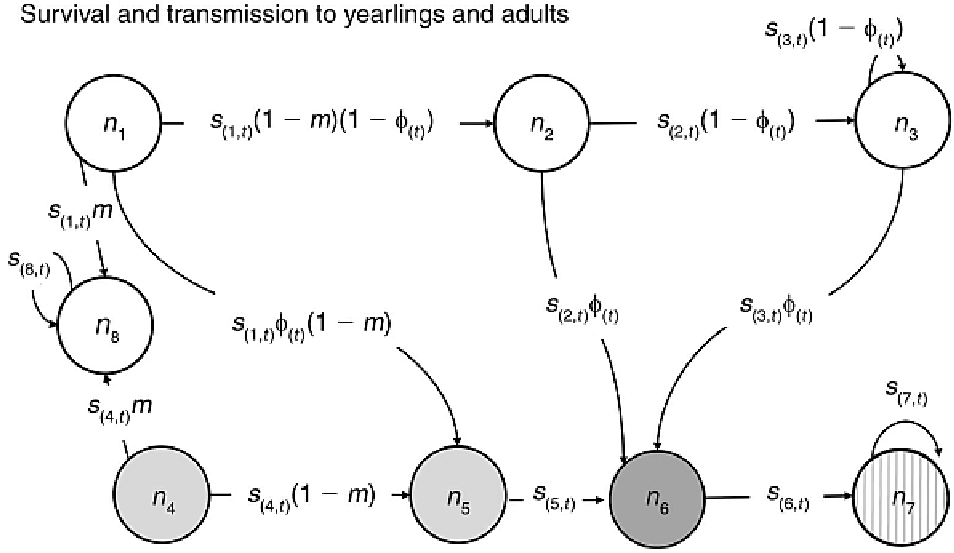
$$\phi_{(t)} = 1 - \exp\left(\frac{-\beta\left(s_{(6,t)}n_{(6,t-1)} + \psi s_{(7,t)}n_{(7,t-1)}\right)\Delta t}{\left((1-m)\sum_{i\in\{1,4\}} s_{(i,t)}n_{(i,t-1)} + \sum_{i\in\{2,3,5,6,7\}} s_{(i,t)}n_{(i,t-1)}\right)^{z}}\right)$$

Figure 22. *From Hobbs et al., 2015, p. 532.*

And here is a graphic representation of modeling bison population dynamics:



Survival and transmission to yearlings and adults



And here is the caption that explains it all:

FIG. 2. Model of brucellosis transmission in the Yellowstone bison population. Elements of the state vector $\mathbf{n}_{(t)}$ are defined in Table 2. Parameters are: f_n, number of juveniles recruited per seronegative adult female; f_p, number of juveniles recruited per seropositive adult female; f_c, number of juveniles recruited per seroconverting (infectious) adult female; ψ, proportion of recovered population that is infectious; v, probability of vertical transmission; $\phi_{(t)}$, probability that a susceptible female becomes exposed during $t - 1 \rightarrow t$; and m, proportion of juveniles surviving to becomes yearling males. The survival probability $s_{(i,t)}$ reflects natural mortality and management removals 3. Survival in the absence of removals is p_1 for juveniles, p_2 for yearling and adult females, and p_3 for yearling and adult males. We estimate $\phi_{(t)}$ at each time step using Eq. 4, and $s_{(i,t)}$ using Eq. 3 as described in the section *Process model*. The dependence of $\phi_{(t)}$ on $\mathbf{n}_{(t)}$ means that the model is nonlinear. See Appendix D for the projection matrix.

Figure 23. [FIG 2 in original document]. ***From Hobbs et al., 2015, p. 531***

Figures 22 and 23 and the caption are shown to demonstrate the complexity of the mathematical models being used by the authors of this paper. Hobbs and Wooten, contributing authors of the study, are also the co-authors of *Bayesian Models: A Statistical Primer for Ecologists*. They observed in the primer that such probabilistic models used to forecast future events or states had a chance to mislead if in the wrong hands. They wrote:

> It is a common concern that if Bayesian models fell into the wrong hands, they could be misused by those seeking to mislead science or policy. However, even under such dubious circumstances, the priors would have to be clearly spelled out in any scientific communication and would be scrutinized just as any other scientific finding is scrutinized during peer review. Furthermore, those with villainous intentions have much easier ways to mislead science or the general public, for example, by outright fabrication of scientific studies. We feel that carelessness by well-intentioned scientists (in the field, in the lab, or in specifying inappropriate likelihoods or priors) is probably a much more common cause of erroneous inference than is mischief (p. 103).

Underscoring the complexity of the modeling process, they further noted in the primer's "Afterword" that:

> We recently submitted a paper reporting a Bayesian analysis of population dynamics to a well-known ecological journal. We discussed the paper with the editor, who remarked it was challenging to find reviewers qualified to evaluate this type of work (p. 273).

Beyond carelessness and the potential for the outright manipulation of data, the Bayesian approach has another inherent risk. Displaying such equations in a study to an audience not trained in the mathematics of probability is like flashing a badge of authority. Those using the study for support could conceivably convince a public to adopt what they say the study says, regardless of whether that is actually true.

A case in point is how this study itself has been used to justify the present culling levels now being carried out by the Interagency Bison Management Plan members. The study specified four goals:

> The first was to annually reduce the probability of transmission of brucellosis to half of its current value. The second was to reduce seroprevalence in adult females below 40%. The third was to maintain the total number of bison in the population within 3000–3500 animals, the approximate current population size. Finally, managers sought to maintain the sex and age distribution of the population within the range of values that could be reasonably expected for an exponentially growing population with a stable age distribution.

The research group evaluated the probability of obtaining these outcomes under five alternatives for management for up to five years into the future, comparing "no action" to four "take action" alternatives, assuming the "take action" alternatives would target 200 animals annually. The authors commented:

> Our intent was not to explore an exhaustive list of management alternatives, but to generally compare the efficacy of hunting, selective removal, and vaccination for meeting management goals. Population size can be controlled using a combination of out-of-park hunting and boundary removals, as has been shown during the past three decades. Thus, the question posed to managers is whether selective removal and/or vaccination can be used to change the management strategy for the conservation of bison.

Measuring the degree of uncertainty in meeting the goals was a key element of the analysis. The authors noted:

> This process for evaluating alternative actions explicitly incorporates uncertainties in the future state of the population in the presence and absence of management. A useful feature of this approach is that the weight of evidence for taking action diminishes as the uncertainty in forecasts increases.

In an ideal world, there would be no uncertainties. But that, of course, is not realistic. What did the team conclude? That intervention, such as culling, had no better chance to achieve the stated goals than taking no actions whatsoever (called the null hypothesis) when considering uncertainties. The authors stated:

> However, including uncertainty in the ability to implement management by representing stochastic variation in the number of accessible bison dramatically reduced the probability of achieving goals using interventions relative to no action.

In addition, the wild bison herd has a built-in natural immune response that has stabilized, resulting in all outside interventions by humans being ineffective. The message: bison on their own are already doing a good job in controlling disease transmission. The authors point out:

> Brucellosis is a chronic condition of the Yellowstone bison population that appears to have reached a quasisteady state. Estimates of the true serological state of the population showed no temporal trend in any age class during the last two decades (Fig. 10). The median, true percentage of the population of adult females that were infectious remained close to 9.6% for the last 35 years with no directional change over that interval, a finding that resembles the earlier results for the percentage that is infectious (~10%) reported by Dobson and Meagher (1996). For the last three decades, the effective reproductive ratio was slightly above 1.0, suggesting that the disease has reached an approximate equilibrium in the population (Fig. 12A), given the lag time between the time animals are exposed and become infectious. Credible intervals on the annual probability that a susceptible animal becomes infected via horizontal transmission failed to reveal any increasing or decreasing temporal trend during 1975–2010 (Fig. 12B). This endemic equilibrium results from the reduction in transmission from each infectious individual as the proportion of bison that acquire immunological resistance increased over time.

The study demonstrated that large-scale culling has done nothing to achieve the goal of reducing transmission of the disease. Instead of disease transmission being dependent on increasing herd density due to population increase, increased transmission is frequency-dependent, with Hobbs et al. explaining: “The formulation for frequency dependence (i.e., when $z = 1$) implies that the addition of newborn females to the population at the birth pulse does not meaningfully change the probability of transmission." The authors stated:

> This relative stasis in the state of brucellosis infection, and the processes governing it, occurred despite large perturbations to the population. A total of 6810 bison were removed from the population by gather and slaughter during 1985–2010. Some of these annual removals reduced the population dramatically (e.g., by 31% in 1997, 21% in 2006, and 39% in 2008). If transmission depended on density, we would expect removals of this magnitude to substantially reduce the probability of horizontal transmission, which we did not observe in the data (Fig. 12). Sixty-six percent of females removed were seropositive, a fraction that did not differ from the serological composition of the population of females (Fig. 10B). Thus, it is likely that removals failed to cause substantial reductions in the proportion of the population that was infectious, and consequently, we would not expect marked changes in probability of frequency dependent transmission or changes in the proportion of the population that was seropositive in response to removals. It follows that the pattern of removals and the relative stasis in brucellosis stages and processes is more consistent with a frequency-dependent mechanism of transmission than a density-dependent one.

In other words, the increasing size of the herd does not contribute to greater disease transmission rates, diminishing the rationale for limiting herd size by culling to reduce density created by more numbers of bison. The authors noted:

> This inference is reinforced by model selection that provided reasonable evidence for frequency-dependent transmission of brucellosis in the Yellowstone bison population relative to the other transmission models (section *Model evaluation and selection*), a finding consistent with observations of bison social behavior and patterns of movement. Bison aggregate in large herds during the calving season when transmission occurs, and the density of these groups does not appear to increase with population size, a requirement for density-dependent transmission. The hallmark of frequency dependence is that population density does not increase as population size increases, allowing contact rates to depend on the proportion of the population that is infectious rather than the number of infectious individuals in the population. We would expect frequency dependence to prevail if the area used by the population expands as the population size increases, allowing density to remain constant. There is ample evidence that bison expanded the area of habitat used after 1975 (Gates et al. 2005, Bruggeman et al. 2006, Plumb et al. 2009).

While density due to increased population size does not contribute to an upswing in disease transmission for wild bison because herd members spread out as the population increases, density due to compacting, such as by hindering migrations, produces an uptick. The authors conclude:

> Moreover, when wildlife movements are compressed, crowding of hosts within protected areas can accelerate disease transmission (Lebarbenchon et al. 2006), and in so doing, amplify the risk of transmission to nearby populations of livestock.

The cited paper by Camile Lebarbenchon et al. titled “Parasitological Consequences of Overcrowding in Protected Areas,” explains this phenomenon:

> The local increase in the number of hosts can have dramatic consequences for the spread of parasites in the whole population (Scott, 1988; Ezenwa, 2004). Both theoretical arguments (Anderson and May, 1978; Roberts et al., 2002) and empirical evidence (Arneberg et al., 1998; Morand and Poulin, 1998; Arneberg, 2001; Nunn et al., 2003) are in total agreement: local host density is a major determinant of infection levels and the number of parasite species supported by a host population. In addition, as illustrated by recent mathematical developments (Hochberg et al., 2000), demographic differences across geographical landscapes can produce selection mosaics in interacting species, with virulent parasites being most likely to be found in habitats where host population density is the highest. As long as protected areas remain synonymous with high animal concentrations, their potential role in amplifying pathogen demography will persist.

What does this mean regarding future management? According to Hobbs et al:

> It follows that a key to management of brucellosis in bison is to choose goals and actions that reduce the risk of undesirable outcomes, particularly in transmission to livestock on lands surrounding the park, rather than attempting to achieve goals that are simply not attainable. Separation of bison and livestock outside of Yellowstone through fencing and intensive hazing of bison has been 100% successful at preventing spillover of brucellosis from bison to cattle (White et al. 2011).

Follow the line of reasoning developed by the study. 1. In an honest evaluation of the possibility of reaching stated goals, such as reducing the level of brucellosis in wild bison and the probability of disease transmission, an analysis shows that due to uncertainties there is no difference in intervention actions such as culling and not culling. 2. Culling does not reduce the level of brucellosis in the herd. 3. Culling to reduce herd numbers does not reduce the probability of transmission of brucellosis. 4. Nor is vaccinating bison efficacious. 5. In fact, not allowing dispersal crowds animals, which can "accelerate disease transmission."

Conclusion: neither culling nor vaccination is necessary, and prohibiting migration can increase disease transmission.

What is efficacious in preventing the spread of brucellosis from bison to cattle? Fencing and hazing (but not culling). One-hundred percent.

But how are these findings coordinated with other studies and implemented? In the study's conclusion the authors state:

> A companion state-space model is used to develop annual harvest recommendations and migration forecasts for Yellowstone bison (Geremia et al. 2011, 2014a, b). Using these models to inform adaptive management engages decision makers and stakeholders in an informed conversation, allowing them to consider the consequences of alternative actions with honest assessments of uncertainty.

The "companion state-space model" is:

- Geremia, C., P. J. White, R. L. Wallen, F. G. R. Watson, J. J. Treanor, J. Borkowski, C. S. Potter, and R. L. Crabtree. 2011. Predicting bison migration out of Yellowstone National Park using Bayesian models. PLoS ONE 6(2):e16848.

The "annual harvest recommendations and migration forecasts for Yellowstone bison" developed from these models are the following references:

- Geremia, C., R. Wallen, P. J. White, and F. Watson. 2014a. Spatial distribution of Yellowstone bison—winter 2015. Technical report. National Park Service, Yellowstone National Park, Mammoth, Wyoming, USA. http://www.ibmp. info/Library/OpsPlans/BisonSpatialDistributions_Final_ Winter2015.pdf

- Geremia, C., P. J. White, and R. Wallen. 2014b. Population dynamics and adaptive management of Yellowstone bison. Technical report. National Park Service, Yellowstone National Park, Mammoth, Wyoming, USA. Available at ibmp.info

The Geremia et al. model found that the only way to reduce harmful large-scale culling was to let wild bison migrate beyond the park's borders. Researchers Geremia, White, Wallen and colleagues noted in the study's discussion of "Predicting Bison Migration out of Yellowstone National Park Using Bayesian Models" that even if the population is kept within the population range of 2,500 to 4,500 animals, the number of bison migrating out of the park will fluctuate dramatically—between a few individuals to thousands, depending on weather conditions:

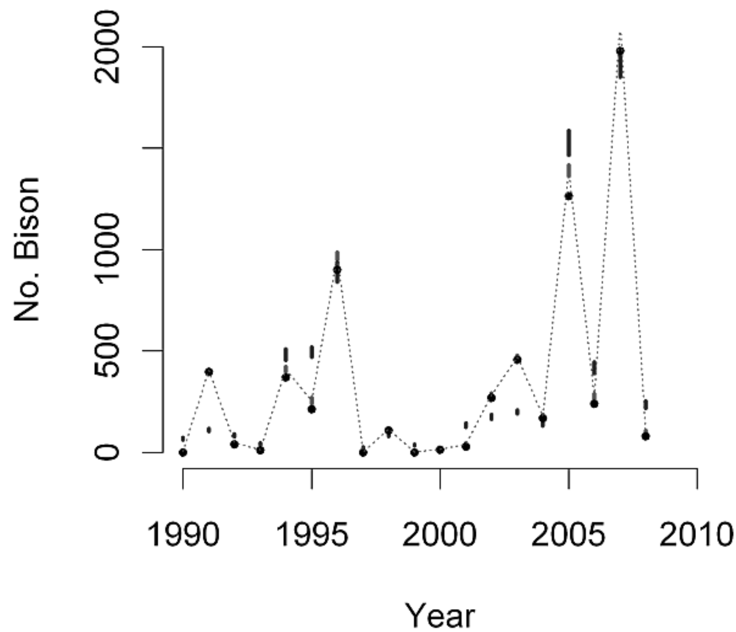
> We showed that migrations are predictable, but the magnitudes of migrations are highly influenced by uncontrollable variables such as snow pack severity and plant production. When accumulated SWE is 150% of the 20-year average, aboveground dry biomass is 50% of the 20-year average, and there are 2,500 bison (1,250 central and 1,250 northern) in the population, we predict a 95% probability (e.g. chance) of [less than or equal to] 1,135 animals migrating beyond the northern and [less than or equal to] 300 animals migrating beyond the western park boundaries. Density exacerbates movements and under similar severe climate conditions and 4,500 (2,500 central and 2,000 northern) bison in the population, we predict a 95% chance of [greater than or equal to] 1,820 animals exiting the north boundary. Dramatically fewer bison migrate under more moderate climate conditions even when there are 4,500 bison due to the logistic form of the migration response (Table 2). Thus, potential migrations range from few individuals to thousands of bison in any year when the population is within the recommended range of 2,500–4,500 animals.

The researchers summed up their findings in the study's abstract, stating:

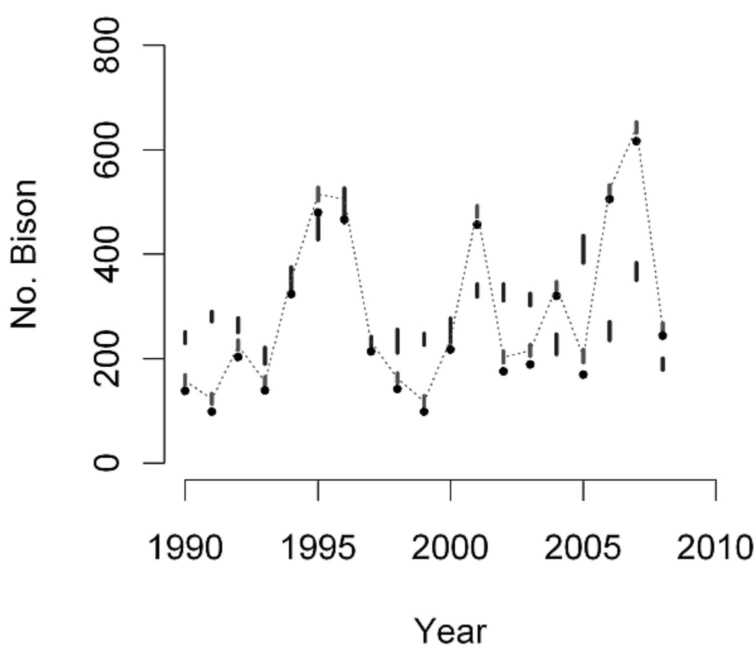
> Simulations of migrations over the next decade suggest that allowing increased numbers of bison beyond park boundaries during severe climate conditions may be the only means of avoiding episodic, large-scale reductions to the Yellowstone bison population in the foreseeable future. This research is an example of how long distance migration dynamics can be incorporated into improved management policies (Geremia, 2011).

More specifically, they noted:

> Yellowstone's restored bison herds have established migratory patterns that lead them to low elevation areas out of the park where they come into conflict with society. Our simulation results suggest scenarios that remove 50% of migrants similar to management policies outlined in the Interagency Bison Management Plan will not prevent future large-scale, recurrent migrations and numbers exiting park boundaries will be much greater than predictions underlying those policies. Thus, limiting bison numbers and 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.



Figures 24-25. BISON MIGRATION NUMBERS FLUCTUATE widely—from a few one year to multiple hundreds the next, as shown by the modified logistic predicted median (dotted lines) and 95% credible intervals (bars) of annual maxima of bison migrating beyond the northern boundary (above) and beyond the western boundary (below) of Yellowstone National Park during 1990–2009 (Geremia, 20111).



The study noted that limiting bison abundance could adversely affect their conservations:

> 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, 2011).

In sum, the Geremia et al. Bayesian analysis coupled with the Hobbs et al. Bayesian analysis found that for wild bison (a.) large scale reductions will not prevent future large-scale migrations out of the park, (b.) allowing large-scale migrations may be the only way of avoiding future large-scale reductions and (c.) limiting bison abundance to lower numbers could hamper the conservation 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, (d.) culling does not decrease brucellosis transmission, but in fact (e.) may amplify disease transmission by preventing dispersal.

Recall Hobbs et al. noted such studies should significantly contribute to adaptive management of park bison. Now recall who is making these observations. Members of Hobbs and Geremia teams include managers and biologists of Yellowstone National Park: Geremia, Treanor, White and Wallen. These managers are abundantly aware that the policies they are helping to execute are exacerbating the brucellosis load in the park. They know that crowding promotes disease and that stopping dispersal increases crowding. They cited the Le Lebarbenchon et al. paper that demonstrates this. They know that the northern herd is less migratory than the central herd and that the northern herd is increasing in population while the central herd is decreasing, stagnating movement. Some even helped compile the data that shows this.

So what is the point of reducing the population to 3,000, set as the maximum for the total size of the herds in Yellowstone allowed by the IBMP? There is no point.

Yet knowing this—in fact *intimately* knowing this because those making the recommendations that follow below (Geremia, Wallen and White) were members of the very research teams that produced the findings in support of future management of park bison in the first place—knowing this, what "improved management policies" did the other two reports recommend for the IBMP to follow relative to "long distance migration dynamics"?

Inconceivably, more large-scale culling—up to 900 animals for 2015 and 2016.

"Population dynamics and adaptive management of Yellowstone bison" states:

> We recommend removing 900 bison during the forthcoming winter, including 180 calves, 70 yearling females, 410 adult females, 60 yearling males, and 180 adult males. To reduce abundance and productivity, it is most important to meet the removal objectives for females and calves.

"Spatial distribution of Yellowstone bison—winter 2015" states:

> If weather conditions are approximately average, then sufficient numbers of bison should move to the Park boundary and into Montana to enable the recommended removal of 900 animals, primarily from the Northern Management Area.

These are incomprehensible responses to the studies' findings. These are the "companion pieces" to the studies just cited. These recommendations of large-scale reductions fly in the face of the Bayesian studies recommending against them, yet here they are, the official stance of the IBMP, with these recommendations espoused by members of the team that helped build the Bayesian models. These are "honest assessments"? This is adaptive management? Adaptive to what? This is an amazing disregard for the very research these biologists helped conduct.

For models, such as Bayesian-based models, there are "three fundamental cornerstones: representation, inference, and learning," according to Daphne Koller, Department of Computer Science at Stanford University, and Nir Friedman, Department of Computer Science and Engineering at Hebrew University, writing in the text *Probabilistic Graphical Models: Principles and Techniques* (Koller and Friedman, 2009).

In Bayesian probability, learning and prediction can be seen as forms of inference from data inputted and updated. It is essentially machine-learning. Ironically, Yellowstone biologists are not learning from what their machines are telling them has been learned.

The model used by the Hobbs et al. study could have been more informative if it had included in its parameters the influence on the transmission of disease out of the park to cattle by elk. The Hobbs and Hooten Bayesian primer notes that "Informative priors, when properly justified, can be tremendously useful in Bayesian modeling (and science, in general)" (p. 90), that "Any constraint we put on data or parameters to obtain inference imparts subjectivity" (p. 98) and "Ignoring prior information you have is like selectively throwing away data before an analysis" (p. 99).

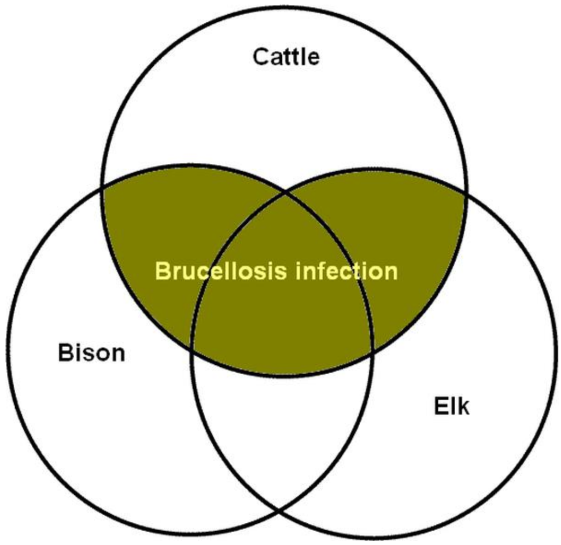


Figure 26. VENN DIAGRAM of the overlapping ranges of cattle, elk and bison in the Yellowstone region. If the spread of disease involves proximity of two wild species and one domestic species, the most feasible method of preventing transmission to the domestic species is to remove the domestic species, instead of the two wild species.

While studying only the intra-species transmission of bison contributes significantly to the body of knowledge regarding the spread of brucellosis out of the park, the issue is not limited to the load of brucellosis in bison alone, but of course also in elk, for it is the transmission of the disease to cattle bordering the park that is the issue, regardless of whether that transmission comes from bison or elk.

Lethally removing bison from the range occupied by cattle does not eliminate the chance of transmitting brucellosis to cattle because elk, also carrying the disease, are still in the picture—and so is brucellosis. This concept is illustrated by the Venn diagram in Figure 26.

Intuitively, including elk parameters would have strengthened the case even more for a finding that culling wild bison in Yellowstone does not contribute to brucellosis mitigation.

The more one studies the pros and cons of allowing migration out of the park, the more one becomes convinced we have nothing to gain by this restriction and everything to lose by such an artificial prohibition. Ecologists are beginning to think twice about the risks associated with migration. In a paper by Alexa Fritzsche McKay and Bethany J. Hoye titled “Are Migratory Animals Superspreaders of Infection?” presented at the annual meeting of the Society for Integrative and Comparative Biology, January 3–7, 2016, Portland, Oregon, and published by Oxford University Press, the authors state:

> Migrations form unique links between disparate locations, involve large numbers of individuals, and may increase parasite exposure through the use of multiple different habitats and increased interspecies interactions. As a result, animal migrations are widely assumed to enhance the cross-species transmission and global spread of parasites.

However, in certain cases the opposite may be the case. Disease acts as a culling agent. McKay and Hoye note:

> Theoretical and empirical work has shown that when infection renders hosts incapable of migrating successfully, this "culling" process reduces transmission potential (Bradley and Altizer 2005; Bartel et al. 2011; Altizer et al. 2015).

Further, discouraging migration causes more disease transmission through prolonged proximity at one locale. The authors noted, regarding monarch butterflies and elk:

> Similarly, increased planting of invasive tropical milkweed in southern regions of the United States has facilitated winter breeding—a more sedentary behavior—in monarch butterflies (Satterfield et al. 2015). Satterfield and colleagues (2016, this issue) show a striking increase in prevalence of the protozoan parasite, *Ophryocytsis elektroscirrha* in year-round breeding monarchs in California, demonstrating the impacts of the loss of migratory behavior for infectious disease dynamics.
>
> Migratory patterns have also shifted in elk, with a reduction in the number of long-distance versus short-distance migrants leading to higher burdens of parasites such as Ixodes ticks (Mysterud et al. 2016). In the western United States, the practice of subsidized feeding grounds for elk not only substantially shortens historical migration distances, but also creates hotspots for transmission of an abortion-inducing pathogen (Brucella abortus) through increased aggregation densities (Merkle et al., unpublished data). Importantly, changes to the local climate, particularly snow cover, interact with the food subsidies to have a profound effect on both animal movements and transmission risk (McKay et al., 2016).

Unwittingly, the Interagency Bison Management Plan may be promoting increasing levels of brucellosis in the Greater Yellowstone Ecosystem. It may be killing only the healthy animals, those that migrate, while concentrating the diseased, those too weak to travel, within the park. A simplistic model illustrates the dynamics. If out of a herd of 1,000 bison, 700 were culled, leaving behind only those that did not migrate—which included the diseased—and if 10 percent of the total herd was diseased, that is, 100, the result would now be 100 infected animals out of 300 remaining. In one year culling has increased the level from 10 percent to 33 percent prevalence. Add to this scenario the potential effect of increasing the proportion of diseased bison at the same location—such as at the park's thermal pools (a wet and warm environment perfect for brucellosis incubation)—by making dispersal lethal more "hotspots" for disease transmission have been created.

But none of these considerations are applied to Yellowstone. As the central bison herd continued to crash, what did wildlife managers recommend for the lethal removal of wild bison for 2017, those recommendations supposedly based on the Bayesian simulation models discussed above and on the biologists' touted policy of "adaptive management," that is, making "honest assessments" of new information and acting on those facts?

Being that the prior years had not resulted in meeting the goal of culling 900 animals annually, they recommended catching up by culling 1,300 wild bison for 2017, unwilling to heed the very studies they helped write which generated evidence against culling. They met their goal. How could these recommendations be made based on the findings of the studies mentioned? The answer is the magic of "adaptive management" in the hands of Yellowstone's biologists. However, studies under adaptive management procedures serve no purpose if the recommendations subsequent to the studies do not correspond to the study's findings, that is, they do not adapt management to new information.

Possibly sensing that their large-scale culling proposal flagrantly violated their studies' findings, what they may have thought was needed was a study from which they could "learn" what they wanted to learn—a rationale for large-scale culling of the migratory.

Following the 2011 study "Predicting Bison Migration out of Yellowstone National Park Using Bayesian Models" and subsequent to its recommended reduced large-scale culling and increased tolerance of migration for bison, another study was made in 2014. It may have served as a green light for the destruction of the central herd.

In "Integrating populations- and individual-level information in a movement model of Yellowstone bison," researchers developed a model that suggested movement out of the park by bison was based on the effects of snow and herd size for the northern herd and learned behavior for the central herd. The authors of this study and their affiliations are: C. Geremia, P.J. White, R.L. Wallen and D. Blanton, Yellowstone Center for Resources, Yellowstone National Park; F.G.R. Watson, Watershed Institute, California State University Monterey Bay, Seaside; and N.T. Hobbs. In the study's abstract they stated the problem—migrating Yellowstone bison:

> Throughout the world, fragmentation of landscapes by human activities has constrained the opportunity for large herbivores to migrate. Conflict between people and wildlife results when migrating animals transmit disease to livestock, damage property, and threaten human safety. Mitigating this conflict requires understanding the forces that shape migration patterns. *Bison Bos bison* migrating from Yellowstone National Park into the state of Montana during winter and spring concern ranchers on lands surrounding the park because bison can transmit brucellosis (*Brucella abortus*) to cattle. Migrations have been constrained, with bison being lethally removed or moved back into the park. We developed a state-space model to support decisions on bison management aimed at mitigating conflict with landowners outside the park. The model integrated recent GPS observations with 22 years (1990-2012) of aerial counts to forecast monthly distributions and identify factors driving migration. 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.

The study stated that it was being conducted to support adaptive management:

> To support adaptive management of Yellowstone bison, we forecast future movements to evaluate alternatives. Our approach of developing models capable of making explicit probabilistic forecasts of large herbivore movements and seasonal distributions is applicable to managing the migratory movements of large herbivores worldwide. These forecasts allow managers to develop and refine strategies in advance, and promote sound decision-making that reduces conflict as migratory animals come into contact with people.

According to the 2014 study:

> The net effect of snow and herd size considerations on northern migration pathways resulted in dramatic year-to-year differences in number of bison moving to the Gardiner basin winter area.

On the other hand, the authors noted:

> We found little net effect of snow and herd size conditions on monthly movement probabilities along central migration pathways. Central herd animals moved to wintering areas that span park boundaries across all observed central herd sizes.

According to the study:

> It is difficult to determine if moving herbivores are responding to food or basing their decisions on experience. We did not directly test whether experience affected movements in our model. GPS histories of central-herd adult female bison indicated that animals increased fidelity to movement patterns with age, which is suggestive of learning. We also found strong year effects on most central Yellowstone migration paths, suggesting that routes become increasingly entrenched over time.

The authors stated:

> Management is further complicated when animals seasonally occupy protected areas such as national parks. These areas serve many purposes, one of which is providing visitors with an opportunity to view wildlife in a natural setting. Management interventions (i.e. culls, harvests, sterilization, contraception) are often limited within these areas, with the unintended consequence of population growth, which increases movement and the chances of episodic reductions outside these protected areas.

The authors concluded:

> Learning and experience may affect movements by allowing a behavior such as the use of migration paths or wintering areas to become increasingly entrenched. If a particular learned behavior increases conflict, it may be reasonable to target animals that exhibit the behavior for removal (Geremia et al., 2014).

In sum, the study contends that the best way to limit movement out of the park is to target the central herd for lethal removal because this herd has learned the way out of the park—in other words, destroy the migratory, regardless of their herd size. It is the herd that is the problem, the migratory herd, the central herd, not the number in that herd. And this gives authority for destruction of the entire herd—the endemic central herd. Why? Because, as the abstract observes:

> *Bison Bos bison* migrating from Yellowstone National Park into the state of Montana during winter and spring concern ranchers on lands surrounding the park because bison can transmit brucellosis (*Brucella abortus*) to cattle.

The study explained in more depth its use of adaptive management protocol:

> Adaptive management is a structured decision-making approach for improving resource management by systematic learning from management actions and

> outcomes (Walters and Holling 1990). It involves the exploration of alternatives for meeting objectives; prediction of outcomes from alternatives using current understanding; implementation of at least one alternative; monitoring of outcomes; and using results to update our knowledge and adjust actions (Williams et al. 2007). Adaptive management provides a framework for decision-making in the face of uncertainty and a formal process for reducing uncertainty to improve management outcomes over time.
>
> White et al (2011) provide an assessment of the Interagency Bison Management Plan indicating that migrations far exceeded expectations of initial models and ~3200 bison were culled during 2001-2011. More than 20% of the population was removed during 2006 and 2008, contributing to a skewed sex ratio, gaps in the population age structure, and reduced productivity, which could threaten the integrity of the population if continued (White et al. 2011). These authors and stakeholders recommended reduced culling of animals at park boundaries and increased tolerance in adjacent areas of the state of Montana to support hunting. Managers agreed to reduce large-scale culls through gather-and-slaughter and requested a predictive model of trans-boundary movements to assess revised management alternatives (Geremia, 2011).

Based on these considerations, the study found that “Supplementing increased numbers of state and tribal hunting permits with moderated late-winter gather-and-consignment (alternative 5) provided the highest certainty of meeting key management criteria over the next five years.” Consignment includes shipment to slaughter, terminal pastures, or research facilities.

As the study outlined, “Managers agreed to reduce large-scale culls through gather-and-slaughter” and the “authors and stakeholders recommended reduced culling of animals at park boundaries and increased tolerance in adjacent areas of the state of Montana to support hunting.”

Somehow, large-scale culling is more justified if done by hunting plus “moderated late-winter gather-and-consignment” and somehow targeting the central herd can be justified because they *might* be migrating because of learned behavior. This new “tolerance” resulted in the lethal removal of 1,300 bison in 2017 as recommended by members of the very study advocating culling target the migratory.

Whether it is learning or seeking forage that causes the dispersal of the central herd, in the name of adaptive management Yellowstone’s biologists can recommend and justify with impunity the lethal removal of 1,300 animals out of a total herd population of 5,500—a recommendation that ended in the culling of almost 50 percent of the park’s endemic subpopulation—because the total herd experienced a decline of only 12 percent.

To develop “a state-space model to support decisions on bison management aimed at mitigating conflict with landowners outside the park,” as the authors of the study state, is biased toward cattle interests, especially when you consider that thousands of bison are killed for the stated benefit of landowners, with the only affected landowners being in the Gardiner Basin. Private herds there number only 87 head (see chapter 13, this petition, first volume).

To launch a lethal removal program that in practice spares the northern herd but targets the central herd is irresponsible wildlife management because it damages the genetic diversity of the entire herd by eliminating the majority of the endemic herd and its rare wood bison haplotypes.

We do not know now, but a haplotype extinction of the wood bison genetic markers that identify an animal as being from the indigenous herd may have already occurred with the 2017 extermination of such a large segment of the central herd's population. The hybrid of wood and plains bison may no longer exist. As it stands, with so few left the herd is now vulnerable to being wiped out by genetic drift or by environmental factors such as disease, severe weather or predation. For those that survived the culling, only testing will reveal if the haplotype specific to wood bison remains in Yellowstone.

What can explain this negligent wildlife management? Apparently, as Hobbs and Hooten expressed in their primer, given the chance, people may use Bayesian models—that is, science, mathematics—to camouflage and promote their own agenda. You might call it the Bayesian bluff. But how can this involve members of Hobbs' and Geremia's own teams? How could this be? What could be the motive here? Why would park wildlife biologists working on the two teams promote not only an anti-wildlife agenda, but one that contradicts the teams' own findings? Why take part in studies if you are going to ignore their findings?

Maybe it is something this simple. In an article about the public resistance to genetically engineered foods (GMOs), despite thousands of studies affirming their safety, *Slate Magazine's* Keith Kloor noted, "most people aren't interested in listening or changing their minds based on the evidence. It's too much of a slog, and it goes against the very human tendency to accept only information that confirms pre-existing beliefs or mindsets" (Kloor, 2017). That this attitude would apply to the media and the public is somewhat understandable. Once outraged by the level of bison culling, now the media and the public wink at it. The massive slaughter of 2017 went largely unnoticed in the press. It has become just too much of a slog to oppose it. But this kind of bias on the part of scientists who are supposed to be objective and devoted to finding the truth? That is disheartening.

Except for a very few, such as those members of the Buffalo Field Campaign, nobody is getting the message. Or if they do get it, they don't want to hear it. Or if they hear it, they do not act. Apparently, facts, even those generated by competent research, do not count in Yellowstone. Adaptive management in the hands of Yellowstone's wildlife managers has become a license to do anything you want. Updating with new information, a hallmark of Bayesian analysis, is routinely disregarded in favor of actions that continue the status quo. Not only is large-scale culling not being reduced, it is getting worse. One-thousand-three-hundred wild bison, most from the central herd—the non-extirpated herd, the only herd that still remains on the land to which it migrated millennia ago—were culled at the beginning of 2017. The central herd numbers are driven down while our wildlife managers watch, pretending they care about the conservation of wild bison, yet orchestrating the herd's destruction. For 2018 these biologists are recommending culling up to 1,250. Recall there are now only 847 bison left in the central herd. All of the central herd could perish in 2018. In Yellowstone, what is being carried out is not adaptive management. It is maladaptive management, management that conforms to bias, not science.

And it is all backed up by Bayes' Law, or rather, the misuse of Bayes' Law. Thomas Bayes, who died in 1761, known for formulating the theorem that bears his name, must be turning over in his grave.

9

Yellowstone's wood and plains bison: Both discrete and significant

Two herds inhabit Yellowstone National Park—the central herd and the northern herd. In past findings by the Fish and Wildlife Service under the provisions of the Endangered Species Act, the two herds were evaluated for protection as though they were a metapopulation, that is, an interacting single herd. The FWS found the herd to be a unique subspecies of bison, the only unfenced, wild bison in the nation that had not been extirpated and that had remained on the same land to which its ancestors had migrated in prehistoric times. In biological jargon such a subspecies is called a "distinct population segment."

This new petition argues that the two herds are *both* distinct population segments.

On August 15, 2007, in response to a petition I submitted February 11, 1999, to list Yellowstone's wild bison as in danger of extinction, the FWS made the following subspecies or DPS determination:

> The Grand Teton National Park/National Elk Refuge bison herd is separate from the YNP herd (Gates et al. 2005, p. 93), and there are less than a dozen other unconfined bison herds in the entire lower 48 States (Gates et al. 2005, p. 2). Therefore, the YNP herd is discrete from other members of the taxon. Recent genetic research confirms that the YNP bison herd is significant because of a lack of nuclear domestic cattle introgression. Although 3 other Federal herds exhibit this characteristic, the YNP bison are the only remnant population that has remained in a wild state since prehistoric times and, therefore, is important to the management of bison genetic diversity. Halbert (2003, pp. 44-45) found only four Federal herds that were sufficiently unique to contribute significantly to overall bison genetic diversity.

> On the basis of the preceding discussion, we believe that there is substantial information to conclude that the YNP bison herd may be discrete and significant within the meaning of our DPS Policy, and therefore may constitute a DPS (see Appendix C, second volume of this petition).

A subsequent DPS determination by the FWS based on two other petitions submitted in 2014 and 2015 made a similar finding in 2016 (see Appendix D second volume of this petition).

Although determined to be a DPS as a single herd, the FWS did not find the combined herd to merit listing as endangered or threatened because it was abundant. However, since 2008 the two herds have diverged in abundance, with the northern herd significantly outnumbering the central herd. This present petition argues that both herds separately merit designation as a DPS, entailing a finding that both the northern and the central herds are discrete and significant.

To determine whether the two populations are distinct population segments, the perspective of looking at the herds as evolutionary significant units may be helpful.

Evolutionary Significant Unit (ESU)

In past petitions evaluating the endangered or threatened status of wild bison in Yellowstone National Park, the biological species concept has been used by the Fish and Wildlife Service. In determining a distinct population segment for listing purposes, the two herds in the park—the introduced northern herd and the endemic central herd—are geographically close enough to theoretically allow interbreeding, that is, gene flow, potentially leading to the classification of the two herds as one. In fact, past evaluators of the relevant petitions have done just this, denying listing the herds in Yellowstone because together they are deemed abundant. However, as time has shown, while the northern herd may be considered abundant, the central herd has significantly declined.

In addition to evaluating the Yellowstone herds as distinct population segments, the Petitioner requests that they also be evaluated as evolutionarily significant units. This has been a concept used to determine the species level of salmon, which share with Yellowstone's bison populations certain characteristics, albiet with different names. Robin S. Waples, National Marine Fisheries Service, in "Evolutionarily Significant Units and the Conservation of Biological Diversity under the Endangered Species Act," describes the application of the ESU to vertebrates other than salmon:

> However, other issues that might appear to be esoteric to salmon have clear analogues in other organisms. For example, the biological consequences of straying in salmon are similar to the consequences of migration or dispersal in other species. Similarly, although run timing is not a concept commonly applied to organisms other than anadromous fish [those migrating up rivers

from the sea to spawn], differences in mating season and other life history traits may be equally important for other vertebrates. More generally, any attempt to define biologically meaningful units for conservation should consider the same types of information identified in the NMFS ESU policy: migration, gene flow, and factors affecting reproduction; physical and ecological features of the habitat; and genetic, phenotypic, and life history characteristics. The basic framework of the ESU concept of NMFS is thus in no way specific to salmon and could be applied to other vertebrates under the ESA.

An evolutionarily significant unit is defined by the NMFS in the following terms:

> A vertebrate population will be considered distinct (and hence a "species") for purposes of conservation under the Act if the population represents an evolutionarily significant unit (ESU) of the biological species. An ESU is a population (or group of populations) that (1) is substantially reproductively isolated from other conspecific population units, and (2) represents an important component in the evolutionary legacy of the species.

Waples explains:

> The evolutionary legacy of a species is the genetic variability that is a product of past evolutionary events and that represents the reservoir upon which future evolutionary potential depends. Some have interpreted this term to mean that NMFS will attempt to determine which populations will play an important role in future evolution of the species. This is not the case; such an attempt would be misguided and probably futile as well. Rather, the intention is to identify the important genetic building blocks of the species as a whole and (because we cannot tell which will be important in the future) conserve as many as possible so that the dynamic process of evolution will not be unduly constrained. In essence, then, the ESU policy of NMFS seeks to implement Aldo Leopold's (1953:147) sage advice:
>
> > To keep every cog and wheel is the first precaution of intelligent tinkering.

What types of evidence should be considered in evaluating each of the two ESU criteria? Waples gives a brief summary:

> Isolation does not have to be absolute, but it must be strong enough to permit evolutionarily important differences to accrue in different population units. Important types of information to consider include movements of tagged fish, natural recolonization rates, measurements of genetic differences between

> populations, and evaluations of the efficacy of natural barriers. Each of these measures has its strengths and limitations. Data from protein electrophoresis or DNA analyses can be particularly useful for evaluation of isolation because they reflect levels of gene flow that have occurred over evolutionary time scales.
>
> The key question with respect to a population's evolutionary legacy is, if the population became extinct, would this represent a significant loss to the ecological-genetic diversity of the species? An affirmative answer would lead to a strong presumption that the unit under consideration is an ESU. Again, a variety of types of information should be considered. Phenotypic and life history traits such as size, fecundity, migration patterns, and age and time of spawning may reflect local adaptations of evolutionary importance, but interpretation of these traits is complicated by their sensitivity to environmental conditions. Data from protein electrophoresis or DNA analyses provide valuable insight into the process of genetic differentiation among populations but little direct information regarding the extent of adaptive genetic differences. Habitat differences suggest the possibility for local adaptations but do not prove that such adaptations exist (Waples, 1995).

Key to preserving the genetic legacy of a species is genetic diversity. Environmental changes, such as culling that significantly reduces populations, defeats this diversity. Joachim Mergeay and Luis Santamaria, writing in "Evolution and Biodiversity: the evolutionary basis of biodiversity and its potential for adaptation to global change," observe:

> For genetic evolution to occur, genetic diversity for ecologically relevant traits is a necessary precondition. The paradox for many species, however, is that they need to adapt fast to a plethora of stressors related to global change while suffering population declines as a consequence of global change itself. Because population declines enhance genetic erosion and drift and constrain adaptive evolution, the conditions for adaptation deteriorate further. To make things worse, inbreeding depression in small populations further reduces fitness (Mergeay, 2012).

To guard against the erosion of the ability to adapt, evaluators of a species' evolutionary components need to look at a population's adaptive characteristic and capacity to evolve. This means to take into consideration the species' genetic history, which must be preserved so that the organism as a species has the "cogs and wheels" necessary to keep ticking into the future. Looked at another way, a species' genetics are like a bank account where deposits have been made over millions of years. If the account is drained, a species has nothing left to survive on.

This petition argues that there are two genetic reservoirs that need to be preserved to retain genetic legacy: the northern herd and the central herd.

Employing the biological species concept here should not defeat this intent, for speciation can occur over a range of breeding separations, that is, from zero to complete, with those ranges called allopatric, sympatric and parapatric.

Allopatric speciation is the evolution of species caused by the geographic isolation of two or more populations of a species. In this case, divergence is facilitated by the absence of gene flow. Sympatric speciation is the process through which new species evolve from a single ancestral species while inhabiting the same geographic region. Parapatric speciation is the evolution of geographically adjacent populations into distinct species. In this case, divergence occurs despite limited interbreeding where the two diverging groups come into contact.

In the special case of Yellowstone's two bison herds, speciation occurred most probably allopatrically. One herd is endemic, the central herd, but another herd was introduced to Yellowstone in the early 1900s, brought by park managers to the northern portion of the park, which is lower in elevation and has a milder climate than the central portion. While the two herds have the potential to overlap geographically, behaviorally the two have maintained substantial breeding separation for over a hundred years, thereby maintaining reproductive isolation and their original distinct speciation. Waples points out in his essay on the ESU:

> Nevertheless, the issue of reproductive isolation deserves a brief discussion here because it plays a central role in both the biological species concept and the ESU concept of NMFS. Critics of the biological species concept have pointed out that use of reproductive isolation to identify species has two limitations: (1) the test is difficult, if not impossible, to apply to strictly allopatric populations, and (2) many "good" species are not completely isolated reproductively from other species.
>
> Neither of these difficulties represents a real problem for the NMFS ESU concept. First, consideration of allopatric populations as possible ESUs need only focus on the strength and duration of isolation that has actually occurred, not whether the allopatric units are hypothetically capable of reproducing successfully. Second, there is no requirement in the ESU concept of NMFS that reproductive isolation be absolute; rather, it need only be strong enough to allow important differences to develop in different population units. Factors affecting the level of differentiation may include pre- and post-mating isolating mechanisms and selection for locally adapted genes or genotypes. Thus, the NMFS ESU concept takes a functional approach that focuses on the evolutionary consequences of reproductive isolation rather than on the isolation itself (Waples, 1995).

Evolution of the two herds

The two herds that inhabit what is now called Yellowstone National Park have diverse origins. The park is unique in that it has served to preserve two separate breeding herds within its boundaries that have descended from two different subspecies, that is, plains bison (*Bison bison bison*) and wood bison (also known as mountain bison) (*Bison bison athabascae*). According to Margaret Mary Meagher, National Park Service research biologist, in her 1973 monograph *The Bison of Yellowstone National Park*:

> the Yellowstone bison of the present derive from two subspecies: plains bison from Montana (Pablo-Allard herd) and Texas (Goodnight herd), introduced in 1902, and a remnant of the original wild population of mountain bison (Meagher, 1973).

Where did these bison come from and how did they get to Yellowstone? Their ancestors from which they eventually evolved originated in Asia and migrated to central North America, crossing the Bering Land Bridge (also known as "Beringia"), an isthmus between the two continents, at times 600 miles broad. It formed when the ocean level receded due to the growth of massive glaciers that capped the top of the world in the Pleistocene, locking up the flow of water to the sea. The Pleistocene is the geological epoch which lasted from about 2.6 million to 11,700 years ago, spanning the world's most recent period of repeated glaciations. The trapped water, in the form of mountains of ice at some points 10,000 feet high at the glacial maximum, covered most of Canada and northern United States. The glaciers were impassible for both humans and animals.

Bison came through what has been called the Ice Free Corridor (ICF), a passage that opened up between two ice sheets, the Laurentide to the east and the smaller Cordilleran to the west. These sheets over vast periods of time periodically coalesced and receded. When the glaciers began to recede, a belt of land stretching from Siberia to mid-continental North America formed along the eastern slopes of the Rocky Mountains. It connected the two continents, the Old World and the New, linking their biology.

Across this land bridge came megafauna, but by the end of the Pleistocene most were extinct—except for bison. A team led by Beth Shapiro, an evolutionary molecular biologist at the University of California, Santa Cruz, in "Rise and Fall of the Beringian Steppe Bison" recounted:

> Periodic exposure of the Bering Land Bridge facilitated the exchange of a diverse megafauna (such as bison, mammoth, and musk ox) supported by tundra-steppe grasses and shrubs. Humans are believed to have colonized North America via this route, and the first well-accepted evidence of human settlement in Alaska dates to around 12 ky B.P. The latest Pleistocene saw the extinction of most Beringian megafauna including mammoths, short-faced bears, and North American lions. The reasons for these extinctions remain unclear but are attributed most often to human impact and climate change associated with the last glacial cycle.

Two living species of bison (European and American) are among the few terrestrial megafauna to have survived the late Pleistocene extinctions. Julien Soubrier, Graham Gower and Alan Cooper, Australian ancient DNA researchers from the University of Adelaide, writing in "Early cave art and ancient DNA record the origin of European bison," found that the European bison today is a hybrid between two extinct species, the steppe bison and aurochs, the ancestor of cattle. They wrote:

> Despite the extensive bovid fossil record in Eurasia, the evolutionary history of the European bison (or wisent, *Bison bonasus*) before the Holocene (<11.7 thousand years ago (kya)) remains a mystery. We use complete ancient mitochondrial genomes and genome-wide nuclear DNA surveys to reveal that the wisent is the product of hybridization between the extinct steppe bison (*Bison priscus*) and ancestors of modern cattle (aurochs, *Bos primigenius*) before 120 kya, and contains up to 10% aurochs genomic ancestry. Although undetected within the fossil record, ancestors of the wisent have alternated ecological dominance with steppe bison in association with major environmental shifts since at least 55 kya. Early cave artists recorded distinct morphological forms consistent with these replacement events, around the Last Glacial Maximum (LGM, ~21–18 kya).

Soubrier et al. noted the role hybridization had on the evolution of wisent:

> The nuclear and mitochondrial analyses together suggest that the common ancestor of the wisent and CladeX [a previously unrecognized genetic clade related to modern and historical wisent] mitochondrial lineages originated from asymmetrical hybridization (or sustained introgression) between male steppe bison and female aurochs (see Supplementary Fig. 20). This scenario is consistent with the heavily polygynous mating system of most large bovids, and the observation that hybridization between either extant bison species and cattle usually results in F1 male infertility, consistent with Haldane's Rule of heterogametic crosses 20, 21, 22. However, it is unclear whether hybridization took place only once or multiple times, and how and at what point after the initial hybridization event(s) the wisent–CladeX forms became distinct from the steppe bison (Soubrier et al., 2016).

American bison descended from steppe bison. A team led by Marie-Claude Marsolier-Kergoat explored a French cave where the bones of bison, along with drawings of them, had been preserved. They noted in a 2015 study titled "Genome in the Trois-Frères Paleolithic Painted Cave," that:

> Despite the abundance of fossil remains for the extinct steppe bison (*Bison priscus*), an animal that was painted and engraved in numerous European

Paleolithic caves, a complete mitochondrial genome sequence has never been obtained for this species. In the present study we collected bone samples from a sector of the Trois-Frères Paleolithic cave (Ariège, France) that formerly functioned as a pitfall and was sealed before the end of the Pleistocene.

The study concluded:

In summary, we have presented here the analysis of a 19,000-year-old bone specimen that made it possible to obtain the first complete mitochondrial genome for the extinct steppe bison. Phylogenetic reconstruction unequivocally points to the basal [earlier in time] position of the *Bison priscus* mitochondrial genome as compared to the clade delineated by extant *Bison bison* genomes.

When did bison first disperse to North America and where did speciation that produced today's American bison occur? It has long been thought that bison came to the southern portion of the ice sheets via the Ice Free Corridor about 10,000 years ago, diverging into the species now present in North America. However, recent studies indicate they came much earlier.

The Ice Free Corridor opened up onto the central plains south of the ice sheets just above Yellowstone National Park. A record of the animals that travelled down the Ice Free Corridor is preserved at the bottom of a sink hole located in the middle of a migratory path on the flanks of Wyoming's northern Bighorn Mountains northeast of Lovell, Wyoming, about 100 miles east of the park. It is called Natural Trap Cave. Its mouth is a yawning oval hole about 15 feet wide on a level ground that penetrates down 85 feet to a long cavern that runs horizontal to the surface. At the bottom are collections of the skeletons of wild animals that have fallen here over the past 100,000 years.

Excavations on the floor of the cave revealed seven major strata, with the third stratum containing bison remains, presumably steppe bison, dated between 18,000 to 20,000 years ago. Larry D. Martin and B. Miles Gilbert in "Excavations at Natural Trap Cave" reported what was found:

Stratum 3 is a "grey" structure with mottled blue and orange clay matrix with large blocks of (ca. 152mm diameter) limestone breakdown. This is the major bone-bearing stratum and contains horse, camel, bison, sheep, wolf, bear, lion, and cheetah-like cat, in addition to collared lemming. It is dated at 17,620 BP (horse bone collagen) near its top, and 20,170 BP (sheep bone collagen) at its bottom. (1978, January 1).

Figure 27. THE ICE FREE CORRIDOR. Map of North America with Pleistocene glaciers shows the assumed path of Beringian wolves as they followed bison from Alaska to the region of Natural Trap Cave. Dog icons represent sites where Beringian wolves have been found and paw prints represent the hypothesized path of the Beringian wolves through the Cordilleran and Laurentide ice sheets. Natural Trap Cave is denoted with a black dot. *Diagram: Open Access. Creative Commons. Author: Julie A. Meachen* (Meachen, 2016).

Note that wolf remains were found with bison in stratum 3. Bison were a viable prey species for wolves, which followed bison to the Natural Trap Cave in the late Pleistocene. Wolves co-evolved with bison. But what kind of wolf?

Julie A. Meachen and fellow researchers analyzed morphometrics of three wolf groups (dire, extant North American gray, Alaskan Beringian) to determine which wolves were present at NTC. Writing in “Extinct Beringian wolf morphotype found in the continental U.S. has implications for wolf migration and evolution,” they stated:

> Results show NTC wolves group with Alaskan Beringian wolves. This provides the first morphological evidence for Beringian wolves in mid-continental North America. Their location at NTC and their radiocarbon ages suggest that they followed a temporary channel through the glaciers.

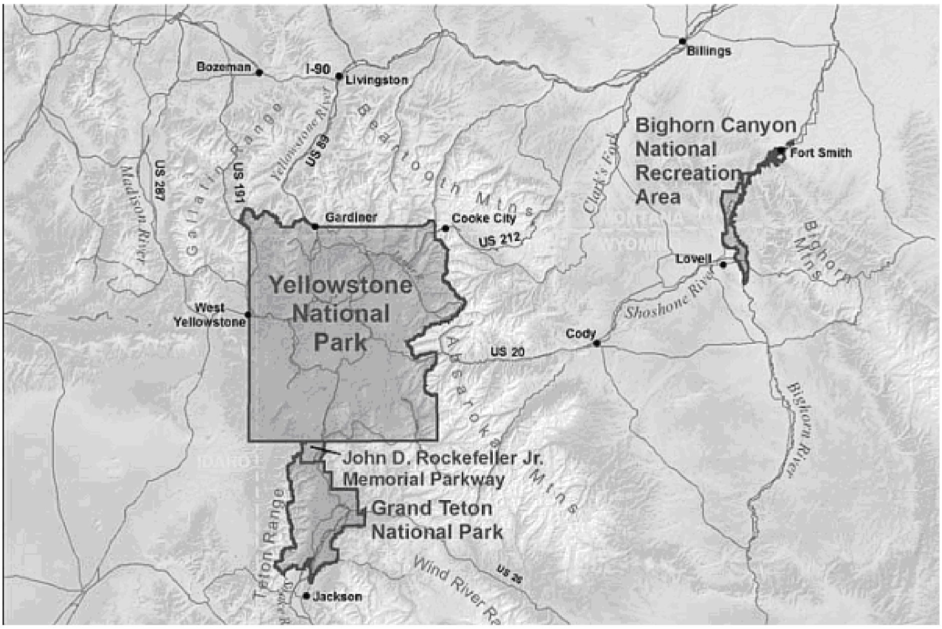


Figure 28. NATURAL TRAP CAVE is located in the southern portion of Bighorn Canyon National Recreation Area near Lovell, Wyoming. It is directly south of the prehistoric ice free corridor and about 100 miles east of Yellowstone National Park. ***Diagram: Yellowstone Network Park Map. Inventory and Monitoring. National Park Service. December 30, 2016***

Did the American bison evolve from the steppe bison that came to the North American continent at the end of the Last Glacial Maximum (LGM), that is about 10,000 years ago? Grant D. Zazula, in collaboration with other researchers, analyzed the remains of a steppe bison discovered in northern Canada that lived at the end of Pleistocene. The 2009 study titled "A late Pleistocene steppe bison (*Bison priscus*) partial carcass from Tsiigehtchic, Northwest Territories, Canada," reported:

> A partial steppe bison (*Bison priscus*) carcass was recovered at Tsiigehtchic, near the confluence of the Arctic Red and Mackenzie Rivers, Northwest Territories, Canada in September of 2007. . . A piece of metacarpal bone was subsampled and yielded a . . . radiocarbon age of 11,830 . . . yr BP . . . Mitochondrial DNA sequenced from a hair sample confirms that Tsiigehtchic

> steppe bison (*Bison priscus*) did not belong to the lineage that eventually gave rise to modern bison (*Bison bison*).

Instead, the ancestors of American bison came earlier. Shapiro et al. noted:

> Pleistocene bison fossils are abundant across Beringia and they provide an ideal marker of environmental change. Bison are believed to have first entered eastern Beringia from Asia during the middle Pleistocene (. . . 300 to 130 ky B.P.) and then moved southward into central North America during the MIS [Marine Isotope Stage] 5 interglacial period (130 to 75 ky B.P.), where they were distributed across the continental United States. During this time, Beringian and central North American bison populations may have been periodically separated by glacial ice that formed over most of Canada.

Shapiro et al., using ancient DNA and Bayesian techniques to reconstruct a genetic history of bison throughout the late Pleistocene and Holocene epochs, found that bison evolved into today's bison south, not north, of the ice sheets:

> It has been hypothesized that modern bison descended from Beringian [steppe] bison that moved south through the IFC [Ice Free Corridor] after the LGM and have since undergone a decline in diversity due to over-hunting and habitat loss. In contrast, our data show that modern bison are descended from populations that were south of the ice before the LGM and that diversity has been restricted to at least 12 ky B.P., around the time of the megafaunal extinctions. All modern bison belong to a clade distinct from Beringian bison. This clade has a MRCA [Most Recent Common Ancestor] between 22 and 15 ky B.P., which is coincident with the separation of northern and southern populations by the western Canadian ice barrier. This clade diverged from Beringian bison by 83 to 64 ky B.P. and was presumably part of an early dispersal from Beringia, as indicated by the long branch separating it from Beringian bison. If other remnants of these early dispersals survived the LGM, they contributed no mitochondrial haplotypes to modern populations.

"After a severe population bottleneck, which ocurred only 200 years ago, two subspecies survive in North America: *Bison bison bison*, the plains bison, and *B. b. athabascae*, the wood bison," Shapiro et al. noted (Shapiro et al., 2004).

A team led by Duane Froese, Department of Earth and Atmospheric Sciences, University of Alberta, used a combined paleontological and paleogenomic approach to provide a timeline for the entry and subsequent evolution of bison within North America. The authors reported their findings in a 2017 study titled "Fossil and genomic evidence constrains the timing of bison arrival in North America":

> We analyzed mitochondrial DNA from the oldest known North American bison fossils to reveal that bison were present in northern North America by 195–135 thousand y ago, having entered from Asia via the Bering Land Bridge. After their arrival, bison quickly colonized much of the rest of the continent, where they rapidly diversified phenotypically, producing, for example, the giant long-horned morphotype *Bison latifrons* during the last interglaciation.

A second wave occurred during the Late Pleistocene, about 45 to 21 thousand years ago, the study found. Froese et al. concluded that:

> Given their relatively shallow history and success in North American ecosystems, the entry of bison stands with human arrival as one of the most successful mammalian dispersals into North America during the last million years (Froese, 2017).

Peter D. Heintzman at Tromsø University Museum, Norway, a researcher in ancient DNA and paleogenetics, led a team to study the Ice Free Corridor, using radiocarbon dates and ancient mitochondrial DNA from late Pleistocene bison fossils. They reported in 2016 in “Bison phylogeography constrains dispersal and viability of the Ice Free Corridor in western Canada” that bison dispersed both north and south of the corridor region, that is, it was a two-way corridor:

> Although bison survived the interval of glacial coalescence both north and south of the continental ice sheets, population bottlenecks and barriers to gene flow affected their mitochondrial diversity. By the time the glaciers began to retreat, bison populations that had been isolated to the south of the continental ice sheets were mitochondrially distinct from their contemporary northern counterparts in Beringia. 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. Thus, the identification of bison from this southern clade within and north of the corridor region can be interpreted as reflecting northward dispersal. Likewise, the appearance of bison from a Beringian mitochondrial clade further south in interior North America can be interpreted as southward dispersal (Heintzman, 2016).

Plain and wood bison ranges

What were the ranges of wood and plains bison historically? According to C.C. Gates et al. in *American Bison: Status Survey and Conservation Guidelines 2010*:

Originally, the American bison ranged from northern Mexico to Alaska. Plains bison occurred from Northern Mexico to central Alberta and wood bison occurred from central Alberta to Alaska (Gates, 2010).

Figure 29. TRADITIONAL RANGE MAP of original distribution of plains bison (*Bison bison bison*) (dark gray), wood bison (*Bison bison athabascae*) (medium gray) and Holocene bison (*Bison occidentalis*) (light gray) in North America (American Bison, 2017).

However, S. N. Rhoads in "Notes on living and extinct species of North American Bovidae," *Proceedings of the Academy of Natural Sciences of Philadelphia, 1897*, made the observation that wood bison may have extended along the slopes of the Rocky Mountains to the United States, which would include Yellowstone National Park. In a description of "Wood Buffalo," he wrote under the heading "Habitat":

> Wooded uplands of the Northwest Territories, formerly from the east slope of the Rocky Mountains to the 95th meridian, and from latitude 63° to latitude 55°; probably ranging south along the Rocky Mountains to the United States.

Under the heading of "Remarks," he wrote:

> The great size, darkness of color, and character of horn and horn-core in the type of *Bison bison athabascae*, granting that it is typical of the form known as the Wood Bison, are quite sufficient to distinguish it from the plains animal and fully justify the opinion of many hunters and travellers as to its separability from the latter (p. 499).

Rhoads also stated:

> The Wood Buffalo as defined by Hind (l.c.) and the Mountain Buffalo of the United States, referred to by hunters and travellers in the Rocky Mountains, are probably identical in their so-called differences from the plains animal in larger size and darker, shorter and softer pelage (Rhoads, 1897, p. 494).

Obviously, a species' range is where it is found or has been found. Of particular relevance to this petition is the range of wood bison or mountain buffalo in or near Yellowstone National Park.

Morphological evidence suggests that the present wild herd, denoted as the central herd, are descendants of the wood or mountain bison species. Meagher writes:

> The genus *Bison* probably invaded North America during the later part of the early Pleistocene. The bison occupying the continent in historic times were descendants of a second migration of Bison from Eurasia, which crossed the Bering Straits at the start of the late Pleistocene according to Skinner and Kaisen (1947). Of the invading species, only one persisted to give rise to *B. occidentalis*, the ancestor of B. bison, the modern form. Two subspecies, *B. b. bison* and *B. b. athabascae*, are recognized by cranial evidence, although historical accounts suggest there may have been others (Roe 1951). The form *athabascae* is apparently the more primitive of the two subspecies (Skinner and Kaisen 1947).

Meagher continues:

> Historical accounts recognizing a mountain buffalo are supported by limited cranial evidence. Skinner and Kaisen (1947) show an overlap in general distribution between mountain and plains bison along the east slopes of the Rockies, including Yellowstone, but state that ranges for historic times must

> be based on early accounts plus occasional bones or crania. Seven skulls from Yellowstone's original wild herd were picked up on the ground along the Gardner River and at Mammoth in 1902. All had weathered surfaces. These were considered as most likely representing *athabascae*. The 1964 skull (Fig. 10) found on the Mirror Plateau was identified by Skinner (1965) as "an exceptionally long horned, apparently young Mountain bison = *B. (B) b. athabascae.* No Yellowstone skulls which predate the 1902 introduction have been identified as plains type.

Concerning the fossilized skull, Meagher noted:

> Just when bison first reached the Yellowstone plateau is not known, but modern bison inhabited the area before historic times, perhaps before the most recent period of intermountain glaciation . . . In 1964 a fossil cranium (*B. b. athabascae*) was found embedded in a natural oil seep on the Mirror Plateau in the park.

Historically, trappers, Indians and travelers recognized wood bison as a distinct species separate from plains bison due to appearance, behavior, preference for mountain regions and altitudinal migration. Meagher continues:

> 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 (Aubrey Haines 1968 pers. comm.). According to the distribution map of Skinner and Kaisen (1947), these were mountain bison . . .
>
> The existence of mountain bison, different in appearance and behavior from the plains type and gone from much of their range by the 1840s, has generally been little known. Christman (1971) reviews historical evidence for the subspecies, their distribution to the west of the plains type, and reasons for their early disappearance. He believes the Indians' acquisition of the horse was the factor underlying the extermination of mountain bison from extensive areas of original range, particularly in Washington, Oregon, and Idaho.
>
> Many early references to Yellowstone bison use the term "wood" or more commonly "mountain" bison or buffalo; some of the characteristics of the race were recognized by a number of early travelers and observers. Historical accounts generally agree that, compared with the plains bison, these mountain animals were more hardy, fleet and wary, and had darker, finer, curlier hair. Sex and age differences among animals seen may account for discrepancies in description of size. The geologist Arnold Hague (1893) provides the following:

The Park buffalo may all be classed under the head of mountain buffalo and even in this elevated region they live for the greater part of the year in the timber . . . most unusual, save in midwinter, to find them in open valley or on the treeless mountain slope. They haunt the most inaccessible and out-of-the-way places . . . living in open glades and pastures, the oases of the dense forest . . . [their behavior characterized by] the rapidity of their disappearance on being alarmed. It is surprising how few buffalo have been seen in midsummer, even by those most familiar with their haunts and habits. They wander about in small bands . . .

Blackmore (1872) was informed that the mountain buffalo congregated usually in bands of 5-30, rarely more. Other observers agree that the bands were small, and the animals quite wary. Superintendent Norris described them as "most keen of scent and difficult of approach of all mountain animals" (Superintendent of the Yellowstone National Park 1880).

Altitudinal migrations were another characteristic of mountain bison (Christman 1971). Historical accounts from Yellowstone also suggest this habit. Superintendent Norris, in his annual report of 1880, describes summer and winter distributions of bison in the park, stating clearly:

> . . . summer in the valleys of the Crevice, Hellroaring, and Slough Creeks, and the mountain spurs between them, descending with the increasing snows, to winter . . . East Fork [Lamar] . . . and as the snows melt . . . returning to their old haunts.

Figure 30. MOUNTAIN BISON. Cows and calves photographed in a remote part of Hayden Valley sometime before 1894. These bison were frequently called mountain bison by early observers. *Photo by John Folsom, a winter keeper at Canyon (Meagher, 1973, p. 15).*

Figure 31. BISON WINTERING IN HAYDEN VALLEY prior to 1894. *Photo probably by John Folsom, early Canyon winter keeper* (Meagher, 1973).

Figure 32. SKULLS OF *BISON BISON ATHABASCAE* (left) and B. b. bison from the Mirror Plateau, Yellowstone National Park. *Photo by David Love, U.S. Geological Survey* (Meagher, 1973, p. 17).

Over-hunting and poaching of the wood or mountain bison that originally inhabited the park reduced the herd to about 23 animals. In 1902 park personnel augmented the park with a small herd of captive plains bison, eventually producing some hybrids between the endemic and introduced herds. According to *Yellowstone bison: conserving an American icon in modern society*, edited by P.J. White, chief of wildlife and aquatic resources; Rick L. Wallen, bison project leader; and David E. Hallac, division chief of the Yellowstone Center for Resources between 2011-2014:

> A restoration program for Yellowstone bison was initiated in 1902 when park managers began to increase bison numbers and perpetuate the species.

> Husbandry (e.g., reintroduction, fencing, herding, feeding) was used to restore and propagate a new herd in northern Yellowstone, and some of these bison were then relocated to central Yellowstone to augment the remaining bison from the indigenous herd (White et al., 2014).

Meagher observed:

> The bison of Yellowstone National Park are unique among herds in the United States, being descendants, in part, of the only continuously wild herd in the country. They are today a hybrid herd, being a mixture of the plains bison (*Bison bison bison* Linnaeus), introduced in Yellowstone National park in 1902, and mountain or wood bison (*Bison bison athabascae* Rhoads), which originally inhabited the Yellowstone and surrounding country. They are a wild population, unrestricted by either internal or boundary fences, and subject to minimal interference by man (Meagher, 1973).

The park was founded in 1872. In her dissertation "The Utilization of Genetic Markers to Resolve Modern Management Issues in Historic Bison Populations: Implications for Species Conservation," Natalie Dierschke Halbert traced the beginning of the two herds:

> From 1872-1886, wild bison in YNP were poached rigorously and without consequence due to inadequate management and funding for law enforcement. At the lowest point in 1902, there were no more than 30 bison remaining in the wild in YNP (Garretson 1938; Meagher 1973). In the same year, Charles "Buffalo" Jones was appointed by President Roosevelt to act as game warden in the preservation of bison in YNP and played an integral role in the building of corrals and supervising the purchase of additional plains bison to supplement the YNP population (Coder 1975). Introductions of 18 female bison from the Pablo-Allard herd in Montana and 3 bulls from the Goodnight herd in Texas were made in 1902 (Garretson 1938; Coder 1975). These 21 bison were originally fenced and treated as captive. One of the Goodnight bulls died in the first winter and thus made very little, if any, genetic contribution to the captive herd (Garretson 1938). After the first year, the herd had increased by 12 head (Coder 1975). A few additions of some "wild" YNP bison were made to the captive herd (Garretson 1938), which continued to increase in numbers until 1915 when the herd was released into the park, eventually intermingling with the growing wild bison population (Meagher 1973).

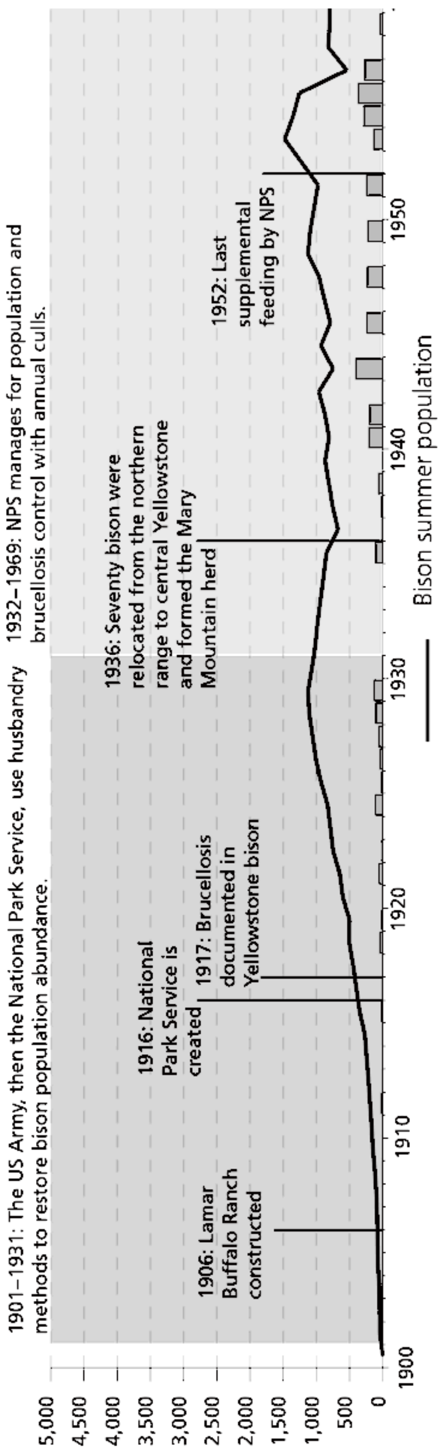


Figure 33. TIMELINE OF BISON MANAGEMENT from 1901 to 1969 shows the recovery of the population, followed by annual culls to control numbers (History of Bison Management, 2017).

Although the introduced herd of plains bison in 1902 were captive, they were captives directly from the wild. Halbert describes the origin of the Pablo-Allard herd:

> After creating trouble for himself by taking two wives from two different Indian tribes at the same time, Samuel "Walking Coyote" Wells captured 3 male and 4 female calves in 1879 in Montana to present to his Pend d'Oreille tribe as a peace offering (Coder 1975). Wells arrived at Flathead Valley with 2 male and 2 female calves, which were used to start a small herd. Charles Allard, Sr. and his interpreter Michael Pablo bought the entire herd of 12 bison from Wells in 1883, thus forming the Pablo-Allard bison herd (Coder 1975; Zontek 1995). In 1893, Pablo and Allard purchased 44 bison from Charles Jones to supplement their herd (Seton 1937). By 1906, the herd was estimated at 350 bison.

Bison from the Goodnight herd were also captured from the wild:

> At the behest of his wife, Charles Goodnight began his famous bison venture in the panhandle of Texas with the capture of 1 male and 1 female calf in 1878 (Haley 1949). Five additional calves were later obtained, but of the 7 total, one was killed and one sold, thus establishing the Goodnight herd with 5 wild bison (Haley 1949; Coder 1975). The herd grew and prospered; by 1887 there were 13 bison and by 1910, the number had increased to 125 (Dary 1989) . . . Over the last 120 years this population has remained reproductively isolated, therefore representing the only extant bison population directly descended from the original Charles Goodnight herd. (Halbert, 2003).

What about the composition of the herd purchased from Jones in 1893 by Pablo and Allard? Jones had started his herd by purchasing a few bison from Charles Goodnight, along with capturing 13 bison from southern Texas (Time Line of the American Bison, 2017).

Exactly when the separate Yellowstone herds began to mix genetically is blurred. Meagher wrote:

> Before 1915, introduced bison of plains stock could not have escaped to form a wild group. The introduced herd was in a small fenced pasture at Mammoth from 1902 until moved to the Buffalo Ranch at Lamar in 1907. From 1907 until at least 1915, these animals were closely day-herded, and apparently put in a fenced pasture at night.

A deliberate attempt was made to have the two herds interbreed in 1936. Meagher noted:

> In 1936, animals were trucked to the Firehole and Hayden valleys for release. They were thought to have formed separate herds, but as numbers increased, some movement between the two valleys became obvious, and they were called the Mary Mountain herd. Two other herds were distinguished, on the basis of wintering areas, as the Lamar and Pelican. None of these herds is geographically isolated at all seasons of the year, but the names are still used to designate the wintering populations.

However, interbreeding had begun prior to 1936. Meagher recounts:

> Sometime between 1915 and 1920, intermingling of the introduced and wild animals began. At first this was probably gradual. Park records do not show the specific year, but after 1915 the close herding practices in use with the introduced herd were abandoned, and the animals were kept on open range all summer. Close account was kept of most of them for several more years, but there were some escapees. After 1921, with construction of a log drift fence across the Lamar Valley above Soda Butte Creek, deliberate efforts were made to keep the introduced herd on the higher summer ranges, where intermingling with the wild bison must have quickly increased.

Despite being outnumbered by the plains-type bison, the wild strain of bison increased. Meagher writes:

> After intermingling of wild and introduced animals began, several factors tended to increase the wild strain in the total population, although the plains type outnumbered the wild roughly 3:1 about 1917, and perhaps 4:1 in 1921. The number of males in the introduced herd was reduced by the yearly segregation of a show herd of bulls beginning in 1909. Additional bulls were removed by live shipment and slaughter. To further reduce the male surplus (from a ranch operation viewpoint), castration of bull calves averaged slightly over 50% from 1916 through 1931. As a result, the number of aggressive, dominant plains-type bulls with the intermingled groups would have been considerably decreased.
>
> . . . An estimated 40% of the bulls older than 5 years were of the mountain bison strain. Their contribution to the breeding activity may have been larger, as discussed above, than their numbers indicate.
>
> The trend toward increased mountain bison strain would have continued during the 1920s. On this basis, a reasonable estimate of wild strain in the present bison population would seem to be 30-40% (Meagher, 1973).

Despite the fact that wood bison, also known as mountain bison, have been officially classified as a subspecies *Bison bison athabascae* and plains bison as *Bison bison bison*, a controversy surrounds these species' designations.

Valerius Geist, a University of Calgary biologist, wrote a paper with the purpose of reassessing bison taxonomy. In “Phantom Subspecies: The Wood Bison *Bison bison ‘athabascae*’ Rhoads 1897 Is Not a Valid Taxon, but an Ecotype,” he stated:

> The proposal that the “hybrid bison” of Wood Buffalo National Park (WBNP) be exterminated and replaced with “wood bison” has no taxonomic justification. The subspecies *Bison bison athabascae* Rhoads 1897 is based on inadequate descriptions and taxonomically invalid criteria, i.e., body size and morphornetrics (Geist, 1991).

In the 1920s, in an effort to make up for low numbers of endemic wood bison, plains bison were shipped to WBNP by the thousands. It was a translocation similar to the introduction of plains bison to Yellowstone National Park in 1902, but more massive. The two herds interbred, creating hybrids. Soon, the herds became diseased. Geist noted what followed years later:

> In 1989 Agriculture Canada, in concert with federal, provincial and territorial wildlife agencies, proposed to exterminate the bison (*Bison bison* Linnaeus 1758) in Wood Buffalo National Park (WBNP) and replace these, allegedly “worthless hybrids” (*Bison bison bison* X *athabascae*; see van Zyll de Jong, 1986) and carriers of bovine tuberculosis and brucellosis, with so-called “wood bison” (*B. b. athabascae* Rhoads 1897) free of the diseases. The Bison Disease Task Force was struck to deal with matters of information and a panel formed by the Federal Environmental Assessment Review Office (FEARO) held public hearings on the plan 15-26 January 1990; the panel upheld Agriculture Canada’s position (Connelly et al., 1990).

Agriculture Canada had proposed spending $20 million to slaughter the park’s 3,500 bison. Options that had been discussed in the past for eliminating the hybrid herd included strafing the animals, using the Royal Canadian Air Force to conduct a search and destroy mission of the park's bison.

Geist had a mission—to obliterate the subspecies designation of *Bison bison athabascae* to save the park’s hybrid herd from slaughter. If it could be shown that there was no difference at the species level between wood and plains bison, then nothing would be gained taxonomically by replacing a hybrid mix of wood and plains bison with a so-called pure form of wood bison.

Geist told *Borealis Magazine’s* Ed Struzik in “The Rise and Fall of Wood Buffalo National Park”:

> There is no doubt in my mind that this was a conspiracy of very narrow-minded interests right from the very beginning . . . What we have here is a small group of badly informed scientists and manipulative politicians who decided to play

> God by proposing the ridiculous idea of killing 3,500 bison and replacing them with what they wrongly assume is a superior animal. Their motives have nothing to do with conservation values or the interests of Wood Buffalo National Park. Rather, they have more to do with protecting cattle and game ranches, and seeing to it that national park interests do not continue to dominate regional economic interests in the future (Struzik, 1995).

In his study, Geist noted:

> The view that WBNP bison be killed off and replaced by genetically impoverished "wood bison" from EINP [Elk Island National Park] would destroy the largest continuous, well tested gene pool of the species B. bison and give priority to the impoverished gene pool of an inbred phantom subspecies.

Commenting on F.G. Roe's "The North American buffalo: A critical study of the species in its wild state," Geist said there was historical evidence for subspecies rankings of *Bison bison*:

> As determined by the careful and critical Roe (1970:43-57), there is little doubt that in historic times bison existed in at least two forms, a dark, large, shy, non-migratory wood bison in the north, and a smaller, lighter, aggressive, migratory plains bison in the south. There may have also been populations of mountain bison (Meagher, 1973), possibly analogous to the small mountain wisent (B. bonasus caucasicus) of Europe (Heptner et al., 1961), as well as some regional differences that native people recognized (Seton, 1929:709). Roe (1970) was not concerned if these differences were taxonomically relevant, that is, of genetic origin, or if they were ecotypic, that is, a product of environmental circumstances; he was concerned if the differences reported had some foundation in reality. He concluded they had.

In his review, Geist noted that genetic studies were inconclusive:

> Concurrent with conventional means of defining wood and plains bison taxonomically, attempts were made to analyze genetic differences among bison populations. The results were ambiguous.

Further, he proposed that morphological differences between the two groups could be considered merely due to local adaptations to the environment, that is, the differences of the subpopulations were ecotypes.

He concluded, (noting incidentally that wolf predation could help eliminate detrimental traits):

> Hybridization is genetic pollution and a biological tragedy when it destroys a population's ability to survive under extreme environmental conditions, such as severe predation or weather, narrow seasonal windows or resource shortages . . .
>
> The test of the effects of hybridization is survival under severe environmental conditions. Using this criterion, then the "predator pit" within which WBNP bison are currently found (Carbyn et al., 1989) should eliminate whatever detriments hybridization might have had. Considering the foregoing, the 1925-28 mixing of plains and wood bison in WBNP, while culturally tragic, because it was avoidable, is not a biological tragedy. There is no evidence for subspecies in *B. bison*, and no taxonomic justification for destroying the bison of WBNP (Geist, 1991).

However, it has been argued that Geist is not correct in denying subspecies status to the wood bison and that instead plains bison and wood bison are distinct entities. The reason is summed up in *American Bison: Status Survey and Conservation Guidelines 2010* by the International Union for Conservation of Nature and Natural Resources, which includes the Bison Specialist Group, "a voluntary network of people professionally involved in the study, conservation, and sustainable management of bison in Europe and North America," edited by C. Cormack Gates, Curtis H. Freese, Peter J.P. Gogan, and Mandy Kotzman. In chapter 4, "Genetics," by Delaney P. Boyd, Gregory A. Wilson, James N. Derr, and Natalie D. Halbert, the authors state:

> Based on their geographic distribution and morphology, plains bison and wood bison were historically distinct entities (Chapter 3). It can be argued that the introduction of plains bison into range occupied by wood bison was a "negligible tragedy" (Geist 1996), because some consider the two groups to be ecotypes (Geist 1991). Others maintain that the interbreeding of these two types should have been avoided to preserve geographic and environmental variation (van Zyll de Jong et al. 1995). The introduction of either subspecies into the original range of the other could, in theory, erode the genetic basis of adaptation to local environmental conditions (Lande 1999). Therefore, hybridisation between plains and wood bison should be considered detrimental to maintaining the genetic integrity and distinctiveness of these two geographic and morphologically distinct forms.
>
> While historically there may have been natural hybridisation events between the subspecies in areas of range overlap, the current hybridisation issue is the consequence of an ill-advised and irreversible decision made nearly 85 years ago. In 1925, the Canadian government implemented a plan to move more than 6,000 plains bison from the overcrowded Wainwright National Park to Wood Buffalo National Park (WBNP). Biological societies from U.S. and Canada strenuously challenged this action, as interbreeding

would eliminate the wood bison form, resulting hybrids might not be as fit for the environment, and diseases such as bovine tuberculosis (BTB) would spread to formerly healthy animals (Howell 1925; Harper 1925; Lothian 1981; Saunders 1925). Proponents of the plan countered the criticism by questioning the subspecies designations, arguing that the introduction site was isolated from, and unused by, the wood bison population, and suggesting that the introduced animals were too young to carry BTB (Fuller 2002; Graham 1924). These arguments did not consider the future habitat needs of the growing wood or plains bison populations, nor the likelihood that the two subspecies would not remain isolated. As well, a recommendation that only yearlings that passed a tuberculin test be shipped to WBNP was rejected (Fuller 2002).

It was not until 1957 that the discovery of a seemingly isolated herd of 200 animals near the Nyarling River and Buffalo Lake alleviated fears that wood bison was lost to hybridisation (van Camp 1989). Canadian Wildlife Service researchers determined that these animals were morphologically representative of wood bison (Banfield and Novakowski 1960). To salvage the wood bison subspecies, bison from the Nyarling herd were captured and relocated to establish two new herds. Sixteen animals were moved to the MBS north of Great Slave Lake in 1963 (Fuller 2002; Gates et al. 2001c), and 22 animals were successfully transferred to Elk Island National Park (EINP) east of Edmonton, Alberta in 1965 (Blyth and Hudson 1987). Two additional calves were transferred to EINP between 1966 and 1968 (Blyth and Hudson 1987; Gates et al. 2001c). Of those bison transferred, 11 neonates formed the founding herd. Subsequent studies revealed that there was contact between the Nyarling herd and the introduced plains bison (van Zyll de Jong 1986). Although hybridisation within WBNP did not result in a phenotypically homogenous population (van Zyll de Jong et al. 1995), genetic distances among subpopulations in the park are small, indicating that there is gene flow and influence of the plains bison genome throughout all regions of the park (Wilson 2001; Wilson and Strobeck 1999). Despite hybridization, genetic distances between plains and wood bison are generally greater than those observed within subspecies. Moreover, wood bison form a genetic grouping on a Nei's minimum unrooted tree, suggesting genetic uniqueness (Wilson 2001; Wilson and Strobeck 1999).

Morphological and genetic evidence suggest that care should now be taken to maintain separation between these historically differentiated subspecies. Efforts are in place to ensure representative wood bison and plains bison herds are isolated from each other to prevent future hybridisation between these important conservation herds. (Harper et al. 2000) (Gates et al. 2010).

Likewise, the bison herds in Yellowstone demonstrate two subspecies—plains bison, wood bison and their descendants—exist side by side in separate herds today. Their existence together as geographically and genetically distinct in Yellowstone proves the two herds are different subspecies.

10

Yellowstone proves plains and wood bison are separate subspecies

Yellowstone National Park functions as a proof of concept that wood and plains bison, that is, *Bison bison bison* and *Bison bison athabascae,* are separate subspecies. Descendants of both groups exist here side-by-side in two separate herds, the central herd and the northern herd. Although geographically close and at some points with their ranges overlapping, the herds have remained as two distinct breeding herds with different genetic and behavioral characteristics for over one hundred years, even in the presence of hybridization events.

Why the females of both herds generally maintain herd fidelity during the breeding season is unknown, but it could be something as basic as herd smells, whereby "a single mutation can cause huge changes in the resulting pheromones, leading to a reproductive isolation of the mutated population and the formation of a new species," (Wicker-Thomas, 2011) or, by extension, maintenance of the separate status of two geographically close subspecies.

Because they are not substantially interbreeding, this proves that plains and woods bison are separate subspecies in nature according to the biological species concept. In the taxonomy battle concerning the designation of their status, the park is a proving ground that the two subspecies exist.

However, findings that support this view have been routinely resisted or ignored by present-day Yellowstone biologists, paving the way for disproportionate culling actions by the IBMP, which is endangering the continued survival of the central wild bison herd and eventually the northern herd as well.

The uniqueness of the park's bison was noted by Yellowstone biologist Meagher in her book *The Bison of Yellowstone National Park,* published by the National Park Service in 1973:

> The bison of Yellowstone National Park are unique among herds in the United States, being descendants, in part, of the only continuously wild herd in the country. They are today a hybrid herd, being a mixture of the plains bison (*Bison bison bison* Linnaeus), introduced in Yellowstone National park in 1902, and mountain or wood bison (*Bison bison athabascae* Rhoads), which originally inhabited the Yellowstone and surrounding country. They are a wild population, unrestricted by either internal or boundary fences, and subject to minimal interference by man (Meagher, 1973).

However, this perspective has changed. The central herd (the original wood bison descendants) no longer counts. The Fish and Wildlife Service, plus biologists associated with Yellowstone at both the government and university level, in spite of the evidence to the contrary, consider the park's separate wild bison herds for management purposes to be one herd and one species only—*Bison bison bison.* The science provided to support this perspective is flawed and the science contrary to this perspective is often disregarded.

For example, in response to the petition I originally submitted in 1999, the Fish and Wildlife Service's finding in 2007 stated under "Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics":

> The petition alleges that the YNP bison herd may be a unique hybrid of the wood and plains bison. No citations are provided, but this conclusion was stated in Meagher (1973, pp. 14-16), who considered the "mountain" bison a separate species. This controversy has since been resolved, and YNP staff now considers the remnant population, as well as the introduced bison, as being of plains bison origin (Boyd 2003, pp. 182-183; Wallen 2006).

The citation "Wallen 2006" refers to a 07/19/2006 memorandum written by Rick Wallen to Chuck Davis, the author of the 2007 FWS finding on my petition submitted in 1999. The memorandum, provided to me by email June 14, 2011 by Sarah Fierce, FWS listing biologist, stated in part:

> As per my quick review of the finding, I compiled the following thoughts . . . On the bottom of page 4 and top of page 5 you talk about hybridization of plains and wood bison at Yellowstone. This is incorrect. The Meagher book referred to "Mountain" bison as a separate species from plains bison but this debate was resolved some time ago and we consider both the remnant population of bison as well as the introduced bison as being of plains bison origin. I refer you to a thesis by Delany Boyd on the conservation status of bison.

Boyd, D. 2003. Conservation of North American bison: status and recommendations. MS Thesis, Univ. of Calgary. 220pp. (Sarah Fierce, personal communication, June 14, 2011).

The “Boyd 2003, pp. 182-183” citation refers to Boyd’s master’s thesis. It states:

> The Yellowstone National Park bison herd is the only population of plains bison in North America that has existed continuously in the wild (Coder 1975; Ward 2000). During the early 1900s, the remnant herd was augmented with bison from the Goodnight and Allard herds (Wallen 2002, pers. comm.).

The references Boyd made to “Coder 1975” and “Ward 2000” were to George D. Coder’s Ohio State University 1975 Ph. D. thesis titled “The national movement to preserve the American buffalo in the United States and Canada between 1880 and 1920,” and to T.J. Ward’s “An evaluation of the outcome of interspecific hybridization events coincident with a dramatic demographic decline in North American bison.”

Boyd’s reference to “Coder 1975” as supporting her claim that “The Yellowstone National Park bison herd is the only population of plains bison in North America that has existed continuously in the wild” misstates Coder. Instead of plains bison that have existed continuously in the wild, the wild herd indigenous to the park “were in fact wood buffalo,” according to Coder, quoting Meagher. In Coder’s 1975 dissertation, he noted:

> For a long while it was believed that the buffalo found in the mountains of Yellowstone National Park were refugees from the slaughter on the plains. On this assumption the ‘wild herd’ and the ‘tame herd’ were mixed in 1920. Not until a brilliant piece of work done by Dr. Mary Meagher in the 1960’s was it discovered that the ‘wild herd’ was indigenous to the Park and were in fact wood buffalo. On the basis of exhaustive studies she estimates the Yellowstone herd today carries approximately 65 per cent wood buffalo blood (Coder, 1975, pp. 312-313).

Compounding Boyd’s error, Ward writes in his dissertation, citing “Coder 1975”:

> The YNP and WBNP populations were chosen to represent native bison genetic variation because they are the only extant populations of North American bison to have continuously existed in the wild, and there is no evidence that they have a direct history of hybridization with domestic cattle (Coder 1975).

And on the same page he states:

> The YNP and WBNP populations represent the plains bison and wood bison subspecies respectively, and contain the vast majority of genetic variation identified in North American bison.

Boyd's claim that "The Yellowstone National Park bison herd is the only population of plains bison in North America that has existed continuously in the wild" is fabricated like a house of cards. One look inside and the link between the park and the site of indigenous plains bison collapses. We find two blatant misquotes: Boyd and Ward both claiming or alluding to plains bison continuously existing in the wild at YNP, when in fact it is wood bison, instead, as stated by Coder and Meagher.

This is irresponsible scholarship, but was used by Wallen to discredit the claim made in my first petition that a hybrid of wood bison existed in the YNP.

Meagher, in her 1973 monograph published by the National Park Service, cited numerous historical sightings of mountain, i.e., wood bison, in Yellowstone, as well as archeological evidence. Meagher, as mentioned in the 2015 petition and above in this petition, stated:

> The 1964 skull (Figure [32]) found on the Mirror plateau was identified by Skinner (1965) as "an exceptionally long horned, apparently young Mountain bison = B. (B.) b. athabascae . . ."

But Wallen brushes away the possibility that wood bison or mountain bison exist in Yellowstone, saying "this debate was resolved some time ago and we consider both the remnant population of bison as well as the introduced bison as being of plains bison origin," when, indeed, at the time of his writing, no resolution had been made.

Taxonomically, wood bison are a recognized subspecies. In "A Review of Information on Wood Bison in Alaska and Adjacent Canada, with particular Reference to the Yukon Flats," Craig L. Gardner, Alaska Department of Fish and Game, and Anthony R. DeGange, U.S. Fish and Wildlife Service, observed:

> Wilson and Strobeck 1999) found that all wood bison herds today likely contain some plains bison genetic material in their gene pool, and that wood bison would be even more distinct genetically from plains bison had the introduction of plains bison to Wood Buffalo National Park not occurred.
>
> Geist (1991) challenged the unspecific status of wood bison contending that phenotypic differences in size and pelage were the result of environmental influences such as food quality. Van Zyull de Jong et al. (1995) however, contend that differences in phenotypic characters between wood and plains

> bison are heritable. Molecular studies provide some clarity to the controversy from a management perspective, but do not completely resolve the question of subspeciation. Studies of blood characteristics, restriction fragment length polymorphisms, mitochondrial DNA haplotypes, and DNA microsatellites all found varying degrees of difference between plains and wood bison (Peden and Kraay 1979; Bork et al. 1991; Wilson and Strobeck 1999). Polziehn et al. (1996) did not dispute the subspecific status of plains and wood bison but conclude that they have only recently been separated from each other and neither is a well-defined taxon. Wilson and Strobeck (1999) concluded that the three populations of wood bison they studied were "functioning as entities distinct from plains bison, and should continue to be managed separately" (Gardner et al., 2003).

While recognized as a subspecies, the question is, do wood bison (or mountain bison or hybrids), exist in the park and as a separate population? Historical observations and the presence of wood bison fossils at the park indicate they once did. But what about now? One way to establish this is through genetic analysis. To begin with, separate herd status has been observed via genetic studies.

Florence Marie Gardipee in her 2007 master's thesis at the University of Montana, titled "Development of fecal DNA sampling methods to assess genetic population structure of Greater Yellowstone bison," analyzed 179 fecal samples collected over two consecutive seasons to evaluate population structure among Yellowstone National Park bison breeding groups and between Grand Teton National Park and YNP bison populations. She noted:

> I found significant genetic distinction between YNP and GTNP bison populations (FST = 0.191, $p < 0.001$). The differences in haplotype frequencies between Hayden Valley and Lamar Valley breeding groups were highly significant (FST = 0.367, $p < 0.001$), and nearly two times greater than between GTNP and YNP thus providing evidence for at least two genetically distinct breeding groups within YNP.

Gardipee speculated that Yellowstone's wild bison are vulnerable to extinction. She noted that "the loss of genetic diversity due to multiple bottlenecks, founder effects, hybridization, and domestication pose the risk of genomic extinction, and reduced evolutionary potential" (Gardipee, 2007). Genomic extinction is what happened to aurochs, as covered in the second volume of this petition (see chapter 16, "A lesson from the wisent and aurochs").

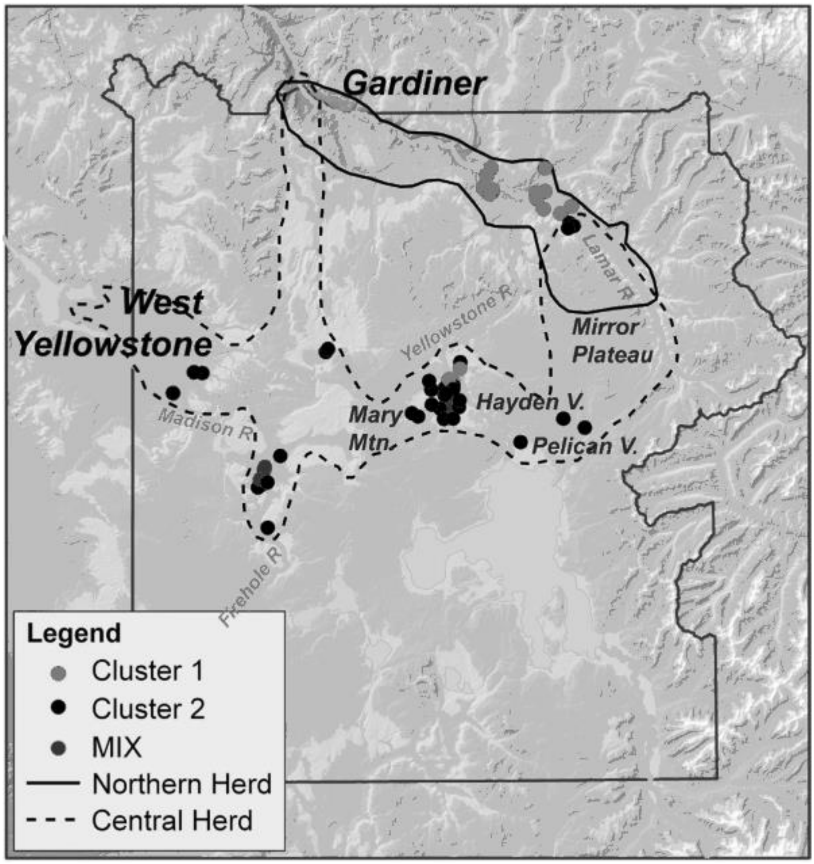


Figure 34. MAP OF GENETIC CLUSTERS indicating the locations and genetic types of bison live-captured in Yellowstone National Park between February 2000 and October 2003. Bison with at least 70% assignment to one of the clusters are indicated by light grey (cluster 1) or black (cluster 2) circles, and medium grey circles indicate bison with less than 70% assignment to a single cluster (mixed). The dashed and solid lines represent the maximum annual distribution of central and northern herd Yellowstone bison, respectively. Abbreviations: R, river; Mtn, mountain; and V, valley (Halbert et al., 2012).

In a study reported in the *Journal of Heredity* titled "Genetic Population Substructure in Bison at Yellowstone National Park," a team led by Natalie D. Halbert found genetic evidence for two biologically distinct herds. Researchers investigated the potential for limited gene flow across this population of wild bison using "multilocus Bayesian clustering analysis" for "probabilistic assignment of individuals" to populations. Using a computer program, they assessed patterns of genetic structure, looking at the distribution of both genotypes and alleles in a set of hair, blood, or liver tissue samples collected from bison from various locations in the park. They identified "[t]wo genetically distinct and clearly defined subpopulations."

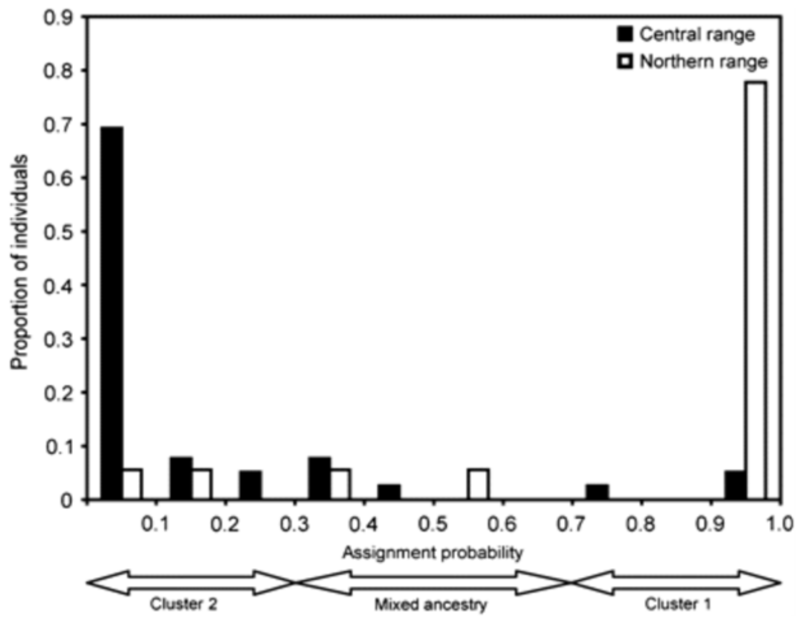


Figure 35. FREQUENCY DISTRIBUTION CHART of cluster assignments for bison live-captured and sampled within the central (n = 39) or northern (n = 18) ranges, indicating a strong association between sampling location and cluster assignments. The proportion of individuals within each range for a given probability class (e.g., 0–0.1, 0.11–0.2, etc.) are indicated with vertical bars. The majority of bison captured in the central range (32/39 = 82.1%) were assigned to cluster 2 (assignment probability = 0.3 to cluster 1), whereas the majority of bison captured in the northern range (14/18 = 77.8%) were assigned to cluster 1 (assignment probability = 0.7 to cluster 1) (Halbert et al., 2012).

In addition to Halbert, researchers included Jacqueline M. Wahl and James N. Derr, all with Texas A&M University's department of veterinary pathobiology; as well as Peter J.P. Gogan, Northern Rocky Mountain Science Center, US Geological Survey; and Philip W. Hedrick, School of Life Sciences, Arizona State University. The authors noted:

> From this analysis, there appears to be a strong association between the genetically defined clusters and sampling locations within Yellowstone National Park, with cluster 1 representing bison from the northern range and cluster 2 representing bison from the central range (Figure 2 [see Figure 35 above]).

Presently, all bison captured and shipped to slaughter are culled at the northern boundary in Gardiner Basin. However, the study noted:

> it is not possible to separate bison at the northern boundary (Gardiner) based on subpopulation origin (Central vs. Northern) without invasive methods (e.g., permanent identification methods or on-site genetic analysis).
>
> 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.

The researchers concluded:

> 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 (Halbert et al., 2012).

More recently this perspective, which emphasizes the importance of the two herds, was called into question in a study by Kory C. Douglas, Natalie D. Halbert, Claire Kolenda, Christopher Childers, David L. Hunter and James N. Derr in "Complete mitochondrial DNA sequence analysis of Bison bison and bison–cattle hybrids: Function and phylogeny." This analysis, with the majority of researchers from Texas A&M University (some participants of the Halbert et al. 2012 study), produced a phylogenetic tree:

> Complete mitochondrial DNA (mtDNA) genomes from 43 bison and bison-cattle hybrids were sequenced and compared with other bovids. Selected animals reflect the historical range and current taxonomic structure of bison. This study identified regions of potential nuclear–mitochondrial incompatibilities in hybrids, provided a complete mtDNA phylogenetic tree for this species, and uncovered evidence of bison population substructure.

The authors noted that: "The data generated in this study is also valuable in understanding the taxonomic classification of American bison, which has been debated at the genus, species, and subspecies level." Samples came from five herds. They stated:

> To maximize haplotype diversity, efforts were made to include representative haplotypes across 5 of the foundation herds including" Yellowstone National Park (Wyoming, USA), Fort Niobrara National Wildlife Refuge (Nebraska,

USA), National Bison Range (Montana, USA), Texas State Bison Herd (Texas, USA), and Elk Island National Park (Alberta, Canada).

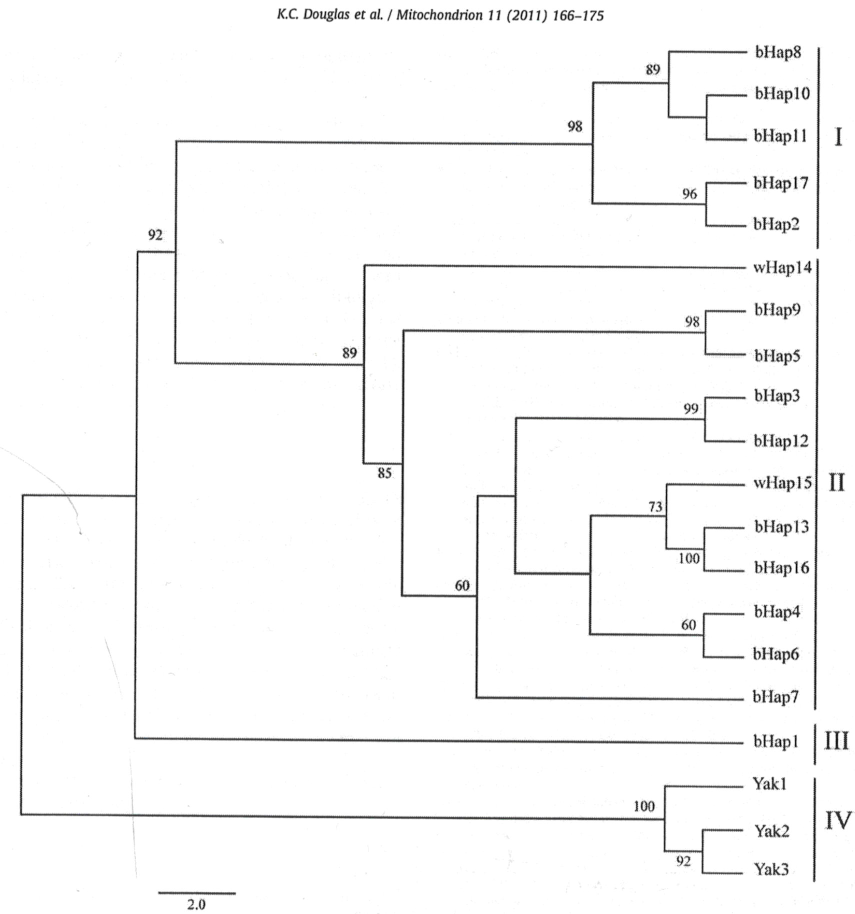


Figure 36. MAXIMUM LIKELIHOOD PHYLOGENETIC TREE of bison complete mtDNA haplotypes rooted by *Bos grunniens* (yak). Clades: I—plains bison (Fort Niobrara NWR, Yellowstone NP, National Bison Range, private herd); II—plains and wood bison (Texas State Bison herd, private herd, Elk Island NP); III—previously published bison sequence (Achilli et al., 2008); IV—Yak. NP, National Park; NWR National Wildlife Refuge. Bootstrap value generated by sampling 1000 replicates (Douglas, 2011).

The study noted:

> We identified significant phylogenetic substructure among bison (Fig. 4 [Figure 36 above]), which can be used to assess the relationship between the currently recognized subspecies of American bison (wood and plains). The two wood bison haplotypes do not form a single clade (wHap 14, 15) and are mixed with plains bison haplotypes (Figs. 1 [not shown in this petition] and 4).

> The fact that both of these haplotypes fall into a clade with plains bison suggests that wood bison may never have been a genetically distinct subspecies, although it is also possible that one or both of these sequences are derived from the introduction of plains bison into wood bison herds in the 1920s (Banfield and Novakowski, 1960; Roe, 1970).

Through the phylogenetic lens of this hybridization study, the researchers concluded that wood bison were not a separate subspecies:

> Regardless of the source of these haplotypes, however, current populations of *B. bison bison and B. bison athabascae* are not significantly different with respect to their mitochondrial genomic sequences and should not be considered subspecies.

Recall, however, that Derr and Halbert, team members with the Douglas et al. study, were co-authors of *American Bison: Status Survey and Conservation Guidelines 2010*, which found that "wood bison form a genetic grouping on a Nei's minimum unrooted tree [a phylogenetic tree], suggesting genetic uniqueness" and that wood and plains bison are "historically differentiated subspecies." The Douglas et al. 2011 team did acknowledge that certain haplotyes were unique to the wood bison they studied and that what they viewed as a non-subspecies has been listed as a subspecies:

> It does appear, however, that the currently listed *B. bison athabascae* are an important source of genetic diversity for the species, since the two wood bison haplotypes were not identified in any of the plains bison populations (also see Wilson and Strobeck, 1999).

Note the quote refers to "the currently listed *B. bison athabascae,"* a reference to the U.S. Fish and Wildlife Service reclassification of wood bison *(Bison bison athabascae*) from endangered to threatened May 3, 2012. According to the Federal Register:

> The wood bison became listed in the United States under the 1969 Endangered Species Conservation Act when it was included on the first List of Endangered Foreign Fish and Wildlife, which was published in the Federal Register on June 2, 1970 (35 FR 8491). In 1974, the first list of federally protected species under the 1973 Endangered Species Act (Act; 16 U.S.C. 1531 et seq.) appeared in the Code of Federal Regulations (CFR), and the wood bison appeared on this list based on its inclusion on the original 1969 list. Because the wood bison was listed under the 1969 Endangered Species Conservation Act and grandfathered in for protection under the Act, there is not a separate Federal Register notice that defined the population(s) and their range or

> analyzed threats to the species. The wood bison was classified as endangered and has retained that designation since the original listing. (Reclassifying the Wood Bison Under the Endangered Species Act as Threatened Throughout Its Range, 2012).

The potential to identify wood bison haplotypes as present at Yellowstone National Park has significant implications, for such a finding would conceivably automatically place the herd, from which this haplotype was sampled, in a protected status, for wood bison are listed under the Endangered Species Act.

By the study claiming that wood and plains bison "should not be considered subspecies" because in the phylogenetic analysis they were "not significantly different with respect to their mitochondrial genomic sequences" is problematic. To attempt to force a species or subspecies that has experienced hybridization into a phylogenetic tree is prone to error. Recall that a phylogenetic tree is a diagram that depicts the lines of evolutionary descent of species or genes from a common ancestor. But hybridization creates a network-type of diagram where there are crosses between species or subspecies. Instead of a tree with a direct descent from a common ancestor (called monophyletic), two common ancestors are involved (called paraphyletic). Tracing the descent of a hybrid is complicated, because it is the result of two different species or subspecies reproducing.

According to Riesberg et al. in "Are many plant species paraphyletic?," for a paraphyletic species, a species classification based on the criterion of monophyly (such as a phylogenetic tree) is unlikely to be an effective tool for describing and ordering biological diversity (Rieseberg, 1994). As Olivier Gauthier et al. observed with regard to reticulations (nets, such as characteristic of the descent of hybrids, instead of trees) in "Hybrids and Phylogenetics Revisited: A Statistical Test of Hybridization Using Quartets":

> The occurrence of reticulations in the evolutionary history of species poses serious challenges for all modern practitioners of phylogenetic analysis. Such events, including hybridization, introgression, and lateral gene transfer, lead to evolutionary histories that cannot be adequately represented in the form of phylogenetic trees (Gauthier et al., 2007).

Further, a study is no better than the assumptions being made in the study. Note that Figure 36 of the phylogenetic tree indicated that the genetic differences between the clades were not enough to call them "genetically distinct subspecies." However, note that clade I is labeled "plains bison" and includes samples from Yellowstone National Park and clade II is labeled "plains and wood bison." But what if haplotypes specific to wood bison were in samples taken from the Yellowstone bison? Indeed, what if the YNP includes the genetics of both wood and plains bison? Stating the YNP is an example of plains bison, when in fact it is historically a combination of both wood and plains bison, and may have hybrids, and then saying the wood bison subspecies does not exist because clades I and II are not different would be in error, for one would be comparing plains and wood bison genetics with plains and wood bison genetics. Of course, there would be no difference. This assumption would then have the chance of throwing the entire analysis off.

What would be needed is a more sophisticated analysis than a phylogenetic tree, say a phylogenetic network (sometimes termed a "network tree"), because descent, when it comes to hybrids, is paraphyletic instead of monophyletic. As mentioned, the evolutionary descent of the organism is shaped like a net instead of a tree. In the case of hybrids, using a phylogenetic tree instead of a network could produce meaningless results.

What bothered me most about the Douglas et al. 2012 study was its exclusive use of genetics to define what a species or subspecies is without regard to what is seen in the field. For instance, two distinct breeding herds exist in Yellowstone and were therefore qualifying to be termed separate subspecies under the biological species concept. To clarify why Douglas et al. claimed wood bison were not a separate subspecies, I wrote the authors August 5, 2017:

> With regard to my general question of what species concept is being employed with regard to the statement: "Regardless of the source of these haplotypes, however, current populations of B. bison bison and B. bison athabascae are not significantly different with respect to their mitochondrial genomic sequences and should not be considered subspecies," the most probable answer is of course the phylogenetic species concept. But Avise et al., 1997, conclude in "Phylogenetics and the origin of species" that "Historical descent and reproductivity ties are related aspects of phylogeny and jointly illuminate biotic discontinuity." Yellowstone's central herd and northern herd are substantially reproductively isolated, according to Halbert et al., 2012. Further, wood bison haplotypes have been found in the indigenous, unextirpated central herd, but not in the introduced northern herd. Since phylogenetics has to do with genetic differences in determining species and subspecies, why is this discounted? Is that not a subjective decision by the authors, that is, to discount the importance of haplotypic differences? Further, would it not be more precise to also evaluate population discontinuity based on the biological species concept, instead of just genetics?
>
> One further question: what is the source of funding for this study?

On August 8, 2017 I received the following reply from James Derr, Professor, College of Veterinary Medicine, Texas A&M University:

> All inquiries of this nature need to go through media public relations department. Dr. Megan Palsa (James Derr, personal communication, August 5, 2017).

In communicating with Palsa, an interesting exchange transpired. She replied:

> Good to hear from you. I have a few questions to help me understand your request. First, who do you write for? What magazine or journal you will be writing for when you receive the responses? We receive numerous requests from the media, and I like to keep track of and in touch with the people who write about our work. Thanks so much. I look forward to hearing from you.

I replied:

> I am the author of a 2015 petition to the Department of the Interior to list Yellowstone's wild bison as endangered under the ESA. I plan to re-submit a similar petition.

She responded by sending me a copy of the very study I was asking questions about, stating:

> For your convenience, please see the attached peer-reviewed article about which you are inquiring. The data, the results, and the interpretation of this scientific publication are publicly available for your use. Thank you for your inquiry (Megan Palsa, personnel communication, September 4, 2017).

Since I did not need another copy, but instead an answer to my questions, I made a repeat query, pointing out the inadequacy of the response, which was ignored. It was puzzling that the faculty of the university's college of veterinary medicine deemed my questions to be best answered by the public relation's department, that is, media specialists, experts in dealing with the public. If research scientists at a university have to have questions about their study answered by the university's public relations department and refuse to answer the questions themselves, it increases the probability that the authors' findings were at least in part governed by politics, not science. My question about the source of the study's funding was never answered.

Recently, two clades or subpopulations have been recognized in the genetic structure of wild bison populations in Yellowstone National Park. In the 2016 article "Mitochondrial Genome Analysis Reveals Historical Lineages in Yellowstone Bison," researchers "assessed mitochondrial genomes from 25 randomly-selected Yellowstone bison."

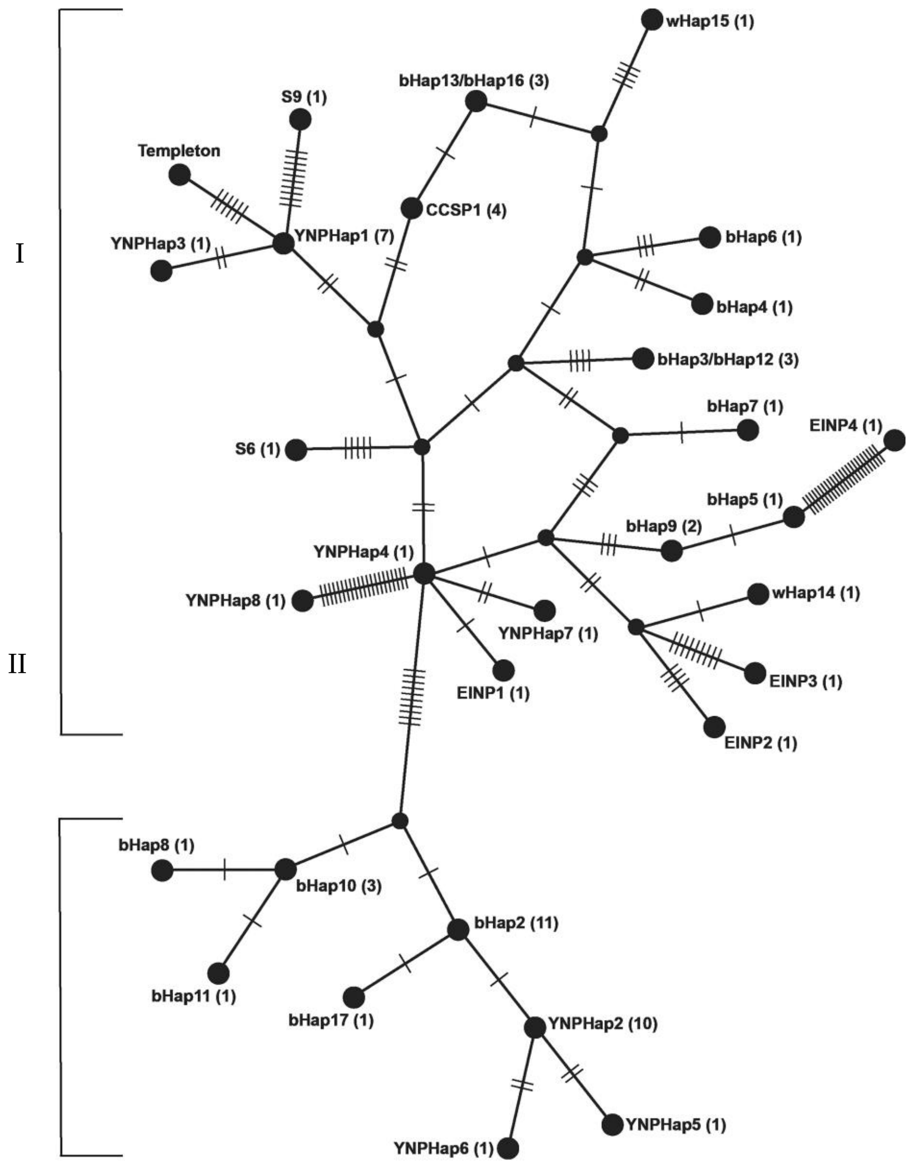


Figure 37. CLADE I AND CLADE II of park bison. Two genetically distinct herds are revealed by this network tree of North American bison, based on all polymorphic sites. Roman numerals I and II represent the two clades identified in this analysis. Each dash represents one single nucleotide difference between two neighboring haplotypes. The numbers in parentheses after the name of each haplotype denote the number of bison belonging to each haplotype. Animals with a wHap and EINP prefix denote wood bison haplotypes, while YNPHap, Templeton, and bHap17 denote Yellowstone bison. S6 and S9 are two historic bison sampled in or near modern day Yellowstone National Park. Chart from Forgacs et al., 2016.

They found 10 different mitochondrial haplotypes. The team was led by David Forgacs and included Lauren K. Dobson, and James N. Derr, all with the department of veterinary pathobiology, Texas A&M University, plus Rick L. Wallen, Yellowstone National Park. The team reported finding two lineages in the park, stating:

> we identified two independent and historically important lineages in Yellowstone bison by combining data from 65 bison (defined by 120 polymorphic sites) from across North America representing a total of 30 different mitochondrial DNA haplotypes. Mitochondrial DNA haplotypes from one of the Yellowstone lineages represent descendants of the 22 indigenous bison remaining in central Yellowstone in 1902. The other mitochondrial DNA lineage represents descendants of the 18 females introduced from northern Montana in 1902 to supplement the indigenous bison population and develop a new breeding herd in the northern region of the park.

The authors noted:

> Comparing modern and historical mitochondrial DNA diversity in Yellowstone bison helps uncover a historical context of park restoration efforts during the early 1900s, provides evidence against a hypothesized mitochondrial disease in bison, and reveals the signature of recent hybridization between American plains bison (Bison bison bison) and Canadian wood bison (B. b. athabascae).

The study found that Yellowstone's wild bison are vulnerable to inbreeding and loss of genetic diversity through genetic drift because of past large-scale lethal reductions:

> One of the most iconic species living in Yellowstone National Park (NP) is the American plains bison (Bison bison bison). American bison survived multiple historic and recent population bottlenecks due to habitat reduction, commercial hunting, and diseases from imported domestic livestock [1]. Populations undergoing major reductions in size with constrained areas of distribution are vulnerable to the effects of inbreeding and the loss of genetic diversity through genetic drift [2, 3].

At the time of reporting the analysis (2016), the Yellowstone herds were found to have high haplotype diversity:

> The analysis of the mitochondrial genome of 25 Yellowstone bison yielded ten unique haplotypes, demonstrating high haplotype diversity in this population 0.78 (± 0.06). These haplotypes had little differentiation between them with

> the overall mean difference of 0.00103, which demonstrates the historic bottleneck and the subsequent process of increasing diversity due to the population boom and good management practices. High diversity is associated with greater population health and higher fitness in animals [22, 23].

In the introduction to the study, Forgacs et al. noted the results of a past study led by Texas A&M colleague Natalie Halbert, which has been discussed above. The Forgacs et al. study noted:

> Halbert et al. [11] evaluated 46 nuclear microsatellite loci from Yellowstone bison and found evidence of a moderately high level genetic diversity (0.626) and gene patterns indicating the existence of at least two subpopulations (the northern and the central herds) with limited gene flow between them.

As mentioned, Forgacs et al. also reported finding two subpopulations in the park, that is, two evolutionary lines of descendants among Yellowstone's bison populations.

To visualize the two units, the study produced a cladogram, using a Java computer program called the Templeton-Crandall-Singh (TCS) network tree to estimate gene genealogies. A phylogenetic network analysis, as mentioned, works better than a traditional phylogenetic tree in the presence of hybridization events, such as has occurred with the two Yellowstone herds, because the evolutionary history is not monophyletic; that is, although grouped together they do not share an immediate common ancestor. The authors noted the complex history of wood bison and that it is "not a single monophyletic group":

> The present study has contributed eight new haplotypes to a large dataset with over a million base pairs of mitochondrial DNA sequence analyzed from bison across North America. These data have significant implications beyond the Yellowstone bison population. For example, the bison network (Fig 3) indicates that wood bison (Bison bison athabascae) are not a single monophyletic group. Approximately 6,600 plains bison from the Conrad herd were used to supplement the local population in Wood Bison NP in the 1920s [7]. Hybridization between plains and wood bison is well documented [26,27], which certainly confuses their current taxonomical status. Elk Island NP received 23 animals from Wood Bison NP in 1965. While Cluster 3 (Fig 3) represents a monophyletic group that is markedly different from the closest plains bison haplotype, others, such as wHap15, represent animals that may phenotypically look like wood bison but their mitochondrial DNA is closely related to plains bison. The closest haplotypes to wHap15 are bHap13/bHap16. These two haplotypes are from the descendants of the historical bison herd of Charles Goodnight which now constitutes the Caprock Canyon State Park herd in Texas. Historical documents show that Conrad purchased a bison heifer

from Goodnight before he sold plains bison to the Canadian government that they used to supplement the bison herd in Wood Buffalo NP [7].

The TCS network tree identified two distinct clades of haplotypes separated by 10 polymorphisms unique to every member of each clade: Clade I, the endemic central herd, and Clade II, composed of the introduced northern herd. As the authors explained:

> When the 10 Yellowstone haplotypes were compared with the 20 other bison haplotypes from across the United States and Canada, there was a clear division between Clade I and II. The comparatively large genetic distance between the two clades—10 single nucleotide polymorphisms in contrast to the smaller distance between internal nodes within each clade—shows the signature of a major historic event that explains the separation between the two. Clade I contains haplotypes that are more similar to the two historic bison (S6 and S9) that lived in or near modern day Yellowstone National Park, while Clade II consists of bison that are genetically more dissimilar to those. Clade II also includes animals that are known to have originated from the Pablo-Allard herd, such as the samples from the National Bison Range, Fort Niobrara National Wildlife Refuge, as well as the bison introduced to northern Yellowstone NP in 1902. Thus, we conclude that Clade I contains haplotypes that are more closely associated with the indigenous bison that lived in the area for hundreds of years while Clade II has haplotypes that resemble the bison introduced to the park from northern Montana in 1902.

Further, the researchers found the central herd to be absent a mutational defect present in the introduced herd, stating:

> Our findings indicate that no bison in Clade I have the mutations implicated in IMOPs, while both mutations were present in all bison in Clade II. Therefore, all the introduced bison from the Pablo-Allard herd and their descendants have these mutations.

IMOP stands for "impairment of mitochondrial oxidative phosphorylation," a disease caused by deleterious mutations in an animal's mitochondrial DNA. In bison, it can significantly impair aerobic capacity, disrupting cold tolerance, winter feeding behaviors, escape from predators and competition for breeding (Pringle, 2011).

The results of this study with regard to the presence of IMOP conflict with the results of another study by Pringle (Pringle, 2011) which associates IMOP more with the central herd.

In a related study titled "Mitochondrial DNA analysis reveals hidden genetic diversity in captive populations of the threatened American crocodile (*Crocodylus acutus*) in Colombia," a team led by Paul Bloor conducted mitochondrial DNA (mtDNA) surveys to identify phylogenetic and population structure below the species level. The analysis found that the absence of a population's haplotypes in other similar populations could be interpreted to indicate two separate lineages and could represent two distinct evolutionary units.

The authors stated: "We suggest that this differentiation needs to be recognized for conservation purposes because it clearly contributes to the overall genetic diversity of the species." In summing up their findings, the researchers made some observations about crocodile lineages that apply to the Petitioner's position that two separate subspecies exist in Yellowstone and should be conserved:

> Two distinct lineages were identified: C. acutus-I, corresponding to haplotypes from Colombia and closely related Central American haplotypes; and C. acutus-II, corresponding to all remaining haplotypes from Colombia. Comparison with findings from other studies indicates the presence of a single "northern" lineage (corresponding to C. acutus-I) distributed from North America (southern Florida), through Central America and into northern South America. The absence of C. acutus-II haplotypes from North and Central America indicates that the C. acutus-II lineage probably represents a separate South American lineage. There appears to be sufficient divergence between lineages to suggest that they could represent two distinct evolutionary units (Bloor, 2015, pp. 130-140).

After laying the groundwork for the existence of two genetically distinct bison herds in the park, what do the authors of the Forgacs et al. study conclude as far as future management of the park? One would think the decision would be to manage the park as two herds because of the haplotypic differences, especially since the IMOP-free status of the endemic central herd (as found by Forgacs et al.) descended from the wood bison. But no, that is not the case.

At the very beginning of the study, a bias is displayed that favors the northern herd, that is, *Bison bison bison*. The first sentence of the abstract states:

> Yellowstone National Park is home to one of the only plains bison populations that have continuously existed on their present landscape since prehistoric times without evidence of domestic cattle introgression.

This statement is in error. Plains bison have not "continuously existed on their present landscape since prehistoric times," since they are composed of the herd introduced in 1902. Instead, it is the descendants of wood bison that have "continuously existed on their present landscape since prehistoric times." In the same abstract a few sentences later, after claiming plains bison are the endemic herd, the authors contradict themselves, stating: “Mitochondrial DNA haplotypes from one of the Yellowstone lineages represent descendants of the 22 indigenous bison remaining in central Yellowstone in 1902,” which are identified as coming from “Canadian wood bison (*B. b. athabascae*).” Of course, the latter sentence is the case and the first statement misleading.

Worse, the findings of the study are then twisted to justify the management of the two herds as one. The reasoning goes like this. Forgacs et al. again refers to the Halbert et al. study, saying it found two breeding herds, but then said that the Forgacs’ team found no geographic subdivision between the two herds. The authors stated:

> Using the 22 Yellowstone bison sampled for this study where sampling locations were well documented, population subdivision was tested on a geographic scale, using the northern and central herds as the two hypothetical populations. This study did not find any evidence of population subdivision between the two herds based on mitochondrial DNA. Halbert et al. [11] found evidence for population subdivision and the existence of at least two breeding herds within the Yellowstone bison population based on STRUCTURE analysis [25] using 43 nuclear microsatellites, but reported similar FST values to ours (0.0321).

In other words, according to Forgacs et al., while the team’s mathematical analysis found two distinct genetic clusters—Clade I correlated with the central herd and Clade II correlated with the northern herd—as did the Halbert et al. study, when the program being used by Forgacs et al. attempted to literally bring the results down to earth, geographic subdivisions were not apparent. According to Forgacs et al., this discrepancy may be due to a number of factors:

> 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.

If the Forgacs et al. study were correct, an examination of the park should not find geographically subdivided herds, but instead one panmixia herd composed of two lineages. However, the Halbert et al. study refutes this, as it geographically identified the two herds as genetically separate, one in the central portion, the other in the northern portion.

Given this differential in findings, what did the Forgacs study conclude vis-a-vis management of Yellowstone’s wild bison? That the two herds can be managed “as a single population with multiple breeding segments.” They state:

> The status of the Yellowstone bison population based on our findings of high haplotype diversity and lack of population subdivision appears to be

> genetically healthy, especially for a population with a history of intensive management that included periods of extreme reductions in size. In recent years, as the number of bison has grown exponentially and more bison leave the park during the winter, culling of animals to control their abundance and distribution has become necessary. Our finding that there is no subdivision based on mtDNA support that Yellowstone bison can be managed—for mitochondrial haplotype diversity—as a single population with multiple breeding segments.

Before actually launching such a program, however, Forgacs et al. recommends more studies:

> 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.

Who funded this study? The paper states:

> Funding: The grant that enabled this study was P12AC71337 (formerly P12AT51121) awarded by the Department of the Interior, National Park Service [https://www.nps.gov/index.htm]. The funding agency had a role in the design and data collection of the study by picking and handling the animals, and also helped with the preparation of the manuscript.

What member of the National Park Service took part in the study, including preparation of the manuscript? Rick L. Wallen, who has been the lead wildlife biologist for the bison program at Yellowstone National Park since 2002. He and his colleagues have demonstrated time and again a bias toward preserving wild bison as one herd, resulting in the depopulation and potential eradication of the central herd. By systematically eliminating the migratory, the northern herd at some point in the future may also go extinct, for that protective trait has been compromised.

Including in the study an employee of the funding agency, who has a stated bias against preserving the central herd, is inviting bias in the study and calls into question the paper's concluding statement that "The authors have declared that no competing interests exist."

11

Managing two herds as one leads to extinction

Even looking at the population of wild bison in the park as a total—not the northern and central herds individually—under the present culling protocols of the IBMP, extinction is possible. Killing only migratory animals will reduce genetic diversity in such a targeted species, exposing the population as an aggregate to extinction.

To keep out of the emergency room of disappearing species (and we are already there with the central herd), members of that species must be fit, in particular fit to adapt to a changing environment. In wildlife, preservation of the traits that enabled a species to survive during its evolution is key to protecting a species from extinction. What specifically does one want to preserve? Whatever contributes to fitness. What indicators would one look for to measure fitness? Such factors as genetic diversity, that is, a wide variation of alleles for a species to rely on so as to adapt to changes in the environment.

The level of heterozygosity is a key indicator of genetic diversity. As noted previously, low genetic heterozygosity is associated with loss of fitness in many natural populations. High heterozygosity means lots of genetic variability. Low heterozygosity means little genetic variability and can be attributed to forces such as inbreeding (McDonald, 2008).

Recall in the previous discussion on heterozygosity of the fruit fly that the (Rr) maggots are of particular value because they enable a population to adjust to whether more or fewer rovers or sitters are needed to adapt to environmental changes. How would this perspective apply to wild bison and migration? Let us say that bison have alleles for movement behavior. What potentially will the systematic culling of bison moving out of the park do to the movement behavior and heterozygosity of this wild species? A number of possibilities exist. Here are two concepts that might happen. Both are highly oversimplified “proof of concept” models, not a real projection (which is probably impossible).

Scenario 1: Migration is under simple genetic control, and when you select against it by culling migrants, it goes away. The non-migrating allele is at low frequency initially, so change is slow at first but then speeds up.

Scenario 2: Migration out of the park is an aspect of general movement behavior. Culling emigrants selects for more conservative behavior, but the effect on emigration rate is limited.

Computational biomodeling builds computer models of biological systems to assess their behavior under different possible assumptions and conditions, when the complexity of the biological system means that we cannot make predictions based on our intuitions. This is accomplished by calculation and visualization software. Computer-generated mathematical simulation models help predict how systems will react under different environments.

Such models can help “predict which species are at greatest risk of extinction” and “identify effective measures for their preservation,” according to *Dynamic Models in Biology,* authored by Stephen P. Ellner, Department of Ecology and Evolutionary Biology and John Guckenheimer, Mathematics Department, Cornell University (Ellner et al., 2006). For the purpose at hand, a simulation model can help predict what the outcomes of the two above scenarios might be.

A programming language widely used by statistical researchers and theoretical biologists for simulating dynamic models of biological systems is simply called R (R Core Team, 2015). Ellner provided the following simulations for Scenarios 1 and 2, using the R language to perform the calculations (see Appendix B, this petition, second volume). A locus is the specific location of a gene (paired alleles) on a chromosome.

Scenario 1: One locus controls migration and nothing else. Individuals with 2 copies of the “A” allele have 20% probability of migrating, and are culled. Individuals with 2 copies of the “a” allele don’t migrate. Heterozygotes are exactly intermediate. Initial state is “A” allele at 99% frequency in the herd.

Scenario 2: Still one locus, but migration is assumed to be one aspect of a general tendency to seek greener pastures when local conditions are poor. Those who migrate out of the park are culled, but this is countered by selection for “seek greener pastures” behavior within the park. As “seekers” become rarer, the odds of a “seeker” finding greener pastures go up (because more of the herd stays where it’s not so good). Thus, as the “a” non-migrant allele increases in frequency, the baseline fitness (fitness unrelated to culling) of the “A” allele goes up, leading to a stable polymorphism. The final frequency of

"A" and "a" alleles could be anything—it's determined by the assumed relationship between "non-seeker" frequency and the baseline fitness of "seekers."

In both examples, segments of the bison population are culled annually to keep them near a 3,000 total population level. Running these simulations provides the following visualization:

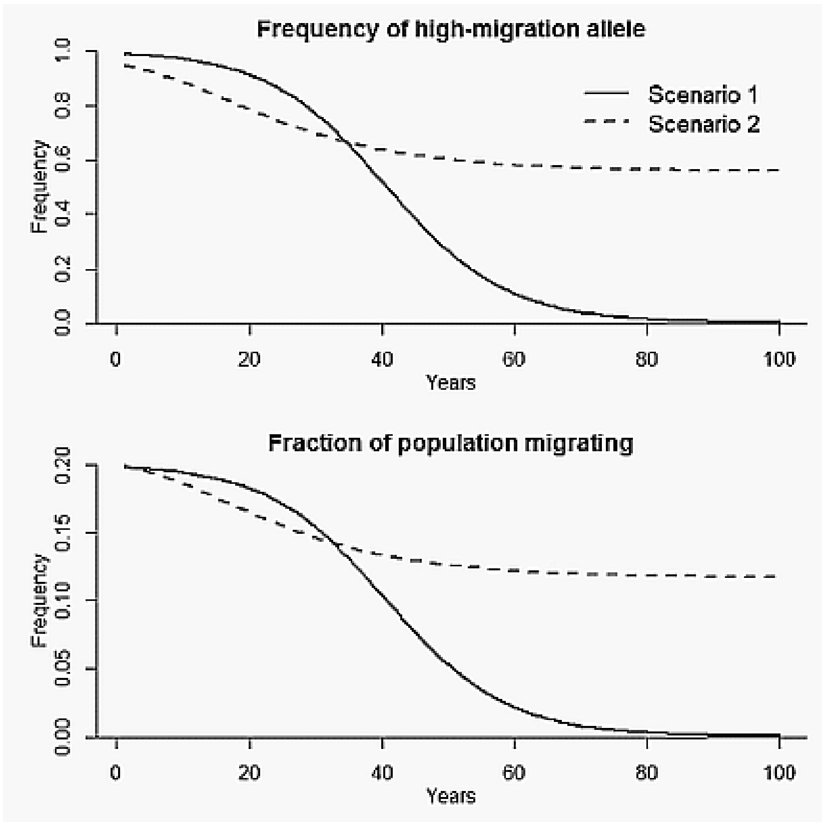


Figure 38. MIGRATION SCENARIOS 1 and 2. See Appendix B, this peition, second volume, for computer script in the R language for calculations (Ellner, personal communication, August 5, 2015).

In Scenario 1, the allele governing migration, and thus the fraction of the population migrating, gradually declines over the years, then starts to nosedive. In this scenario the wild, migratory herd is headed for extinction as it approaches 80 years of culling at 20 percent. This is what could happen if the present culling of wild bison continues at the present rate, for 900 animals culled is about 20 percent of a herd size of 4,900.

In Scenario 2 a heterozygous herd is maintained. This is what could happen if bison come down from the higher elevations of the park in winter and congregate in the lower interior valleys, such as Lamar, Madison, Firehole and Hayden. Those that drift into Gardiner Basin would be culled, but high heterozygosity would be maintained, because the probability of being culled as a result of migration is counterbalanced by the advantage of the movement behavior at other times and places.

As scenarios, these simulations are of course not a reflection of reality but merely show a range of possible outcomes. What is happening in Yellowstone is most likely a combination of both scenarios and with different variables.

But there is a third scenario—a worst case scenario. It has many variants. Let us take a look at one of them.

Let us say that after a number of years of Scenario 1 (strong selection against migratory genotypes), punctuated by a few years of Scenario 2 (selection for intermediate movement behavior), the herd's heterozygosity is diminished. This means the herd would become less adaptive year by year. Let us say the bison population has increased because bison that have tested positive for brucellosis have been culled, resulting in a higher percentage of disease-free animals. While this may be immediately beneficial for the herd, what is being eliminated along with those that have an active disease are those bison that have immunity to the disease, for testing does not discriminate between those with active disease and those that have an immune response. This means that over time the herd will become less resistant to *Brucella abortus.*

During severe winters, large segments of both the northern herd and the central herd migrate out of the park, resulting in high numbers culled. As mentioned, Yellowstone's bison herd was reduced from a population of 3,500 in 1996 to 1,700 in 1997, including births. A total of 1,100 head were culled and another 1,000 head died of starvation inside the park that winter (NASDA Policy Statements, 2011), totaling a reduction of 2,100 animals. This represents a 60 percent reduction of the herd.

In 2008, 1,087 bison were captured and shipped to slaughter from the Stephens Creek and Horse Butte capture facilities. Another 166 bison were lethally removed by state-licensed and tribal hunters. Total herd population went from 4,700 to 3,000, winter die-off accounting for the mortality of another 500 animals (National Park Service, 2008). This represents a 64 percent reduction of the herd.

Culling is now directed at the Gardiner Basin dispersal sink. Being lower in elevation than the interior of the park, it is a place where animals find refuge when the going gets rough. Here bison instinctively migrate to survive the Yellowstone winters, descending first from the high elevation regions such as Mirror Plateau (9,000 feet), down to the high valleys and basins, such as Lamar Valley or Lake Hebgen (both 7,000 feet) and then down to Gardiner Basin (5,000 feet). During a harsh winter they have nowhere else to go.

Let us say during one severe winter, one-third of the bison are culled in Gardiner Basin at the Stephens Creek capture facility, another one-third die of starvation or freeze to death and another one-third die of disease, those congregated around the thermal pools. When the rangers make their count of winter kill the following spring, what number would be left? Zero. What would have been left if not slaughtered by the IBMP? The third that had escaped to the dispersal sink, Gardiner Basin.

Scenario 3, the worst case scenario, can have multiple components and outcomes. Another possibility is that all bison perish except a few non-migratory bison within the park. What has survived is *only* the non-migratory. Result? Extinction of the migratory—genomic extinction.

Whether scenario 1 or 3 turns out to be the case, Gardiner Basin is the escape hatch, the life boat for bison, as well as other wild ungulates. It is the genetic insurance policy nature has built into the environment to protect the diversity of wild bison in a changing environment. But in the middle of this life boat the IBMP has poked a hole. That hole is the Stephens Creek capture facility and the IBMP's policy of large-scale reduction of migratory bison. All bison that attempt to use it will perish. At some point this artificial practice guarantees extinction.

12

Biologists' defense against government criticism

In March 2008 the Government Accountability Office published a review of the Interagency Bison Management Plan titled *Yellowstone bison: Interagency plan and agencies' management need improvement to better address bison-cattle brucellosis controversy"* The GAO found the plan lacking, stating:

> The plan has two broadly stated goals: to "maintain a wild, free-ranging population of bison and address the risk of brucellosis transmission." The plan, however, contains no clearly defined, measurable objectives as to how these goals will be achieved, and the partner agencies have no common view of the objectives (Yellowstone bison, 2008).

In response to that critical review, a report was prepared in 2008 and updated in 2014 by P. J. White, Chief, Wildlife and Aquatic Resources; Rick Wallen, Bison Ecology and Management Program; and John Treanor, Yellowstone Wildlife Health Program, entitled "Yellowstone National Park: Monitoring and Research on Bison and Brucellosis." Contained in that report is a flowchart summarizing the conditions desired and the means by which those conditions would be achieved. That chart is reproduced below.

Upon inspection, the report is disappointingly Janus-faced. Out of one side of their mouths the authors espouse high-sounding bison conservation concerns such as preserving their migratory behavior, ecological role and function in an ecosystem, the role of natural selection and evolutionary potential as well as their demographic health—of which a key promoter is availability of habitat. To control brucellosis transmission they indicate the need for the separation of cattle from bison. This is all fine and dandy.

DESIRED CONDITIONS

- Bison abundance averages 3,000-3,500 per decade, while maintaining 95% of existing genetic diversity.
- Increased tolerance for bison outside Yellowstone, while maintaining separation between bison and cattle.
- Decrease in brucellosis prevalence in bison to levels similar to sympatric elk (5-10%).

Manage Brucellosis Transmission Risk	**Conserve a Wild Bison Population**	**Brucellosis Suppression**
Separation to prevent bison-cattle mixing	Migratory behavior	Vaccination/Fertility Control
Cattle management	Ecological role and function in ecosystem	Culling infectious bison
Management culls and harvests of bison	Natural selection/ evolutionary potential	Disease surveillance
Adaptive management	Demographic health	Socioeconomics
Research: disease dynamics/transmission		Brucellosis research

Figure 39. PRESENT CONCEPTUAL MODEL of "conservation and brucellosis management for Yellowstone bison."

But out of the other side of their mouths they list the need for culling and harvesting bison to achieve this separation, as opposed to the permanent removal of cattle from critical migratory habitat historically occupied by bison. Further, by setting a goal of 95 percent retention of genetic diversity, IBMP is tolerating a 5 percent reduction of that diversity. This is unacceptable ecologically, especially when you consider that no identification has been made of which genes may be expected to be lost, that this reduction is biased toward certain traits expressed behaviorally (such as non-migratory behavior) and that lethal selections will be progressively incremental toward that bias.

When one reads through the document to find ecological justification for such culling, one finds the opposite.

Lethal removal of large numbers of mammals from a population has the potential of reducing the genetic fitness of that group. If a subpopulation of a group of animals (such as wild bison) is genetically rich, it would stand to reason that one would do everything possible to preserve that strength—namely, adaptive capabilities with relatively high genetic diversity—instead of depleting it.

In fact, this is the conclusion some of the authors of the above report came to in a 2010 study, "Management of Yellowstone bison and brucellosis transmission risk: Implications for conservation and restoration." In this study, P. J. White, Rick L. Wallen, Chris Geremia, John J. Treanor and Douglas W. Blanton concluded:

> In summary, the risk of disease transmission from migratory ungulates to livestock near reserve boundaries often restricts ungulates to areas that do not contain all the seasonal habitats necessary for their survival. Even relatively large reserves such as Yellowstone National Park generally contain only a subcomponent of the habitat needed by migratory ungulates. Long-term conservation of plains bison requires restoring populations to other locations. Yellowstone bison provide the wild state and adaptive capabilities needed for restoration but, to date, the brucellosis issue has prevented their use in restoration efforts. Thus, management plans should incorporate a conservation component that does not limit wildlife to isolated reserves, but facilitates responsible restoration efforts for long-term conservation (White et al., 2010).

Yellowstone bison genetically have what it takes to survive in the wild. They are a genetic treasure trove. They have "the wild state and adaptive capabilities" essential for the genetic restoration of other bison herds because of their genetic strength and fitness, an attribute of their wildness. And wildness means being left alone to evolve through natural selection and survival of the fittest. And that means not fencing such wild animals, for fencing is the primary tool of domestication. It is used to selectively separate the wilder animals from the more tame. Fencing comes in many forms: wire, wood, stone and management actions that retard movement and confine, such as by lethal removals and hazing.

However, while the government acknowledges that fencing is not compatible with wilderness, under the auspices of the IBMP, it is not only fencing in wild bison by restricting their migratory movements through hazing, but it is killing those very animals that in effect touch that "fence," that invisible park boundary.

This is not wilderness. Again, this is domestication. Wilderness is where animals are free from enclosure and are unrestricted in movement. Wilderness and domestication do not mix. Domesticated animals do not have what it takes to survive in a wilderness. They lack fitness.

Nudge nudge, wink wink

Let us look at a sampling of the findings of the report "Yellowstone National Park: Monitoring and Research on Bison and Brucellosis." It is a self-justification of the management practices directed toward wild bison now being conducted by the IBMP inside and outside Yellowstone National Park.

If you want the public to support a dubious position, in addition to instilling fear, you praise what the public wants, but do what you want. In Yellowstone, it goes like this: first you say something like "Watch out, the bison are coming! They are migrating into your back yards!" Then you warble to a shaken public: "But we love buffalo. They are so iconic. We love to see them roam, nudge nudge, wink wink." Then you roam them into a bison trap and migrate them off to a slaughterhouse. By the thousands. Such love.

On examination, the report is a collection of contradictions when one matches words (assessments) with actions. Petitioner's observations of IBMP's actions (under "Contradictory action being taken,") will follow each self-assessment passage by IBMP as found in the report.

The report, an exercise in apologetics by IBMP and its advising biologists, states:

> ***Page 6:*** Overarching principles for conserving bison were to (1) maximize the number of bison in a population (i.e., 'maximum sustainable' rather than a 'minimum viable' population size) to better retain natural variation and provide more resiliency to 'surprises' or catastrophic events, (2) support and promote 'wild' conditions and behaviors in an environment where bison are integral to community and ecosystem processes, exposed to natural selection, and active management interventions are minimized, (3) preserve genetic integrity and health by maintaining bison lineages and carefully evaluating all movements of bison between populations, and (4) conducting routine monitoring and evaluation of demographic processes, herd composition, habitat, and associated ecological processes that are central to evaluating herd health and management efficacy.

Contradictory actions being taken: Instead of acting on these proclaimed "overarching principles for conserving bison," the IBMP has 1. scheduled a reduction of the number of wild bison by a factor of up to 900 animals in 2015, another 900 animals in 2016, another 1,300 in 2017 and another 1,250 in 2018; 2. discouraged wild behavior by culling those obeying the instinct to migrate; 3. depleted the genetic integrity and health of the herds by these actions. Management did not "preserve genetic integrity and health by maintaining bison lineages," but instead drastically undermined them by culling the native central bison herd lineage from a high of 3,531 animals in 2005 to 847 in 2017. The term "overarching principles" as used here is lip service.

> ***Page 8:*** Bison from the central herd were partially migratory, with a portion of the animals migrating to the lower-elevation Madison headwaters area during winter while some remained year-round in or near the Hayden and Pelican valleys.

Contradictory action being taken: While acknowledging the existence of a partially-migratory herd, the IBMP is continuing to cull only the migratory, i.e., those that attempt to leave the park, favoring survival of the non-migratory herd.

> ***Page 9:*** Simulations of migrations over the next decade suggest that a strategy of sliding tolerance where more bison are allowed 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.

Contradictory action being taken: Scheduling and carrying out large-scale reductions year after year, disregarding the findings of simulation studies recommending a sliding scale of tolerance.

> ***Page 10:*** Based on mitochondrial DNA analyses, there was significant genetic differentiation between bison sampled from the northern and central breeding herds, likely due to strong female fidelity to breeding areas (Gardipee 2007).

Contradictory action being taken: Scheduling culling winter after winter that has disproportionally reduced the size of the central herd, thereby diminishing its genetic health, which in turn will diminish the health of both the central and the northern herds due to the increased potential for inbreeding depression, a reduction of fitness associated with small populations and less gene flow.

> ***Page 10:*** Yellowstone bison have relatively high allelic richness and heterozygosity compared to other populations managed by the Department of Interior.

Contradictory action being taken: Instead of doing all it can to conserve this "allelic richness and heterozygosity," the IBMP is depopulating this valuable source of heterozygosity by means of scheduling continued large-scale reductions for the future.

> ***Page 10:*** Yellowstone bison are the only population with no molecular evidence (i.e., microsatellite markers) or suggestion (i.e., SNPs [Single

Nucleotide Polymorphisms]) of potential cattle ancestry (i.e., introgression of cattle genes). Thus**,** this population constitutes a genetic resource that must be protected from inadvertent introgression.

Contradictory action being taken: Protecting from "inadvertent introgression" is achieved by separating domestic cattle from wild bison. This is simple to do—do not bring a domestic animal into the vicinity of a wild animal. On the other hand, separating a wild animal from the vicinity of a domestic animal means either fencing, hazing or culling the wild animal. It is costly and destroys wildlife. Instead of keeping cattle from the vicinity of wild bison, the simple solution, the IBMP has chosen the costly one that destroys wildlife and is more prone to "inadvertent introgression."

Page 11: NPS staff collaborated with colleagues at the University of Montana to conduct a mathematical modeling assessment that provided predictive estimates of the probability of preserving 90 and 95% of the current level of genetic diversity values (both heterozygosity and allele diversity) in Yellowstone bison (Pérez-Figueroa et al. 2012).

Findings suggested that variation in male reproductive success had the strongest influence on the loss of genetic variation, while the number of alleles per locus also had a strong influence on the loss of allelic diversity.

Fluctuations in population size did not substantially increase the loss of genetic variation when there were more than 3,000 bison in the population. Conservation of 95% of the current level of allelic diversity was likely during the first 100 years under most scenarios considered in the model, including moderate-to-high variations in male reproductive success, population sizes greater than 2,000 bison, and approximately five alleles per locus, regardless of whether culling strategies resulted in high or low fluctuations in abundance.

However, a stable population abundance of about 2,000 bison was not likely to maintain 95% of initial allele diversity over 200 years, even with only moderate variation in male reproductive success. Rather, maintenance of 95% of allelic diversity is likely to be achieved with a fluctuating population size that increases to greater than 3,500 bison and averages around 3,000 bison.

Contradictory action being taken: Culling a separate breeding population, i.e., the central herd, below the level of 2,000 animals, in fact, down to 850 animals, is in complete disregard for the findings of mathematical models.

Further, this is an example of governmental sleight of hand. The IBMP's plan in fact does not involve random culling, but instead is aimed squarely at migrating bison. The study does not simulate what is actually going on at the border of Yellowstone National Park vis-à-vis culling strategies. The *in silico* model is not relevant. The computer simulated bison populations study simulates the wrong populations. The culling transpiring at the park's border is not random, juvenile, or adult, but instead limited to those bison that are migratory.

Therefore the study is useless as a predictive model regarding the loss of genetic variation by the population reduction methods being used at the park. It is an example of garbage-in, garbage-out.

In point of fact, the park service knows that the large-scale culling removals are *not* random. As "Estimating probabilities of active brucellosis infection in Yellowstone bison through quantitative serology and tissue culture," by John J. Treanor, Chris Geremia1, Philip H. Crowley, John J. Cox, Patrick J. White, Rick L. Wallen and Douglas W. Blanton (some of the very same authors who wrote the report "Yellowstone National Park: Monitoring and Research on Bison and Brucellosis"), explains:

> These large-scale bison removals have not been random, because bison social structure and the reproductive demands of pregnancy predispose female bison and their recent offspring (i.e. male and female calves and yearlings) to culling as they move onto low-elevation winter ranges outside the park. The effects of several large, nonrandom culls during the past decade have contributed to a skewed sex ratio in favour of male bison, gaps in the population's age structure and reduced productivity that, if continued over time, could reduce the potential of Yellowstone bison to respond to future challenges (White et al. 2011) (Treanor, 2011).

Further, the Pérez-Figueroa study makes the following claim, which has produced a misunderstanding:

> conservation geneticists have suggested that a reasonable management goal for maintenance of genetic variation is to retain approximately 95% of H_e [heterozygosity] over 100–200 years.

This statement, upon which the White report is based, contains a conceptual error. A 2002 paper by F.W. Allendorf and N. Ryman titled "The role of genetics in population viability analysis" is cited as an authority for this claim. Yes, that paper says that "We recommend retaining at least 95% of heterozygosity in a population over 100 years." But it also stresses that this is a worst-case scenario:

> The population size required to meet this genetic criterion should not be considered a goal, but rather a lower limit below which genetic considerations are likely to reduce the probability of population persistence (Allendorf, 2002, p. 51).

Page 12: Allowing the bison to migrate and disperse between breeding herds would be in the best interest of the bison population for the long term.

> The NPS will continue to allow ecological processes such as natural selection, migration, and dispersal to prevail and influence how population and genetic substructure is maintained in the future rather than actively managing to perpetuate an artificially created substructure. The existing population and genetic substructure may be sustained over time through natural selection or it may not.

***Contradictory action being taken**:* The IBMP, instead of allowing ecological processes to prevail, is doing the opposite by slaughtering migrating animals and thereby killing a disproportionate number in the central herd, reducing breeding opportunities, promoting artificial selection biased toward non-migratory herd members and discouraging natural selection forces. While verbally condemning "actively managing to perpetuate an artificially created substructure," that is in fact what IBMP's culling is doing. Targeting the migratory for lethal removal has resulted in the exponential growth of the northern herd, the artificially introduced herd of captive plains bison brought to the park in 1902, which is significantly less migratory and thus less exposed to culling.

> ***Pages 14-15**: B. abortus* isolates from bison, elk and cattle . . . [were collected to] test which wildlife species was the likely origin of recent outbreaks of brucellosis in cattle in the greater Yellowstone area (Beja-Pereira et al. 2009).
>
> Findings suggested that isolates from cattle and elk were nearly identical, but highly divergent from bison isolates. Thus, elk, not bison, were the reservoir species of origin for these cattle infections.

Contradictory action being taken: Instead of acting on these findings in accord to adaptive management practices, the IBMP continues to target only bison for slaughter as a means of controlling brucellosis that tests show is being spread by elk, not bison.

> ***Page 15:*** The risk of transmission of brucellosis from bison to cattle is likely to be a relatively rare event, even under a 'no plan' (no management of bison) strategy.
>
> The risk of transmission of brucellosis from bison to cattle will increase with increasing bison numbers and severe snow fall or thawing and freezing events. As the area bison occupy outside Yellowstone in the winter is enlarged and overlaps cattle grazing locations, the risk of transmission will increase. Thus, adaptive management measures to minimize risk of transmission will be most effective.

Contradictory action being taken: Brucellosis is rarely transmitted in winter, but to reduce that chance to zero—the only acceptable level for the IBMP—removing cattle from the habitat now shared is the only solution. However, the IBMP refuses to take this action, the most cost-effective and most disease-preventive adaptive management measure. So far "adaptive management" in the hands of the IBMP is management heavily biased toward the cattle industry and against wildlife and conservation interests in the middle of one of the world's largest and most valued ecosystems.

> ***Page 16:*** Allowing bison to occupy public lands outside the park where cattle are never present (e.g. Horse Butte peninsula) until most bison calving is completed (late May or early June) is not expected to significantly increase the risk of brucellosis transmission from bison to cattle because: 1) bison parturition is essentially completed weeks before cattle occupy nearby ranges; 2) female bison consume many birthing tissues; 3) ultraviolet light and heat degrade *B. abortus* on tissues, vegetation, and soil; 4) scavengers remove fetuses and remaining birth tissues; and 5) management maintains separation between bison and cattle on nearby ranges.
>
> 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. The risk of brucellosis transmission to cattle can still be minimized through effective management of bison distribution.

Contradictory action being taken: Instead of managing the disease of brucellosis, the IBMP manages only bison, exempting elk which calve until late June when cattle are grazed on land that has the high potential of containing brucellosis-infected birthing materials from elk, nullifying any disease-control efforts directed toward bison.

> ***Page 16:*** There was a reproductive cost of diminished birth rates following brucellosis infection, with only 59% of seropositive and recently seroconverting females with calves compared to 79% of seronegative females with calves.

Contradictory action being taken: Instead of allowing natural ecological processes, killing bison without regard to an animal's status of brucellosis immunity increases the chance of reducing the percentage of immune animals. On the other hand, by culling female bison showing signs of past infection with brucellosis, the IBMP is increasing the proportion of more fertile bison, a status contrary to its expressed goal of a reduced bison population.

> ***Page 17:*** Population size and winter severity were major determinants influencing bison movements to lower elevation winter grazing areas that overlapped with private ranches and federally-regulated cattle grazing

> allotments. Increasing population size resulted in higher bison densities and increased bacterial shedding . . .
>
> Natural bison migration patterns and boundary management operations were important for minimizing brucellosis exposure risk to cattle from bison, which supports continued boundary management operations for separation between bison and cattle.

Contradictory action being taken: The passage is self-contradictory. "Natural bison migration patterns" apparently is a phrase thrown into the sentence to sound good, but migration patterns do not "minimize brucellosis exposure risk to cattle from bison;" they increase it. Effective, realistic, cost-effective separation without harming the ecosystem can only be achieved by removing cattle from the park environs in the face of "natural bison migration patterns."

> ***Page 17:*** *B. abortus* field strain persisted up to 43 days on soil and vegetation at naturally contaminated bison birth or abortion sites.

Contradictory action being taken: Infection with *B. abortus* causes ungulates to abort regardless of the species shedding it in birthing material in the field. Both elk and bison spread the disease, yet only bison are excluded from the habitat grazed by cattle. Result: no disease control between brucellosis-infected ungulates and cattle.

> ***Page 18:*** This study [by APHIS] indicates that elk play a predominant role in the transmission of *B. abortus* to cattle located in the greater Yellowstone area.

Contradictory action being taken: Despite warning after warning, the IBMP continues to target only bison for slaughter as a means of controlling brucellosis that tests show is being spread by elk.

> ***Pages 19-20:*** 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 herd immunity, thereby reducing the spread of disease.

Contradictory action being taken: Without paying attention to disease status or recovery levels, the IBMP continues and sometimes accelerates bison culling, promoting the eventual collapse of the herd due to dwindled immunity.

Further, the statement that "Removing brucellosis-infected bison is expected to reduce the level of population infection" is in error. Such culling has not reduced the level of brucellosis in bison. The study "Estimating probabilities of active brucellosis infection in Yellowstone bison through quantitative serology and tissue culture," led by Treanor of Yellowstone National Park, points out that:

Additionally, boundary culling has not contributed to a measurable reduction in brucellosis infection in the bison population. The proportion of seropositive adult female bison has increased slightly since 1985 or remained constant at c. 60% (Hobbs et al. 2009).

In fact, as the study states, such culling may be counter-productive, collectively harming the immune response in bison.

Page 20: Intensive management near conservation area boundaries maintained separation between bison and cattle, with no transmission of brucellosis.

Contradictory action being taken: This is untrue. Transmission of brucellosis from elk to cattle has occurred, regardless of the separation maintained between bison and cattle.

Page 20: However, brucellosis prevalence in the bison population was not reduced and the management plan underestimated bison abundance, distribution, and migration, which contributed to larger risk management culls (total >3,000 bison) than anticipated.

Contradictory action being taken: While recognizing this, the IBMP continues large-scale culling, despite evidence that it has not reduced the disease among bison and despite evidence that such culling is dramatically increasing the abundance of the northern herd and dramatically decreasing the population of the central herd, exposing the endemic central herd to the risk of extinction.

Page 20: Culls differentially affected breeding herds, altered gender structure, created reduced female cohorts, and temporarily dampened productivity.

Contradictory action being taken: While recognizing this, the IBMP continues large-scale culling.

Pages 20-21: This assessment was used to develop adaptive management adjustments to the IBMP in 2008 (USDI et al. 2008) and similar future assessments will be essential for effective management to conserve the largest free-ranging population of this iconic native species, while reducing brucellosis transmission risk to cattle.

Contradictory action being taken: The IBMP plans to continue massive culls to "conserve the largest free-ranging population of this iconic native species." During its operation, the IBMP, established in 2000, has swelled the introduced non-native bison herd from 590 animals to 3,969 animals and reduced the herd native to the park from 2,118 animals to 847 animals in 2017. The endemic central herd, which garnered the Yellowstone subspecies the designation of a distinct population segment, now stands on the brink of extinction.

A realistic alternative plan

A conceptualization of why the Interagency Bison Management Plan is not working and what would be a more realistic and thus more workable flowchart is as follows—comparing one that keeps cattle in the migratory habitat of bison and elk and one that removes cattle from it:

Start

↓

Desired condition:
No brucellosis transmission between bison, elk and cattle.

↙

Alternative 1:
Allow cattle on bison and elk migratory habitat adjacent to park.

↓

Does this promote disease transmission to cattle?

↓

Yes.

↓

Problem solved?

↓

No.

↓

Haze and lethally remove only migratory bison from habitat adjacent to park

↓

Problem solved?

↓

↘

Alternative 2:
Remove cattle from bison and elk migratory habitat adjacent to park.

↓

Does this promote disease transmission to cattle?

↓

No.

↓

Problem solved?

↓

Yes.

No.

↓

Rationalize lack of success,
issue misleading scientific
reports and disinformation.

↓

Problem solved?

↓

No.

↓

Go back to **Start.**

Figure 40. REALISTIC CONCEPTUAL MODEL of brucellosis management.

The ballyhooed "adaptive management" in Yellowstone is, in truth, not adaptive. To be so, nature must be left in charge, not humans. When humans manage what is wild, it ceases to be wild. What little wilderness we have left is being destroyed by the very systems designed to preserve it (The Abstract Wild, 2016). One of those systems is the IBMP. What we need from its agency managers and biologists is honest talk and the abandonment of hidden agendas. One of its sham agendas is that it is devoted to controlling the spread of brucellosis from wildlife to cattle in the Greater Yellowstone Ecosystem. It should be a real agenda, but it is not. Its real and hidden agenda is to continue to graze cattle in this ecosystem regardless of the costs both ecologically and financially. The IBMP functions as a front for the Montana cattle industry, taking for its benefactors property rights once held in common. Extinction of wild bison and the alienation of tribes is the price.

While Yellowstone's wildlife managers state what is needed to adaptively manage wild bison, they uniformly fail to adapt. Talk that does not result in action remains only talk. The interagency has demonstrated one thing: you cannot stop the spread of brucellosis in an ecological setting by its methods. The reason the plan is not working is because those in charge do not practice what they preach. The plan is duplicitous, internally contradictory and thus irrational. Only a magician could make it work.

13

Extinction + $3 million yearly + brucellosis = price for fattening a few cows in the GYE

How many cattle and wild bison are involved in this turf war on the border of Yellowstone National Park? This is important to know because a lot of money is being spent on behalf of cattle grazing on the park's perimeters, because the risk of the spread of brucellosis nationwide is increased by shipping cattle in and out of a biohazardous wildlife area and because extinction of wild bison is the risk of continuing the practice of fattening cattle in the Greater Yellowstone Ecosystem.

Establishing the population of bison is relatively easy. According to "Status Report on the Yellowstone Bison Population, September 2017," in 2017 the total number of bison in the park was estimated at 4,816. This included two sub-populations in Yellowstone: northern (3,969) and central (847) (Geremia, 2017). Generally speaking, the combined herds total about 5,000 bison in the park.

However, obtaining the number of cattle on the perimeters of the park is another story. According to a 1999 report by the Government Accountability Office (GAO), "Depending on the time of year and the size of the cattle herds, over 2,000 cattle can occupy public and private land in the Montana portion of the Greater Yellowstone area." But this is not the whole story. The GAO report continues:

> According to the Park Service, it is important to note that only a portion of these 2,000 cattle actually occupy lands where bison are most likely to move. Specifically, on the north side of the park, approximately 300 cattle occupy private lands and about 80 cattle occupy public lands where bison are likely to move during the winter and early spring. On the west side of the park, approximately 350 cattle occupy lands where bison are likely to be found. However, these cattle are not grazed year-round and are not present when bison are actually in the area. As a result, only about 730 of the 2,000 cattle in

> the Greater Yellowstone area actually occupy lands that bison generally use when they leave the park.

While this may be the case, the report states:

> Montana officials noted, however, that if the Yellowstone bison were left uncontrolled, they would likely continue to migrate farther north along the Yellowstone River valley and northwest along the Madison River valley, to where more cattle are maintained year-round on extensive private lands. (Wildlife Management: Negotiations on a Long-Term Plan for Managing Yellowstone Bison Still Ongoing, 1999).

A number of years have passed since this report was made. Let us do some research of our own as an update to either confirm or revise these figures.

The "Draft Joint Environmental Assessment: Year-round Habitat for Yellowstone Bison, 2013," reviews the status of the cattle population adjacent to the park. It notes:

> there are two active grazing allotments within the existing bison tolerant area, one on each side of the Yellowstone River near Yankee Jim Canyon: Slip n' Slide on the east side and Green Lake on the west side that are used during the summer when bison are not present.

These active allotments are at the northern end of Gardiner Basin and abut Paradise Valley. The document also states:

> there are two year-round and six seasonal livestock producers in and near the Gardiner Basin. The two year-round operators winter their cattle in the Gardiner Basin and move the cattle to the Cinnabar Basin to graze in the summer. The seasonal producers manage herds ranging in size of 100-600 cow/calf pairs on private lands. The seasonal arrival date of cattle on private lands is mid-May, and all are moved out of the northern management area by the end of December.
>
> Some of the livestock operators have improved their existing fencing or installed new fencing with the DOL's assistance in order to maintain spatial separation between cattle and bison. Three active grazing allotments are within the existing bison-tolerant zone within the GNF. Use of the allotments range from mid-June until mid-October, and the allotments are only used by cattle. In additional to those allotments, there are three more allotments just north of the hydrological divide boundary of the bison-tolerant zone.

Along the western boundary area, according to the “Draft Joint Environmental Assessment”:

> there are two private landowners that lease out their pastures for cattle grazing and one livestock owner that leases one of the USFS allotments. There are ten active grazing allotments within the GNF in the proposed year-round bison-tolerant zone. Use of the allotments range from mid-June until mid-October, and the allotments are used by either cattle or horses depending upon the location.

Let us take a look at what the cattle population for allotments near the park is today (as of 2015). According to figures supplied by Kim Reid, Range Management Specialist, USDA Forest Service, cattle population levels for National Forest allotments in the Gardiner Basin region are as follows:

Table 4. 2015 National Forest Allotments by the park’s northern border (Kim Reid, personal communication, August 19, 2015).

Allotment	Allotment Status	Acres	Permit Type	Permitted Numbers	Livestock
Slip and Slide	Active	6773	Term	47	Cow/Calf Pairs
Wigwam	Active	2487	Term	76	Cow/Calf Pairs
Green Lake	Active	3586	Term & Term Pvt Land	46	Cow/Calf Pairs
Horse - Reeder Creek	Active	5115	Term	81	Cow/Calf Pairs
Horse - Reeder Creek	Active		Term	22	Yearlings (cattle)
Horse - Reeder Creek	Active		Term/Term Pvt. Land	30	Horses
Section 22	Vacant	592			
Mill Creek	Vacant	406			

522 cattle graze in allotments along northern border

Table 4 summarizes active and vacant allotments along the northern border for the year 2015. Cow/Calf pairs equal two cattle. As the table denotes, cattle in the area number (47 + 76 + 46 + 81) x 2 = 500. Adding the yearling cattle one gets 500 plus 22 for a total of 522 cattle. Figure 41 shows the location of the allotments.

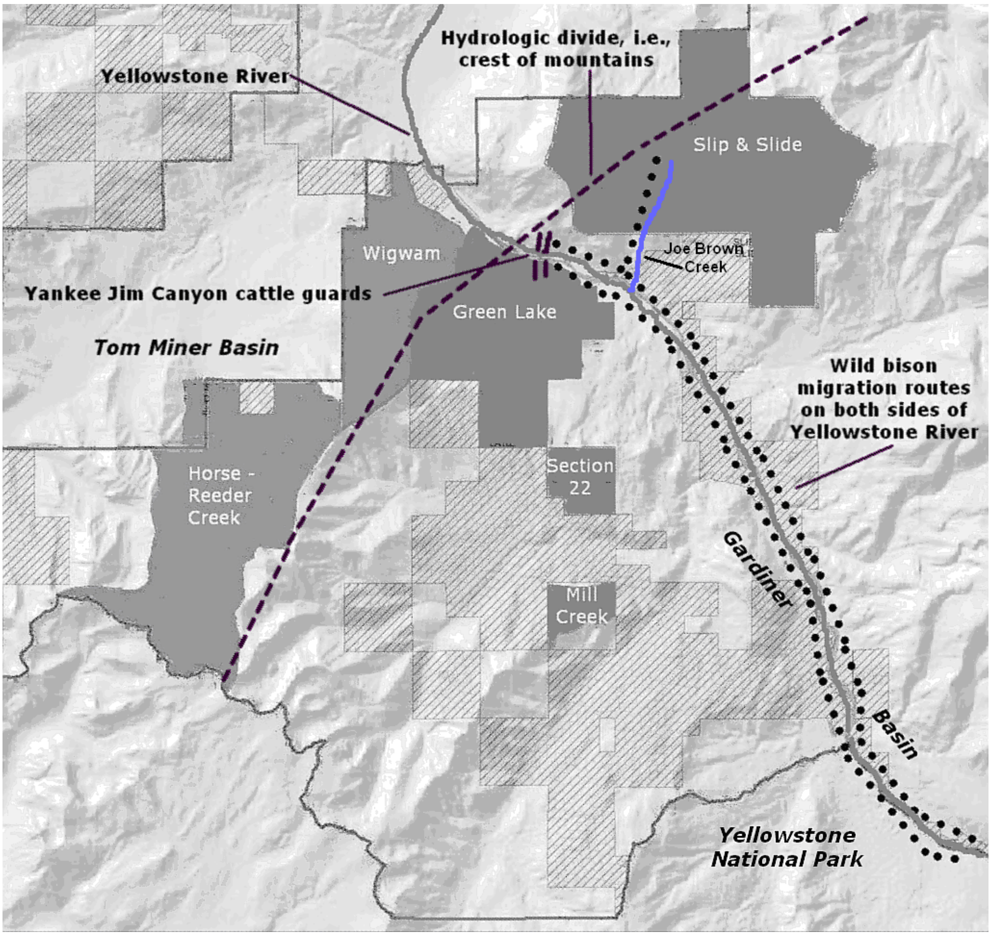


Figure 41. GARDINER RANGER DISTRICT, Custer Gallatin National Forest, 2015 grazing allotment status. Dark gray indicated grazing allotments contiguous to Gardiner Basin and medium gray those contiguous to Tom Miner Basin. Diagonal hatching indicates privately owned land (Map from 2015 Custer Gallatin National Forest Grazing Permit Information as provided by Kim Reid, personal communication, August 19, 2015). ***Map modified by James Horsley, including converting to grey-scales, names other than allotment designations, bison migration routes and location of hydrologic divide.***

But the allotment population figures in Table 4 are misleading in terms of the number of cattle needing separation from bison dispersing north out of the park. Instead of 522 cattle needing protection via separation activities (hazing and lethal removal) by the IBMP north of the park, only 186 actually need that protection. Here is why: Yankee Jim Canyon stops bison in their tracks.

Only 186 cattle in allotments in Gardiner Basin

For bison, there are only two ways out of Gardiner Basin into Tom Miner Basin and Paradise Valley, according to Sam Sheppard, region three regional supervisor, Montana Wildlife, Fish & Parks. One is via the saddle between Dome Mountain and Red Mountain east of the Yellowstone River. That is reached by ascending Joe Brown Creek, a tributary of the Yellowstone River. Bison generally follow the Yellowstone River out of the park when heading north. But bison rarely take the route up the tributary Joe Brown Creek (Sam Sheppard, personal communication, August 25, 2015).

One bull tried in 2013. On the morning of Friday, April 12 a bull bison heading toward Joe Brown Creek wandered into a remote wildlife sanctuary called the Dome Mountain Wildlife Management Area. But this sanctuary is in Zone 3, designated by the IBMP as a killing zone for bison. As noted in an opinion piece in the *Bozeman Daily Chronicle* headed "Guest columnist: Bison management out of touch with reality," agents of the Montana Department of Livestock and the Montana Wildlife, Fish & Parks tracked him down and killed him in this refuge (Watermann, 2013).

Wild bison are not even safe in a wildlife refuge. Why? Because wild bison are not considered wildlife in the eyes of the Montana Department of Livestock and this department rules outside the park—as well as inside, for the Stephens Creek capture facility is located here.

Bison prefer to take paths of least resistance, according to a memorandum by the Montana Wildlife, Fish & Parks titled "Bison Habitat Evaluation East of the Yellowstone River from Dome Mountain to YNP." The memorandum states:

> Preferred bison habitat on the east side of the Yellowstone is determined largely by topography, elevation, and vegetation. Bison tend to use relatively low elevation habitat, typically using flat areas or rolling foothills dominated by sagebrush grassland vegetation. When available they will also use irrigated hay meadows, livestock pastures, and wet riparian sedge/grass areas. Bison habitat east of the river ranges from approximately 5,100' to 7,200' in elevation, with most of the heavily used areas occurring below 6,400'. Bison typically avoid using steep rocky terrain or densely timbered habitat for any length of time. They can of course pass through these areas, but are constantly looking for open paths of least resistance in moving from one preferred area to the next. Bison have no problems traveling along narrow corridors to avoid steep, rugged or timbered terrain.
>
> In areas that bison have previously occupied, they are creatures of habit, using the same general routes to return as a social unit to preferred locations. However, when exploring new territory without a known destination, bison travel routes may be determined largely by terrain or topography. Without a relatively easy pathway, bison may easily "miss finding" suitable adjacent

winter range areas such as those in Cedar and Slip and Slide Creek drainages. In both cases there are existing roads that may help lead bison into these areas.

The route of least resistance out of Gardiner Basin north is via Yankee Jim Canyon. The memorandum explains:

> The natural travel route for bison on both sides of the Yellowstone leads to Yankee Jim Canyon. Once there, bison can easily and quickly traverse the narrow canyon using the county road and the abandoned railroad right-of-way on the west side and Hwy 89 on the east side to enter Paradise Valley. When bison leave Yankee Jim Canyon they enter a huge area of biologically suitable bison winter range. However, in reality, for disease and private landownership reasons among others, wild bison are not currently allowed in this area (Lemke, 2006).

But bison today do not leave Yankee Jim Canyon, which sits on the hydrologic divide defined by the crest of mountains in that region. There are two cattle guards along the roads through the canyon, one on either side of the Yellowstone River. The highways down which the bison travel skirt the whitewater region of the river, are walled in by steep canyons and fencing, and are closed by gates in the winter. It is virtually impassable for bison.

However, the IBMP claims in its 2014 annual report that numerous bison *did* cross this hydrologic divide and entered Tom Miner Basin. The Montana Department of Livestock and the Montana Fish, Wildlife & Parks annually document the dates and the number of bison that attempt to move north of Yankee Jim Canyon into Tom Miner basin or Paradise Valley. The agencies reported that in 2014:

> Bison crossed the hydrological divide and moved into Tom Miner basin on several occasions in early April. Four operations took place to return the bison to Zone 2 (Table [5]). This breach into Zone 3 seems to have been caused by dispersal of animals when the total abundance in the northern management area exceeded 450 to 500 animals (Figure [43]). The IBMP management agencies moderated the abundance to fewer than 500 animals and breaches of Zone 3 did not recur for the remainder of the management season.

Figure 42. YANKEE JIM CANYON, a bottleneck restricting bison passage into Paradise Valley, Montana. Notice cattle guard, cliffs and fencing to the right, and railing and the Yellowstone River gorge to the left. ***Photo courtesy of Buffalo Field Campaign.***

The following table and figure were provided to illustrate the actions:

Table 5. Bison moving north of Yankee Jim Canyon (Annual Report of the IBMP, 2014).

Date	Number	Type	Location	Hazing operation
4/3/2014	136	mixed bison	Tom Miner	Yes
4/4/2014	65	mixed bison	Tom Miner	Yes
4/5/2014	365	mixed bison	Tom Miner	Yes
4/7/2014	3	mixed bison	Tom Miner	Yes

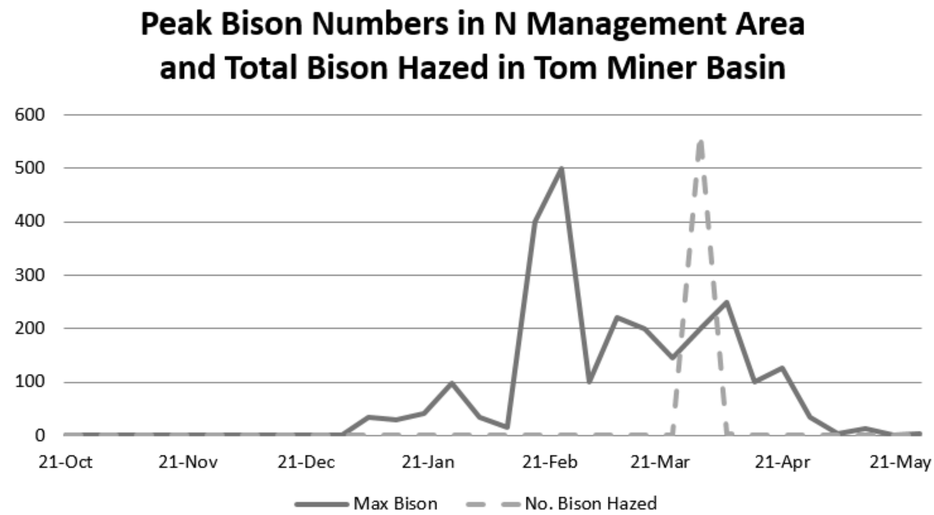


Figure 43. BISON IN THE N MANAGEMENT AREA and the Tom Miner basin during the 2013-2014 management season (Annual Report of the IBMP, 2014).

Curious about how all these bison got through Yankee Jim Canyon into Tom Minter Basin and what eventually happened to them, I emailed Sam Sheppard. On August 20, 2015 I wrote:

> As I recall, you said during our recent phone conversation that occasionally a bull will cross or attempt to cross the hydrological divide via Joe Brown Creek, travelling through the saddle there, but bison usually can not proceed beyond the cattle guards at Yankee Jim Canyon. In looking at the annual reports for the IBMP, I see this is confirmed by the 2013 report, which states that "The only report of bison attempting to exit Zone 2 was a single bull entering the Dome Mountain area near Yankee Jim Canyon. This bull was lethally removed on April 12, 2013."

I then noted the numerous breaches by bison into Zone 3 as delineated in IBMP's 2014 annual report. I asked:

> How many bison actually crossed the hydrological divide and how many entered Tom Miner Basin or Paradise Valley? How did they get past the Yankee Jim Canyon cattle guards or did they go over the saddle at Joe Brown Creek? What happened to the bison that were hazed? Were they hazed eventually into the Stephens Creek capture facility? How many of the hazed bison were lethally removed?

He answered August 25:

> The bison left the Gardiner basin via the hydrological divide south and west of the highway (hence Tom Miner). The bison were hazed back into the Gardiner Basin. They were not hazed into the Stephen's Creek facility. None of these bison were lethally removed during these operations.

Still puzzled, on August 26 I wrote:

> It is still unclear to me if the bison crossed the cattle guards at Yankee Jim Canyon. If they did, how did they do this and how far from the guards did they get before they were hazed back? Was there snow over the guards? Can other wildlife traverse these guards, such as pronghorn antelope, bighorn sheep and elk?

He replied the same day:

> The bison did not cross the cattle guard. Other species such as antelope, sheep are able to get through the jack leg fencing. Also most antelope migration occurs prior to the gates adjacent to the cattle guard being closed for the winter season.

Technically speaking, the IBMP may be correct when it says bison entered Tom Miner Basin, for one could say Tom Miner Basin begins at the hydrologic divide. The cattle guards in Yankee Jim Canyon are in the region of the divide. Gardiner Basin is on the south side, Tom Miner Basin on the north side. Encroach into the region dividing the two basins and one can say as one proceeds north that Tom Miner Basin has been entered—even if one does not go beyond the cattle guards. Or the gates.

However, by reporting that bison have entered Tom Miner Basin, the IBMP is dissembling. Its members signatory to the annual report are behaving like the errant husband who calls his wife and says he has to work late and is calling from "The Office." He is correct. He is calling from "The Office," but "The Office" is a bar.

White lies are still lies. All the whitewashing in the world will not make a lie the truth. The truth is, no bison entered Tom Miner Basin in 2014. Although the IBMP claimed it "moderated the abundance" of bison by its hazing, it was not separating bison travelling north in Gardiner Basin from cattle in Tom Miner Basin. No, instead it was the cattle guards, fencing and cliffs that did the job.

So, subtract 76 cow/calf pairs (152 cattle) in the Wigwam allotment, 81 cow/calf pairs (162 cattle) and the 22 yearling cattle in the Horse-Reeder Creek allotments, totaling 336 cattle, from the total needing protection from Yellowstone's migrating bison and one gets the grand total of 186 cattle in allotments needing protection in the region north of the park.

Table 6. 2014 Ownership and Turn-out dates for Northern Management Area*

Owner	Zone	No. Cattle	Maxi-mum	Class	On-date	Off-date
BH	GB	20/1		pairs/ bull	year-round	n/a
JT	GB	23		pairs	year-round	n/a
Grizzly Creek	3	100	250	pairs	May 21	Dec 31
Yellowstone Cattle Co	3	100	600	pairs	May 21	Dec 1
B-Bar	3	150	600	pairs	June 15	Nov 15
Anderson Ranch	3	100	160	pairs	June 15	Nov 15
West Creek Ranch	3	100	100	pairs	June 1	Nov 1
Bridger Cunningham	3	64/4	68	pairs/ bulls	July 5	Oct 6

**** All zone 3 producers are in Tom Miner Basin except Bridger Cunningham and West Creek Ranch, which are in Paradise Valley (Leslie Doely, Montana Department of Livestock, personal communication, September 15, 2015). GB is Gardiner Basin.***

1,319 cattle graze on private land along the northern border

The "2014 Annual Report of the Interagency Bison Management Plan" provides the following data for the number of cattle grazing on the northern and western borders of the park on private land. In Gardiner Basin, Tom Miner Basin and Paradise Valley there are (20 + 23 + 100 + 100 + 150 + 100 + 100 + 64) x 2 = 1,314. Five bulls plus 1,314 cows and calves = 1,319 cattle grazing on private land along the northern border. The data supporting this figure is summarized in Table 6 (Annual report of the IBMP, 2014).

Only 87 cattle are on private land in Gardiner Basin

In Gardiner Basin (denoted GB above) the total number of cattle grazing on private property is (20 + 23) x 2 = 86. One bull plus 86 cows and calves = 87. Since the cattle needing protection from wild Yellowstone bison are limited to Gardiner Basin due to the restrictions at Yankee Jim Canyon—which prohibits movement into Tom Miner Basin and Paradise Valley—those cattle north of the Yankee Jim Canyon do not enter into the count, meaning that a total of only 87 cattle on private land need protection from intermingling with migrating wild bison.

All told, only 273 cattle need protection north of park

With 186 cattle on allotments and 87 cattle on private land, a grand total of 273 cattle grazing on land in Gardiner Basin need protection in the northern management area of the Yellowstone region. This is an infinitesimal amount of cattle compared to the total number of cattle in Montana.

140 cattle graze in allotments along the western border

The table and map below summarizes the details of each allotment's use and their locations.

Table 7. 2015 National Forest Allotments along the park's western border (Kim Reid, personal communication, August 19, 2015)

Allotment	Allotment Status	Acres	Permit Type	Permitted Numbers	Livestock
Grayling	Active	123	Livestock Use Permit	24	Horses
Moose	Active	23	Term	4	Horses
North Cinnamon	Active	1043	Livestock Use Permit	60	Horses
Sage Creek	Active	15552	Term	129	Horses
South Cinnamon	Active	1599	Livestock Use Permit	35	Horses
South Fork	Active	148	Term	15	Cow/Calf Pairs
Taylor Fork	Active	976	Livestock Use Permit	90	Horses
Watkins Creek	Active	3654	Term	55	Cow/Calf Pairs
Sheep Mile	Vacant	3500	N/A	N/A	N/A

As delineated in Table 7, in the Hebgen Lake region there are eight active allotments in the Gallatin National Forest, the majority used for grazing horses. Total number of cattle permitted is (15 + 55) x 2 or 140 cattle grazing on allotments along the western border of the park.

1,099 cattle graze on private land along the western border

Along the western border of the park in the Hebgen Lake region there are a total of 1,099 cattle grazing on private land. The data supporting this figure is summarized below.

Table 8. Ownership and Turn-out dates for the Western Management Area (Annual Report of the IBMP, 2014)

Property Owner	Livestock Owner	Zone	Date in	No. Cattle	Class	Date out
SR—Red Creek Ranch	BM—Reed Point, MT	2	Jun 20	200/4	Pairs/Bulls	Oct 9
PP—Deep Well Ranch	LM—Twin Bridges, MT	3	Jun 15	320/10	Pairs/Bulls	
LD—Quarter Circle JK	CC/BF—Cameron, MT	3	Jul 1	22/1	Pairs/Bulls	

The number of cattle on private land in the Hebgen Lake region total (200 + 320 + 22) x 2 = 1,084 plus 15 bulls, for a grand total of 1,099.

Breaking down the number of cattle north and west of the park, one gets the following summations:

For the north:

- 522 cattle graze in allotments along the northern border,
- 186 cattle are in allotments in Gardiner Basin north of park,
- 1,319 cattle graze on private land along the northern border.
- 87 cattle are on private land in Gardiner Basin north of the park.

Since bison can not go beyond Gardiner Basin because of the bottleneck and cattle guards at Yankee Jim Canyon, only

- 273 cattle, all told, need protection from migrating bison north of the park.

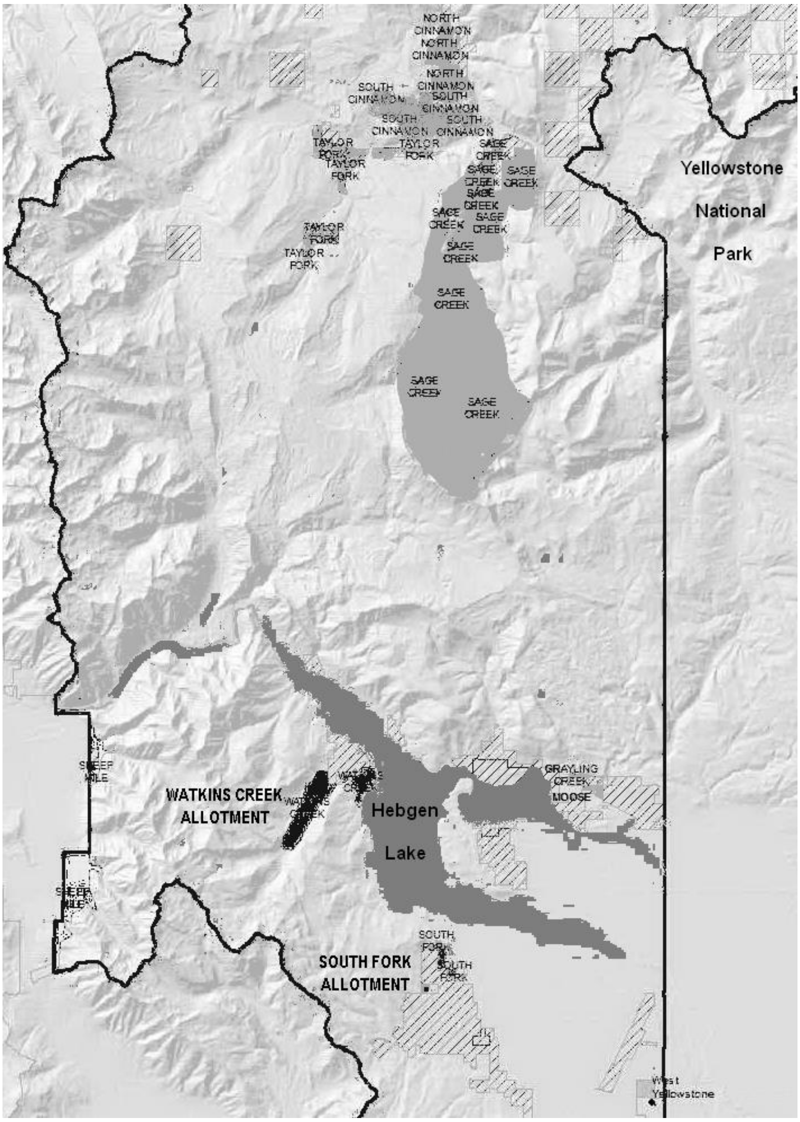


Figure 44. HEBGEN LAKE RANGER DISTRICT, Custer Gallatin National Forest, range allotments for 2015. Black areas are cattle allotments, lighter gray areas are horse allotments. Note the majority of land (acreage) is devoted to horse allotments. (Map from 2015 Custer Gallatin National Forest Grazing Permit Information as provided by Kim Reid, personal communication, August 20, 2015). ***Colored map modified by James Horsley, converting to grayscale and labeling cattle allotments.***

For the west:

- 140 cattle graze in allotments along western border,
- 1,099 cattle graze on private land along the western border.

Since there are no natural divisions separating bison from cattle in the Hebgen Lake region, other than Horse Butte, a peninsula that extends into Hebgen Lake on which there are no cattle,

- 1,239 cattle all told need protection from migrating bison west of the park.

With 273 cattle north and 1,239 cattle west, this gives a grand total of

- 1,476 cattle needing protection from bison migrating north and west of the park or, roughly speaking, 1,500 head of cattle.

But bison population numbers and the rationale on which the epidemiology of separation and lethal removals are based gets murky. Only bison migrating into Gardiner Basin have been sent to slaughter since 2009. The other capture facilities west of the park at Horse Butte and Duck Creek are no longer in operation. In 2016, the IBMP planned to cull wild bison at the Stephens Creek capture facility in the north of the park between February 15 and the end of March (Reichard, 2016), but nowhere else. That policy continues. Further, while bison used to be hazed back into the park from Hebgen Basin annually after May 15 by helicopters and horsemen, new rules of tolerance have been instituted, allowing bison year-round in some areas west of the park.

According to Andrea Jones, Montana Fish, Wildlife & Parks' regional information and education program manager in Bozeman, writing in *Montana Outdoors'* March-April 2017 issue, a push for greater tolerance was instituted by members of the Interagency Bison Management Plan to avoid negative publicity:

> Several years after the bison plan was first put in place, the multidisciplinary team that wrote it started looking more critically at hazing and culling. Though both practices keep cattle safe, the work is expensive and casts the entire bison management operation in an unfavorable light. A possible solution to the conundrum came in the early 2000s, when scientists learned that bull bison present almost no risk of brucellosis transmission. Suddenly it seemed feasible to consider allowing males outside the park. Inspired by the new science, in 2010 the Citizens Working Group on Yellowstone Bison, a diverse collection of ranchers, tribal members, and bison advocates, recommended letting bison live year round in areas of Montana next to Yellowstone. IBMP partners agreed to let bulls roam on public land north of the park, from Gardiner Basin as far north as Yankee Jim Canyon, about 11 miles from the boundary. As part

> of the agreement, fences and cattle guards were installed to prevent the bison from roaming farther north into Paradise Valley, home to several large cattle ranches. New fences in Gardiner would protect trees, backyards, and gardens from the free-roaming animals. Bison ranging outside the new tolerance areas would be hazed back inside or lethally removed. Since 2011, bison leaving the northern park boundary in winter have been, for the most part, left alone. No brucellosis transmission to cattle has occurred.

This demonstrates that hazing and fencing are effective ways of keeping cattle and bison separate, instead of lethal removal, and are effective in controlling the spread of brucellosis. However, stating that "bison leaving the northern park boundary in winter have been, for the most part, left alone" is misleading. Hundreds leaving the park are killed annually at the northern border in Gardiner Basin, a grassland bisected by the park's northern border. While bison outside of hunting season may be tolerated north of the border, most never get a chance to get there, since they are trapped just south of that border in Gardiner Basin by means of the Stephens Creek capture facility, which operates on park property. In 2017 a total of 1,300 bison were either culled or harvested either inside or outside the northern boundary.

Jones continues:

> Heartened by the success of the Gardiner expansion and urged on by the citizen's working group, the IBMP partners next decided to look at allowing bison expansion outside the park's western border. Bison cows were leaving the park's snow-crusted meadows in early spring in search of grass, which they found on the south-facing slopes of Horse Butte in Hebgen basin. "That's really important for them in late winter and early spring, when they're in late pregnancy and carrying calves. They need that extra nutrition," says Rick Wallen, the park's bison ecologist. What's more, cattle no longer grazed on Horse Butte, and few grazing allotments remained in the larger area. Yet at the time, the IBMP still called for hazing bison that crossed the western boundary back into the park by May 15. Was that arbitrary deadline still necessary?
>
> In 2015, after FWP and the Montana Department of Livestock were unable to agree whether hazing needed to continue, Governor Steve Bullock issued a decision to allow bison in a limited area on Yellowstone's west perimeter, including Horse Butte and the Taylor Fork drainage. To allay ranchers' fears that bison would continue expanding west, Bullock ordered that the animals not be allowed beyond prescribed boundaries, varying by season. Culling, hazing, and hunting would still be options to keep the bison within the new expanded range.
>
> In spring of 2016, following Bullock's decision, 300 to 400 bison moved to Horse Butte and public lands to the north and grazed there for a few months

> before most returned to the park during summer. “The governor's decision saves money by not having to conduct large-scale hazing operations in the Hebgen Basin, and lets bison be bison while not putting livestock at risk,” says Sam Sheppard, FWP regional supervisor in Bozeman. Bison can now live year round outside the park, north and west, on more than 400 square miles of public land.

This new tolerance has been met with mixed reactions. Jones writes:

> Supporters of the new bison policy include the Greater Yellowstone Coalition. “Bison are wildlife and should be treated as such. I see this decision as a move in that direction,” says Shana Dunkley, of the organization's Wildlife Program. [Tom] McDonald, [director, Fish, Wildlife, Recreation, and Conservation Program] of the Confederated Salish and Kootenai Tribes, welcomes the governor’s decision. “This is restoring our traditional relationship with bison,” he says.
>
> Not everyone is on board. [Pat] Povah, the [West Yellowstone cattle] rancher, opposes the new policy, fearing it will damage the land and vegetation. “When bison come out of the park in early spring, this ground is extremely fragile. If you let bison or cattle trample it, it won't recover in our lifetime,” he says.

But in the end, large-scale culling still continues. Jones concludes:

> The governor's decision doesn't end the need for periodic lethal removal to keep Yellowstone bison numbers at a healthy level. In fact, in January 2017, the IBMP partners announced plans to cull the population, which had grown to a near-record level of 5,600 due to mild weather the previous winter, by up to 1,300.

At a healthy level? Healthy for whom? Certainly not wild bison, for such periodic culling has dwindled the central herd’s population from a high of 3,531 to 847 animals.

If separation between bison and cattle is the epidemiological strategy used to prevent the spread of brucellosis out of the park, is it not fair to ask why this tolerance, especially when it is being most exercised in the spring when brucellosis is shed? And why then are bison culled only in the winter when brucellosis is not shed?

The only conclusion one can come to is that brucellosis is not the problem, because separation is not being strictly employed as a solution to the bison-cattle conflict. Instead bison population is the problem, with the targeted population being the migratory, i.e., those animals that come to graze on forage consumed by cattle.

More bison equal more grazing competition for that forage. This view is supported by cattle-rancher Povah, who fears bison "will damage the land and vegetation."

Bison population size, as well as brucellosis, is also a concern of Paradise Valley cattle rancher Alan Redfield (R-Livingston), who was interviewed by co-host Amy Martin on National Public Radio's "All Things Considered," February 4, 2016 after Gov. Bullock announced the new tolerance. Following is a portion of the transcript:

> REDFIELD: Most people don't have a vested interest. They say, well, we want the bison to roam free—not going to affect them. This is our livelihood.
>
> MARTIN: Rancher Alan Redfield unrolls huge bales of hay behind his tractor, and his cattle gather to feed. His land is not included in the area where the governor will now allow bison to roam, but Redfield still opposes the decision. He fears brucellosis, a bacterial disease present in some bison, and he also believes there are just too many bison and elk in Yellowstone National Park.
>
> REDFIELD: Got a problem with both species—overpopulated, overgrazing.
>
> MARTIN: Redfield believes the bison population should be reduced by more than half.

What is not considered is that wild bison were the livelihood of American Indian tribes for over 10,000 years. Would the tribes not consider Montana overpopulated with its 2.6 million cattle (three head of cattle for every human), compared to the 5,000 wild bison in Yellowstone? What is not considered is that it is far more expensive to raise cattle than bison in the Greater Yellowstone Ecosystem. Under the terms of the Multiple-Use Sustained-Yield Act regarding national forests, bison instead of cattle should be in the GYE because they are more profitable. The act states:

> The Secretary of Agriculture is authorized and directed to develop and administer the renewable surface resources of the national forests for multiple use and sustained yield of the several products and services obtained therefrom. In the administration of the national forests due consideration shall be given to the relative values of the various resources in particular areas. The establishment and maintenance of areas of wilderness are consistent with the purposes and provisions of this Act (Multiple-Use Sustained-Yield Act, 1960).

What has more relative value—bison that are self-sustaining or cattle that take $3 million a year to sustain in an environment with wildlife diseases, aside from all other costs related to cattle ranching in Yellowstone?

What is not considered is that cattle in the Yellowstone Ecosystem expose the nation to a biohazard—the spread of brucellosis out of the park and the potential loss of millions of dollars in subsequent eradication efforts. What is not considered is that by the obsessive drive to depopulate Yellowstone of its wild bison, it is driving that population to extinction.

But for what purpose?

Given the new rules announced by Gov. Bullock, except for a few episodes of hazing outside Horse Butte, the cattle in Hebgen Basin are not given and have been deemed not to need protection by the Interagency Bison Management Plan. This brings us back down to only 273 cattle needing "protection" from the spread of brucellosis by wild bison. But what good is this so-called protection from brucellosis by culling in the winter at Gardiner Basin when it is shed in the spring during calving, which primarily takes place outside the park in the vicinity of Hebgen Basin, where bison are tolerated year-round?

This makes no sense vis-a-vis disease control. Yet the IBMP persists. It and its advising biologists are playing a game of chicken with brucellosis, seeing how close they can come temporally and spatially to the transmission of the disease to cattle by bison before swerving away. One would think, given the IBMP's claim that it wants to reduce to zero the probability of cattle contracting brucellosis from bison, that all efforts would be made to avoid contact with bison during the height of its transmission period, that is, during calving season. But that is not the case, as the new tolerance rules for Hebgen Basin demonstrate.

Science is not being followed here. Management, again, is not adapting, even in the face of studies stressing the importance of separation. For instance, the implications of a study, which incidentally involved some members of the IBMP itself, have been ignored. Research indicates that temporal separation on shared habitat must be maintained in order to reduce uncertainty in managing the risk of brucellosis transmission from infected bison to cattle. Researchers concluded in a December 6, 2011 *Journal of Wildlife Management* paper titled "Environmental Persistence of *Brucella abortus* in the Greater Yellowstone Area" by Keith Aune, The Wildlife Conservation Society; Jack C. Rhyan, National Wildlife Research Center; Robin Russell, Montana Department of Fish, Wildlife and Parks; Thomas J. Roffe, US Fish and Wildlife Service; and Barbara Corso, Animal and Plant Health Inspection Service:

> Our findings confirmed the need to temporally separate cattle and brucellosis-exposed bison when managing the risk of transmission associated with sharing grazing habitats adjacent to Yellowstone National Park. Our predictive model enables managers to quantify the uncertainty associated with various temporal separations strategies. The combined model data could be used to reduce persistent management tensions in the GYA associated with allowing bison and cattle to share pastures at different time schedules.

The authors performed field studies at Gardiner Basin and Hebgen Basin to determine persistence of *Brucella abortus* (RB51) purposely applied to fetal tissues and placed at those sites, as well as the persistence of naturally-contaminated birth or abortion sites in the GYA. What did they find?

> Results from these field experiments established that *Brucella* bacteria can persist on fetal tissues and soil or vegetation for 21–81 days depending on month, temperature, and exposure to sunlight. Bacteria purposely applied to fetal tissues persisted longer in February than May and did not survive on tissues beyond 10 June regardless of when they were set out. *Brucella abortus* field strain persisted up to 43 days on soil and vegetation at naturally contaminated bison birth or abortion sites.

In general, they found that *"Brucella* persisted for days (or even months) on undisturbed fetal tissue exposed to the natural environment in the GYA," that the "most prominent risk period for indirect transmission was from February through early June," and noted that "These grazing landscapes were typically occupied by cattle from mid-June through October" (Aune, 2011).

But now in Hebgen Basin, migrating bison and elk, some infected with brucellosis, share the landscape year-round with cattle, yet only bison are massively slaughtered in Gardiner Basin to keep the bison population below 3,000 animals to supposedly keep bison from migrating, but pay no attention to the fact that bison will migrate at any population level and are doing so routinely, pay no attention to the risk of brucellosis transmission by elk, and pay no attention to the need to maintain adequate and consistent separation in time and space between cattle and all infected species not only north, but west of the park also. This is brucellosis control? No, it can only be a range war, for what else could explain such a cavalier disregard of scientific studies? This mockery, is it worth risking extinction?

The continuation of this conflict, a conflict dominated by commercial interests, has serious national defense risks. How can the Interagency Bison Management Plan justify its existence when it expends funds that do not protect the nation's cattle from brucellosis, but in fact subjects the nation to the heightened chance of its spread by persisting to graze cattle in a wildlife area that contains ungulates infected with brucellosis—both bison and elk? Realistically, the cold facts amount to two alternatives to prevent the spread of brucellosis out of the park: either remove almost all the elk and bison from the park or all the cattle from just outside the park. The choice is that simple.

At present, killing only migratory bison and feeding elk at feeding grounds is stagnating the park. With stagnation comes disease. Over time, brucellosis seroprevalence rates have increased in some Montana elk herds. More than 50 percent of the elk sampled from the Mill Creek area of Paradise Valley tested positive for exposure to brucellosis, Montana Fish, Wildlife and Parks reported in February 2015 (French, 2015). That rate is similar to the rate historically occurring in the Yellowstone bison herd. While bison are aggressively managed, elk are not. While only migratory bison are killed, eliminating the healthy behavior of dispersal, the non-migratory are increasing dramatically in population, crowding those animals, leading to an increased brucellosis transmission risk.

Even if the 273 cattle in Gardiner Basin were counted as meriting protection, rounding that number off to 300, one gets a ratio of 300 cattle being protected from 1,300 migrating bison (the amount killed in 2017) at a cost of $3 million annually, or an expenditure in taxes of $10,000 for every cow, with the lives of over four bison taken for every head of cattle protected. But, again, for what purpose and how realistic is this plan? For brucellosis to be controlled from spreading out of the park, it has to be controlled consistently. It is contradictory epidemiology to base a program's success on separation of infected species that are not effectively separated temporally and spatially both north and west of the park.

Refuse to deal with this problem now—given the mechanics of disease transmission—at some point in time there is a high likelihood that brucellosis will explode out of the park, the last remaining reservoir of *Brucella abortus* in the nation, via infected elk and bison in close proximity to cattle.

14

Solution: A *cordon sanitaire*

Wild bison are being held captive in Yellowstone National Park by our government at both the state and national levels. We have looked again and again at the many problems cascading from such captivity. Like an avalanche, captivity is heading inevitably to one result: extinction of Yellowstone's wild bison. The captors, the members of the Interagency Bison Management Plan, pretend they are fighting brucellosis by stopping wild bison in their tracks as they attempt to leave the park, keeping this species locked in only part of the habitat they require for survival. Result? Incubation of Brucella abortus among those held captive.

The mounting evidence of research shows that close proximity of animals, crowding and captivity cause the spread of brucellosis and that under these conditions disease can jump the "species barrier" and cause interspecies transmission.

That captivity promotes disease transmission is recognized even by those who hold wild bison hostage. Rick Wallen, Yellowstone National Park bison biologist, in an interview by Stephany Seay, Buffalo Field Campaign's media coordinator, confirmed that holding bison in pens, as they are currently doing, increases the risk of brucellosis transmission among bison due to crowding.

As shown on YouTube, the following exchange took place in 2010 in front of the Stephens Creek capture facility:

> SEAY: "I have a question. This is a holding pen of the animals, of the pregnant females, females giving birth. All this mismanagement, I am going to call it, against wildlife, is supposedly due to brucellosis. Don't you feel that—holding these animals during their calving, having abortions, causing abortions, giving birth in close proximity—don't you feel you are exacerbating any potential of risk?"

WALLEN: “The risk to transmission among the bison?”

SEAY: “Among the buffalo.”

WALLEN: “Yes, that is correct.”

SEAY: “So you do feel you are increasing the risk?”

WALLEN: “Yes” (Seay, 2011).

In the park, the proportional population densities between migratory and non-migratory bison is progressively being tipped more toward population growth of the non-migratory herds, as opposed to the migratory for the simple fact that only migratory bison are culled. This leaves behind an increased proportion of non-migratory breeding stock.

Where do these non-migratory bison, that is, those that do not leave the park in the winter, congregate? Many gather for survival around the thermal pools and the streams they feed into. Here the warm water keeps the pools and streams open and allows bison to forage sedges and other grasses along the banks.

Figure 45. WILD BISON CONGREGATE in the water and along the banks of Firehole River, which remains open all winter because of the warm water from the thermal pool region. ***Meagher, 1972, NPS Scientific Monograph No. 1.***

On October 15, 2014 I asked Rick Wallen:

> have any studies been made that a source of brucellosis in the wild bison is from the fact that during the winter they congregate at the thermal pools for warmth and forage? It would seem that if that were the case, killing migratory bison would promote a bias toward the non-migratory herd and thus increase populations at the pools, such crowding creating conditions more favorable for *Brucella abortus* transmission.

He replied:

> I do not know of any such studies. I would suggest you review the transmission dynamics about how brucellosis persists in infected populations (Rick Wallen, personal communication, October 24, 2014).

Fair enough. I reviewed the literature on such transmission dynamics. According to the Center for Food Security and Public Health at Iowa State University, "some *Brucella* species have been detected in secretions and excretions, including urine, feces, hygroma fluids [such as in cysts], saliva, and nasal and ocular secretions." Further,

> *Brucella* can be spread on fomites [sources of contamination] including feed and water. In conditions of high humidity, low temperatures, and no sunlight, these organisms can remain viable for several months in water, aborted fetuses, manure, wool, hay, equipment and clothes. *Brucella* can withstand drying, particularly when organic material is present, and can survive in dust and soil. Survival is longer when the temperature is low, particularly when it is below freezing (Brucellosis, 2009).

Such sources of contamination and weather conditions exist routinely in the Yellowstone area, especially in the thermal pool regions where there is high humidity, low temperatures, water, aborted fetuses, and brucellosis contaminated forage, feces and urine. And crowding. These conditions can also persist at Gardiner Basin and Hebgen Basin.

By concentrating wild bison in capture facilities, by a culling regimen that has skyrocketed the population of the non-migratory northern herd and depleted the migratory central herd to record low levels and by not allowing bison to disperse via migration, promoting increased population densities at the thermal pool regions of the park as well as in the lower elevation valleys, IBMP member agencies are creating the ideal environment for brucellosis transmission. Given all this evidence against the present plan, what is the solution? What is needed is a buffer around the Greater Yellowstone Ecosystem that includes the migratory habitat of wild animals, especially wild ungulates. That buffer zone should mirror the historical boundaries of wild bison as depicted in Figure 11).

Mary Meagher, the renowned Yellowstone National Park biologist, advocates creating a *cordon sanitaire* around the park free of cow-calf operations. A 1996 study published in *Ecology* titled "The Population Dynamics of Brucellosis in the Yellowstone National Park" determined that neither vaccinating bison nor culling were viable methods of controlling the transmission of brucellosis from bison to cattle. The study conducted by Andrew Dobson, department of ecology and evolutionary biology, Princeton University, and Meagher, National Biological Services, Midcontinent Ecological Center, Greater Yellowstone Field Station, Yellowstone National Park, found that sustained infections of brucellosis require bison herds in excess of 200-300 animals. Once a herd drops below this number brucellosis tends not to be present. The authors state:

> The removal of animals crossing the boundaries of the park is the present policy for bison in the Yellowstone ecosystem. The historical records that detail the relationship among stock, recruitment, and removals, and the relationship between population size and prevalence can be combined to examine the relationship between culling intensity and resultant prevalence . . . This analysis suggests one would need to almost eradicate the bison before one could produce significant reduction in prevalence. More significantly the levels of removal required to eradicate *Brucella* may be sufficient to also drive the bison to extinction.

They concluded that:

> The analyses presented here suggest that the best approach to brucellosis control would be to create a *cordon sanitaire* or buffer zone around the park. This could easily be done by allowing vaccinated or sterile cattle in areas around the park. There are two alternatives to pay for this program; government subsidies could pay for brucellosis vaccination scheme in cattle, or, present levels of subsidies could be reduced, or removed, from ranchers who continue to ranch cow-calf herds in this area. A complete transformation to either heifers and steers for an area within 30-80 km [about 20 to 50 miles] around the park should insure that brucellosis is contained within the area of the park (Dobson et al., 1996).

But would this be enough? According to APHIS, vaccinating cattle:

> is not 100 percent effective in preventing brucellosis; it typically protects about 70-80 percent of the vaccinated cattle from becoming infected by an average exposure (Facts about brucellosis, 2015).

Nor would limiting the presence of cattle to spayed heifers and steers near the park reduce the risk of brucellosis transmission from bison to cattle to zero, which is the goal of the IBMP. Although they can not abort, they can become infected with brucellosis and spread the infection through exposure to multiple sources of contamination.

Instead of creating no-tolerance zones for bison in Gardiner Basin, Paradise Valley and the Hebgen Lake region, they should be designated as no-tolerance zones for cattle. Such a practice would comply with proper herd management strategies to aid in the avoidance of the disease as recommended by APHIS, namely, maintaining closed herds. Such separation of cattle from the source of disease, namely wildlife in the park, would assure that brucellosis would not be transmitted to cattle outside the park. It would allow bison to migrate unmolested in the winter to the most critical area, Gardiner Basin, at least up to the natural and man-made bottleneck of Yankee Jim Canyon, as well as into the Hebgen Lake region for calving in the spring, already being allowed for Horse Butte in Hebgen Basin. It would preserve the gene purity of the last wild herd of bison, preventing them from mating with cattle that now graze in the basins. And it would save taxpayers $3 million annually on IBMP's epidemiologically futile efforts.

It would also allow closure of the Stephens Creek capture facility. The wildlife park should not function as a stockyard. At present, every day when the facility is occupied and while the bison are held there prior to slaughter, a green tractor rumbles through the fenced pasture, spreading alfalfa from round bales as hundreds of wild bison run after it, pausing to snatch mouthfuls of hay. This is wilderness?

No, because wildlife disease is promoted by captivity and the stresses of confined conditions, this is not wilderness but the breeding ground for brucellosis. This is indeed a stockyard.

To preserve the genetic diversity of wild bison, no culling should be permitted. To keep the bison herd at range capacity and to maintain the balance of nature, only wolf predation and the hunting of bison as migratory animals, just like elk, should be allowed to remove bison from the Yellowstone habitat, while hunting of the wolf should be banned in the GYE.

The idea is to separate such wild animals as bison from cattle and other livestock spatially and temporally so they cannot occupy the same space at the same time. Livestock, whether caged, fenced or free-range, can act as vectors of zoonotic diseases and therefore should not occupy a wildlife ecosystem where such diseases can spill over. Hunting and wolf predation have a better chance of operating within the parameters of natural selection, where the less physically fit or the least fearful are easier prey. Such practices would help restore the wildlife integrity of the Greater Yellowstone Ecosystem as well as most efficiently and most economically promote the national security with regard to the transmission of such diseases as brucellosis, both in the same species and between species.

Using bison to generate income via hunting and other fees would be more profitable than cattle and other livestock here in the GYE. Studies should be conducted to determine how to do this so that it would be fair to the public, private property owners, business operators and their employees.

Such a plan should be given time to develop so that data can be collected. With the potential of highly positive outcomes, both for wildlife and for the people either living in, near or visiting the Greater Yellowstone Ecosystem, patience in monitoring the outcome of allowing wild bison to migrate into such areas as Gardiner Basin and the Hebgen Lake region should be exercised so that adjustments could be made.

Such adjustments could entail compensation of persons who have suffered property loss or damage by migratory wild bison, lethal removal of specific individual animals that pose a risk or the fencing of property to prevent damage by keeping bison out. Where needed, the idea would be to protect or fence individual properties from bison damage, instead of the entire denial of bison from their migratory habitat by such methods as lethal removal or hazing. Dividing wild bison migratory habitat, either public or private, into various zones and sectors, where bison may or may not occupy within this or that space or time, has proven not only unworkable, but harmful to the wildlife of the ecosystem.

Recall that in a report written in 2008 and updated this year, the National Park Service wrote:

> Simulations of migrations over the next decade suggest that a strategy of sliding tolerance where more bison are allowed 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 (White, 2008 and 2014).

Sadly, this strategy has not been implemented. Not only that, the very biologists who have helped write the reports recommending such tolerance, routinely, year in and year out, recommend large-scale reductions be implemented by the IBMP. It is as though they were operating under an invisible threat to maintain the status quo or else.

Many members of the community have been working toward these objectives. Bison range expansion efforts have been ongoing. By means of government and private efforts to increase grazing habitat for bison outside the park in these regions, land has been acquired, creating a patchwork of areas where bison are allowed. However, the complexity of such land-use designations is hard for humans to understand and control. And of course it is incomprehensible to bison, which do not have the capacity to recognize invisible property lines.

Modifications to the presently existing Interagency Bison Management Plan have been under study by Montana’s Department of Livestock and Department of Fish, Wildlife and Parks because some of the contested habitat areas were no longer occupied by cattle and because some grazing allotments had been closed to cattle. Further, APHIS has adopted changes to longstanding brucellosis regulations so that if an outbreak occurs, a cattle producer is no longer required to depopulate an entire herd nor would a state be automatically downgraded from a Brucellosis Class Free status (Draft Joint Environmental Assessment: Year-round Habitat for Yellowstone Bison, 2013).

Proposed alternatives included using mountain crests as a dividing line for the Gardiner Basin area, with the only way out, other than crossing over the mountains, being Yankee Jim Canyon, where fencing and a cattle guard discourage further migration. In the Hebgen Lake region, terrain habitually used for calving by bison has been studied and as of 2016 year-round habitat for bison was granted by the governor of Montana for Horse Butte in the Hebgen Basin.

Over 100,000 comments from the public were received concerning the joint proposal by the Montana FWP and the Montana DOL to expand the tolerance zone for bison outside the park. However, that plan was tabled indefinitely by the Montana Board of Livestock (BOL) in May, 2014. It would have enabled bison to roam on as much as 421,000 acres of federal, state and private lands west and north of the park (Rice, 2014; Forrest, 2014). The status quo, lethal removal, by default remains the policy.

The NPS and the state of Montana are in the process of revising the IBMP through the writing of an environmental impact statement. Alternatives include allowing a range of bison populations in the park—from 2,500 to 7,500. However, no alternatives for removing cattle from the regions bordering the park are on the table, biasing the entire EIS. The revision is still in limbo.

Dr. Ralph Maughan, professor emeritus of political science at Idaho State University and president of the Wolf Recovery Foundation, commented in general about the conflict:

> It is the Montana Department of Livestock and certain politicians pushing us around and showing us their power by killing the bison that leave Yellowstone. It is a clash of cultural values and they kill bison to show who is really in charge in this area (Hudak, 2011).

Those who thought the conflict between cattle and bison could be solved by more habitat are learning that the central issue is a numerical one: the acceptable number of bison in the park. That number, according to the wild bison population gurus, is about 3,000. The balance of nature, which would limit bison populations by weather (such as winter kill), range capacity and predation (such as by wolves and disease), has been discounted. Instead, government has placed itself in the role of Mother Nature. It will have tragic consequences. It is just a matter of time.

At stake is not only the health of the herds, but also their unique identity and composition as distinct species. What is troubling is that the government, via its interagency coalition, has launched a culling program without knowing specifically what it is doing or its effects downstream. At the time of culling, neither the IBMP nor its biologists know what lethally-removed animal is from what herd, resulting in the continued disproportionate culling of the central herd and its near extinction status. All it knows and all it cares about is what it wants: only cattle grazing on land outside the park. No bison.

Treating wild bison like livestock to be owned and managed by the IBMP is not the answer. Clearly, the present management of the wild bison in Yellowstone National Park may be sufficiently off track, in the words of Meagher, to "drive the bison to extinction."

The presence of the gray wolf within this *cordon sanitaire* is critical to restoring the balance of nature in the ecosystem. Protection of the wolf should be specifically required as an integral part of the protected habitat for bison. Wolves remove bison by means of natural selection, instead of the artificial selection now conducted by the IBMP. Their predatory activity would contribute to a more economical control of bison populations, as well as a means of preserving the genetic diversity of wild bison. For the same reason, bison hunting should be continued, as wild bison have coexisted with human populations hunting them for millennia, but it should be done on the basis of sustainability, not the despoliation of a wild species.

While listing wild bison under the Endangered Species Act would make it unlawful for any person to take such species, the act provides that exceptions may be granted to enhance the propagation or survival of the affected species. Survival would be enhanced by hunting. Under the act, an applicant can request a permit to hunt wild bison, but must first submit a conservation plan that specifies such things as the impact likely to result from such taking and the funding available to implement such conservation steps (Endangered Species Act, 1972).

It would seem probable that an applicant such as a member or group from an American Indian tribe, as well as other hunters, could demonstrate that historically over the course of 10,000 years during pre-settlement times, wild bison evolved here in the presence of human hunters and were at the height of their population numbers and genetic diversity in such a hunting environment.

It should be obvious, however, that the hunting going on at Beattie Gulch near Gardiner, Montana, is not acceptable. It is merely an extension of the lethal removal policy of the IBMP. The Buffalo Field Campaign reported in January 2015:

> Snow has been accumulating in Yellowstone country, and buffalo are beginning to seek lower elevation habitat. Nine buffalo have been gunned down at the north boundary of Yellowstone National Park since our last writing, bringing this year's death toll to at least fifteen.
>
> Over the weekend, a group of thirteen buffalo approached Beattie Gulch, the boundary between Yellowstone National Park and Gallatin National Forest. We thought for sure that this whole family group would be wiped out. Hunters were literally lined up on the Forest Service side of the line, just waiting for them to cross. The hunters ended up waiting all day and the buffalo

> bedded down on the Park side of the Gulch. As the light waned, the hunters went away empty handed. The buffalo, sensing temporary safety, crossed in the middle of the night and were found on private property the next morning, where they could not be hunted.
>
> Over the course of the next few days, some buffalo eventually left the relative safety of private property, and one by one, they are being picked off. On Wednesday, treaty hunters hastily shot into a group of buffalo that had crossed into Montana at Beattie Gulch, killing a couple and wounding at least one. The buffalo that didn't die turned around and ran into Yellowstone National Park, where they cannot be pursued. BFC patrols have been monitoring one wounded adult female. If the Park Service spots her, they may "dispatch" her, and the hunter who shot her will still get to fill his "unused" tag.
>
> Hunters are swarming into the Gardiner Basin, just waiting for buffalo to step over the boundary. Tens of thousands of acres of habitat have recently, though temporarily, been opened to buffalo, but they never get a chance to access these new lands as they are gunned down before they make it very far. This firing line style of killing is another stark illustration that this so-called hunt is nothing more than a livestock industry-driven extermination program aimed to prevent wild, migratory bison from re-inhabiting even fractions of their native Montana landscape (Update from the field, 2015).

As Laura Lundquist reported for the *Bozeman Daily Chronicle*:

> Since hunters have to wait for the bison to leave the park, they wait for their chance in the open Forest Service land near Beattie Gulch, and the bison don't get much farther.

She wrote on Christmas Day, 2014 a story on the issues concerning wild bison migrating out of the park. She said:

> Four tribes—the Confederated Salish and Kootenai Tribes in Montana, and the Nez Perce, Umatilla and Shoshone-Bannock in Idaho—have treaty rights to hunt Yellowstone bison. Montana hunters also get a limited number of tags.
>
> With only two places to hunt—near Gardiner and West Yellowstone—hunters would like to stalk bison on a broader landscape.
>
> "Coming from a ranching family, I can see it from both sides. I can understand some of the concerns that ranchers have," said Kootenai wildlife manager Tom McDonald. "But what we really need to do is just allow bison to get out and express themselves on the landscape, and over time through our diligence, people can become accustomed to them on the landscape."

> But so far, ranchers' concerns have constrained wandering bison to bulges of land near the park, creating problems with gut piles, overgrazing and, ultimately, population control.
>
> As of this summer, about 4,900 bison lived inside the park. The northern herd, which migrates out near Gardiner during the winter, has 3,500, and the rest belong to the central herd, which trundles out near West Yellowstone.
>
> That's more than ranchers and the Montana Department of Livestock want.
>
> So during recent Interagency Bison Management Plan meetings, DOL representatives pushed for the removal of as many as 1,000 bison through hunting or capture-and-slaughter this winter.
>
> Last winter, about 650 animals were removed, half by hunters.
>
> The IBMP partners reached a tentative compromise of 900 for this year.
>
> But as of three weeks ago, the tribes were still trying to work that number down, worried that the cull would select against animals with migratory tendencies. Plus, a larger herd means more animals leave the park, providing more hunting opportunity.

Lundquist noted that steps are being taken for increased tolerance of wild bison outside the park:

> After a year's delay, more area around Hebgen Lake may open up to bison year-round.
>
> The DOL and FWP conducted an environmental study of a policy of allowing bison onto almost 422,000 acres of national forest land with no cattle in the upper Gallatin Basin.
>
> The majority of almost 120,000 public comments submitted in September 2013 supported the proposal.
>
> It stalled in May after the Board of Livestock refused to vote on the study, saying it would wait for a new Yellowstone bison management plan, which is only in initial development (Lundquist, 2014).

That study, as mentioned, is still in limbo. The bottom line is this: while elk are managed as wildlife and are allowed to move in and out of Yellowstone National Park, wild bison are managed as livestock and their movements outside the park are subject to prohibition and population reduction. While both species carry the disease brucellosis and while cattle may contract the disease from both elk and bison, only bison are controlled.

A buffer zone around the park equal in size to wild bison's historic migration boundaries that exclude cattle, an invasive species, would allow bison to migrate as elk do out of the park, would put an end to this double standard, would contain brucellosis within the park and would restore the integrity of the ecosystem as a wildlife sanctuary.

In summation, to protect the wild herds of bison in Yellowstone from extinction a number of things must be done.

First and foremost, work toward restoring the health of the herds. This means allowing them to inhabit their full range so they can live in their “house,” the ecosystem.

Work toward allowing the herds to restore their altitudinal migratory range, that is, up and down the Madison and Yellowstone Rivers. This is what most likely helped prevent the extinction of bison in the first place.

Work toward restoring the predator-prey relationships in the ecosystem. This is the only way to establish a healthy herd, for the wolf and other predators instinctively know which animals need to be culled, such as juveniles, the diseased, the undernourished, the injured, the old and those that stay behind.

Allow the bison herds to cure themselves of the disease brucellosis under the care of Mother Nature by allowing the herds to disperse—and that again means restoring historical migratory habitat. That also means keeping the herds within healthy numbers, which only predators such as the wolf know how to do, along with regulated hunting. The more fearful bison, and thus the more genetically healthy, will make themselves less of a target to predators, both animal and human.

Manage wild bison not as one herd, but as two distinct population segments, for two separate breeding herds exist in Yellowstone, that is, the northern herd and the central herd.

Instead of a sultan’s view of nature, which decimated the bison and the wolf in Eurasia, adopt the heart of the American Indian tribes toward bison and wolves and all other predators, such as bears and mountain lions. They are the ones who evolved successfully with these keystone animals.

Economically, wild bison can pay their own way, for they have been the staff of life for millennia. They can be of more profit to the local economy than cattle. Hunting of bison outside the park should be continued under the joint supervision of the government, a citizens group and Native American tribes.

The integrity of the GYE should be preserved. It is one of the last remaining large, nearly intact ecosystems in the northern temperate zone on earth and is one of the world's foremost natural laboratories in landscape ecology and geology. It is a world-renowned wildlife refuge, covering about 28,000 square miles. However, it cannot function in full health if it is fragmented.

In sum, to restore the balance of nature in this ecosystem, leave it alone. Allow wild bison to be wild. Within and on the borders of the Greater Yellowstone Ecosystem, remove invasive species such as cattle, make the culling of wild bison by government agents unlawful and ban the killing of wolves. Let Yellowstone be wild.

15

Factors warranting listing

Once it has been determined that a subspecies is a distinct population segment, under Section 4 of the Endangered Species Act:

> The Secretary shall . . . determine whether any species is an endangered species or a threatened species because of any of the following factors:
>
> > (A) the present or threatened destruction, modification, or curtailment of its habitat or range;
> >
> > (B) overutilization for commercial, recreational, scientific, or educational purposes;
> >
> > (C) disease or predation;
> >
> > (D) the inadequacy of existing regulatory mechanisms; or
> >
> > (E) other natural or manmade factors affecting its continued existence.

The two herds of wild bison in Yellowstone National Park should be listed in the Federal Register as threatened or endangered species due to factors covered throughout this petition, both first and second volumes. What follows is a summation of those factors, although not necessarily limited to them.

Factor A:
The present or threatened destruction, modification or curtailment of its habitat or range

The central and northern herds of Yellowstone's wild bison are endangered by the curtailment of their range by the Interagency Bison Management Plan, which by culling and hazing does not allow migration out of the park into winter and spring habitat necessary for survival.

A justification for such lethal removals from critical habitat by means of capture facilities is that these facilities serve as natural "dispersal sinks." This is in error and is a conclusion not made "on the basis of the best scientific and commercial data available." Dispersal sinks are suboptimal habitats that are temporary refuges of escape from environmental changes, such as a severe winter, experienced by a population in a habitat that was the source of dispersal. Under present management of the IBMP, habitat such as Gardiner Basin does not provide a place for survival, but instead results in the death of almost all bison that enter it in winter, since all are herded into the Stevens Creek capture facility, located there on park property, or harvested by hunters. Because deaths exceed births there, extinction will be the long-term result.

Factor B:
Overutilization for commercial, recreational, scientific or educational purposes

Yellowstone's wild bison's historical migratory habitat is being overutilized by disallowing bison to use it in favor of cattle for commercial purposes, that is, using bison's historical in-park and out-of-park range for the exclusive purpose of fattening cattle so as to bring them to market for the realization of a greater profit.

Further, bison are being overutilized for scientific purposes by imposing separation of bison from cattle to control brucellosis through lethal removals, hazing and quarantine. These actions are not "on the basis of the best scientific and commercial data available," in part because elk also are vectors of brucellosis but are not separated.

Factor C:
Disease or predation

The existence of Yellowstone's wild bison is endangered by disease because the presence of brucellosis among some wild bison exposes the herds to the culling actions of the IBMP. Ranchers have a mutualistic relationship with cattle. Because some bison carry an organism that infects ungulates, namely the *Brucella abortus* bacteria, ranchers protect their cattle by having bison killed. IBMP has a parasitic relationship with wild bison, while the American Indian tribes and conservationists have a mutualistic relationship. A mutualistic relationship with the park's wild bison should replace the present parasitic one so as to promote the survival of the herds.

As noted in this petition, studies have shown that such culling has no effect beyond not culling in reducing the transmission of brucellosis among wild bison. IBMP's misguided large-scale herd reductions have no meaningful disease-control outcome for wild bison.

Further, separating bison through lethal removal or hazing, but not doing so with elk, which also have brucellosis, provides no epidemiological benefit to cattle. Such putative disease-control actions endanger the bison herds by destroying their genetic diversity and reducing their numbers to dangerously low levels.

In a natural setting, wolves help reduce the level of disease in a herd by preying on old and diseased animals. By delisting wolves, the reduction of wolf numbers by hunting and trapping has reduced this beneficial disease-control influence. On the other hand, human predation by members of the IBMP and by hunters, who under present management are surrogates for government culling, is endangering the herd by removing from the breeding pool those with diverse genetic traits, such as migration and disease resistance, as well as exposing the central herd to genetic drift due to its resultant small population status.

The Greater Yellowstone Ecosystem has experienced an increase in disease prevalence due to the disruption of the trophic cascade or nutrient cycle by stopping migration through lethal removals of bison, by feeding elk, and by killing wolves. With the prevention of dispersal, stagnation occurs, and with the killing of predators which select diseased animals as prey, disease is concentrated in populations, resulting in the spillover of disease (see "Introduction" and chapter 13, "Trophic cascade," second volume of this petition).

Instead, as argued throughout this petition, cattle should be separated from the park's wildlife, which means not grazing cattle or other domestic animals in the Greater Yellowstone Ecosystem.

Factor D:
The inadequacy of existing regulatory mechanisms

The current existing regulatory mechanisms governing wild bison, as noted throughout the petition, are not merely inadequate, but promote the destruction of the park's bison via their lethal removal, endangering their continued existence. Specifically, the IBMP regulates the number of bison to be annually culled on the basis of inadequate scientific studies that establish the maximum number of bison in the park at the 3,000 level—supposedly the level at which bison are most likely to migrate out of the park and mingle with cattle—in disregard to studies that show bison can migrate out of the park at any population level.

Further, examination of laws and policies show that their application often favors the livestock industry and have been in error, or the laws themselves unconstitutional. Ranchers claim they have a right to graze their cattle on national forest and public lands because of the multiple-use mandate, but disregard that such use must also provide sustained yield. According to the Multiple-Use Sustained-Yield Act, sustained yield is defined as "the achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable resources of the national forests without impairment of the productivity of the land."

Destroying wildlife to protect invasive cattle in the Greater Yellowstone Ecosystem, and spending millions in tax dollars to do that, is not sustained yield. Rather, it is sustained loss. By violating the precepts of the Multiple-Use Sustained-Yield Act, the IBMP is standing in the way of economic growth and job creation for the area (especially those associated with the potential for increased regulated bison hunting opportunities), needlessly draining away public funds to protect the business of cattle ranching in our national forests. In the process, it is exposing wild bison to extinction (see discussion in "Introduction," second volume of this petition).

Further, while grazing permits convey no right, title or interest held by the United States in any national forest or public lands, permittees holding expiring grazing permits are given first priority for new permits, according to the Code of Federal Regulations on grazing permits. This makes ranchers that were granted permits in the past heirs of the publicly-owned land of the ecosystem, which is fundamentally unconstitutional, prohibited under the constitution's title of nobility clause (see discussion in "Introduction," second volume of this petition).

The overarching goal of the IBMP is to reduce the productivity of wild bison by killing large segments of the population, especially mothers and calves. Killing wildlife, including bison and predators, in great numbers to protect cattle diminishes the productivity of the land by means of reducing the reproductivity of wild species and by the associated high cost of lethal removals. It also puts in jeopardy the sustained yield in perpetuity of these resources by exposing targeted animals to decreased birth-rates and the potential for extinction. Instead, cattle are assured a high-level of output at the expense of wild bison and tax payers.

The mission of the IBMP is supposed to be guided by the Department of the Interior's *Adaptive Management Technical Guide*. It states:

> Adaptive management focuses on learning and adapting, through partnerships of managers, scientists, and other stakeholders who learn together how to create and maintain sustainable resource systems.

Increasing wild bison culling goals, yet publicly claiming its goal is to decrease culling to the point of no human interference, and grazing cattle in the Greater Yellowstone Ecosystem that ends up costing millions of dollars in public funds to protect them, threatening to drive wild bison into extinction, is not learning from experience or adapting. It is doing just the opposite of its stated mission to "create and maintain sustainable resource systems." Instead, it is depleting them.

The execution of such laws and policies defeats the mitigation of brucellosis in the ecosystem. By not allowing bison to migrate and by feeding elk on the perimeters of the park, the prevalence of the disease is increased, since both acts promote crowding of animals. Close proximity of diseased animals to healthy ones is the hallmark cause of disease transmission. Further, the presence of predators has been shown to reduce the incidence of disease in an ecosystem, especially in ungulates, because predators prey on animals weakened by disease, thereby reducing the prevalence of disease among a population. The taking of predators that prey on bison in the region designated as critical habitat should be prohibited.

Wild bison in the Yellowstone region are a tribal trust resource, that is, a natural resource, either on or off Indian lands, retained by Indian tribes through treaties, obligating the United States government to protect them. Exposing them to extinction is not protection. Limiting the herd to 3,000 bison and killing only the migratory members of the herd, which is now the outcome of the law that established the IBMP, is not conserving the herd as a resource for the American Indian tribes nor the public at large, for it prohibits the growth of the herd as a wild herd and counters the operation of natural selection, further endangering the herds (see discussion in "Declaration," second volume of this petition).

Factor E:
Other natural or manmade factors affecting its continued existence

The US Fish and Wildlife Service reclassified wood bison *(Bison bison athabascae*) from endangered to threatened May 3, 2012. With the identification of the central herd as a separate breeding herd with a lineage of wood bison genetics, that herd should be listed as at least threatened.

16

Protect critical habitat

Critical habitat under the Endangered Species Act is to be designated concurrent with making a determination that a species is endangered or threatened. For such species, critical habitat is the key to survival. According to the ESA, the term “critical habitat” means:

> i. the specific areas within the geographical area occupied by the species, at the time it is listed . . . on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and
>
> ii. specific areas outside the geographical area occupied by the species at the time it is listed . . . upon a determination by the Secretary that such areas are essential for the conservation of the species.

In other words, critical habitat represents the habitat essential for the species’ recovery.

According to the 90-day finding submitted by this Petitioner in 1999 (see Appendix A, this petition, second volume), the Fish and Wildlife Service in its evaluation must consider whether there are any significant portions of the wild bison population’s range where the herd is in danger of extinction or is likely to become endangered in the foreseeable future. The 90-day finding stated:

> On March 16, 2007, a formal opinion was issued by the Solicitor of the Department of the Interior, “The Meaning of ‘In Danger of Extinction Throughout All or a Significant Portion of Its Range’” (USDI 2007). We have summarized our interpretation of that opinion and the underlying statutory language below. A portion of a species’ range (in this case, “species” refers to

the potential YNP bison herd DPS) is significant if it is part of the current range of the species and is important to the conservation of the species because it contributes meaningfully to the representation, resiliency, or redundancy of the species. The contribution must be at a level such that its loss would result in a decrease in the ability to conserve the species.

The first step in determining whether a species is threatened or endangered in a significant portion of its range is to identify any portions of the range of the species that warrant further consideration. The range of a species can theoretically be divided into portions in an infinite number of ways. However, there is no purpose to analyzing portions of the range that are not reasonably likely to be significant and threatened or endangered. To identify only those portions that warrant further consideration, we determine whether there is substantial information indicating that (i) the portions may be significant and (ii) the species may be in danger of extinction there or likely to become so within the foreseeable future. In practice, a key part of this analysis is whether the threats are geographically concentrated in some way. If the threats to the species are essentially uniform throughout its range, no portion is likely to warrant further consideration. Moreover, if any concentration of threats applies only to portions of the range that are unimportant to the conservation of the species, such portions will not warrant further consideration.

If we identify any portions that warrant further consideration, we then determine whether in fact the species is threatened or endangered in any significant portion of its range. Depending on the biology of the species, its range, and the threats it faces, it may be more efficient for the Service to address the significance question first, or the status question first. Thus, if the Service determines that a portion of the range is not significant, the Service need not determine whether the species is threatened or endangered there; if the Service determines that the species is not threatened or endangered in a portion of its range, the Service need not determine if that portion is significant.

The terms “resiliency,” “redundancy,” and “representation” are intended to be indicators of the conservation value of portions of the range. Resiliency of a species allows the species to recover from periodic disturbance. A species will likely be more resilient if large populations exist in high-quality habitat that is distributed throughout the range of the species in such a way as to capture the environmental variability found within the range of the species. In addition, the portion may contribute to resiliency for other reasons—for instance, it may contain an important concentration of certain types of habitat that are necessary for the species to carry out its life-history functions, such as breeding, feeding, migration, dispersal, or wintering. Redundancy of populations may be needed to provide a margin of safety for the species to withstand catastrophic events. This does not mean that any portion that

> provides redundancy is a significant portion of the range of a species. The idea is to conserve enough areas of the range such that random perturbations in the system act on only a few populations. Therefore, each area must be examined based on whether that area provides an increment of redundancy is important to the conservation of the species. Adequate representation ensures that the species' adaptive capabilities are conserved. Specifically, the portion should be evaluated to see how it contributes to the genetic diversity of the species. The loss of genetically based diversity may substantially reduce the ability of the species to respond and adapt to future environmental changes. A peripheral population may contribute meaningfully to representation if there is evidence that it provides genetic diversity due to its location on the margin of the species' habitat requirements.

The 90-day finding determined that Gardiner Basin was a critical habitat for the park's wild bison:

> Applying the process described above for determining whether a species is threatened in a significant portion of its range, we next addressed whether any portions of the range of the potential YNP bison herd DPS warranted further consideration. According to Gates et al. (2005), most bison in the YNP herd are confined within Yellowstone National Park for all or most of the year. Rut takes place within YNP from around mid-July to mid-August (Meagher, 1973) in one of three rutting areas—the largest rutting aggregation is in the Hayden Valley, the second largest in the eastern Lamar Valley, and a small aggregation occurs in small high elevation grasslands on the Mirror Plateau and Cache/Calfee Ridge (Gates et al. 2005). Most bison remain in YNP during winter, especially in the geothermally-influenced central portion of the Park. Calves are born in April-May on the winter range (Meagher 1973). For these reasons we have determined that there is substantial information that Yellowstone National Park may constitute a significant portion of the range for the potential YNP bison herd DPS.
>
> In late winter/early spring, varying numbers of bison may move outside the Park's boundaries into Montana near West Yellowstone and Gardiner looking for forage. Bison that move outside YNP usually return by late spring (YNP, 2007). The proportion of Yellowstone bison that move to winter ranges outside YNP varies from 3 to 30 percent per year, depending on conditions (YNP, 2007). Bison move beyond Park boundaries in late winter in response to forage limitation caused by interactions between population density, variable forage production, snow conditions, and grazing competition (Gates et al. 2005). The Gardiner basin has been considered important winter range for bison since at least the 1940s and is an important component of the Northern winter range; in contrast, the West Yellowstone area does not have unique ecological value as winter range according to Gates et al. (2005). For

> these reasons we believe there is substantial information that the Gardiner basin provides resiliency to the herd during harsh winters, and, therefore, may constitute a significant portion of the range for the potential YNP bison herd DPS (Appendix C, second volume, this petition).

The population count of the two herds in 2006 on which it is assumed the 2007 90-day finding was based was 1,464 for the northern herd and 3,531 for the central herd. As mentioned, for 2017-2018, the northern herd numbered about 4,000 animals, while central herd was about 850. Due to the disproportionate population levels and due to the park biologists' stated objective to keep the herds' populations equal, the birthing grounds of the central herd, namely Hebgen Basin, should also be designated critical habitat.

The Endangered Species Act requires that other federal agencies cooperate with the Fish and Wildlife Service to help protect listed species. It directs that any other federal agency in the operation of its programs shall:

> in consultation with and with the assistance of the Secretary, insure that any action authorized, funded, or carried out by such agency . . . is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species which is determined by the Secretary, after consultation as appropriate with affected States, to be critical . . . (Full Text of the Endangered Species Act, 2017).

As mentioned, the mission of the Interagency Bison Management Plan is to control the spread of brucellosis out of the park from infected wild bison to cattle, which means separating the two species from each other, one wild and native, the other domestic and invasive. Under present disease-control procedures by the IBMP, separating only wild bison from cattle, but allowing elk, which also have the disease, to come in contact with cattle will not stop the transmission of brucellosis to cattle. The only efficacious disease control method, without harming both elk and bison, would be to ban the shipment of cattle into the habitat designated critical.

In the past and at present, the IBMP provides separation by removing bison from this shared habitat, doing so by means of hazing, quarantine and lethal removal. This program is putting the continued existence of the bison herds in jeopardy, especially the central herd for reasons cited in this petition.

Live cattle are routinely shipped in and out of the Greater Yellowstone Ecosystem, the only region in the United States that still contains a reservoir of brucellosis-infected ungulates. The GYE has this status because brucellosis can only be contained by separating infected animals from uninfected animals, which is usually achieved by fencing. Fencing an ecosystem that contains migratory animals is not feasible. Cattle that have been placed in this area of contagion along unfenced park borders have the potential of acquiring brucellosis through proximity to infected wildlife and spreading it state- and nation-wide, posing a significant biohazardous threat.

To prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological and human health impacts that invasive species cause, the 1999 Executive Order 13112 on invasive species was promulgated. This order should be invoked by the FWS to ban shipments of cattle into the ecosystem. ''Invasive species'' here means an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health. Under this executive order, federal agencies cannot authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species unless all reasonable measures to minimize risk of harm have been analyzed and considered (Executive Order 13112, 1999). Complying with this executive order means that cattle can not be shipped into the ecosystem until it can be shown that their exposure to the pathogens of this ecosystem does not pose a risk of disease transmission by this invasive species when shipped out of the ecosystem. Until this can be done, the Interagency Bison Management Plan should not be funded, for its sole purpose is to keep cattle in this hazardous ecosystem.

The Endangered Species Act states federal wildlife agencies must make listing decisions based on the best scientific data after taking into consideration cost and national security. According to the EPA, Section 4:

> The Secretary shall designate critical habitat, and make revisions thereto, under subsection (a)(3) on the basis of the best scientific data available and after taking into consideration the economic impact, the impact on national security, and any other relevant impact, of specifying any particular area as critical habitat. The Secretary may exclude any area from critical habitat if he determines that the benefits of such exclusion outweigh the benefits of specifying such area as part of the critical habitat, unless he determines, based on the best scientific and commercial data available, that the failure to designate such area as critical habitat will result in the extinction of the species concerned (Endangered Species Act, Section 4, 2016).

Critical habitats for wild bison historically and at present include those regions that extend out of the park down the Madison River to the west and down the Yellowstone River to the north, with Gardiner Basin and Hebgen Basin—where bison migrate in the fall, winter and spring—being most important to the survival of this species.

Of these two habitats, the most critical is Gardiner Basin, a dispersal sink and the site of the Stephens Creek capture facility, which annually destroys a large percentage of migratory bison, putting in jeopardy their continued existence as a distinct population segment (DPS).

To have a critical habitat that has been used for survival by Yellowstone's wild bison for millennia as the on-site location of a bison extermination center is an ecological travesty. To rationalize culling here as mimicking a natural "dispersal sink" is scientifically unjustifiable. Allowing millions of dollars to be annually spent on a failed disease-control plan that puts at risk the continued existence of wild bison and contributes in fact to the spread of brucellosis out of the park, jeopardizing our national security by favoring the presence of an invasive species, that is, cattle, in a wildlife habitat would not be making decisions on the basis of the best scientific and commercial data available. Instead, data, as provided by the preponderance of scientific studies, shows that both herds of wild bison merit listing due to factors enumerated in both the first and second volumes of this petition.

Conclusion

Yellowstone's wild bison are composed of two subspecies or distinct population segments: an endemic population that occupies the central valleys of Yellowstone National Park and a population of introduced bison that occupies the northern valleys of the park. They represent two evolutionary distinct lineages.

The existing regulatory mechanisms that govern the park's wild bison operate under a policy of adaptive management executed through a coalition of federal, state and American Indian tribes called the Interagency Bison Management Plan, which is advised by biologists with Yellowstone National Park, subsumed under the National Park System. A stated goal of park biologists is to keep the herds equal in size. Since the winter of 1995-1996 the northern herd has grown from 866 animals to about 4,000 animals in 2017, while the central herd has declined from 3,062 to 847 animals in 2017, the persistent culling reversing their demographic structure. The resultant imbalance of the two herds' populations demonstrates a failure to work toward meeting the goal of keeping the herds' populations equal, exposing the central herd to loss of genetic diversity and extinction. Despite this decline, park biologists have recommended culling up to 1,250 bison for 2017-2018. With only 847 bison left in the central herd, because it is the predominately migratory herd, and since culling is directed only toward the migratory, the possibility of annihilating the herd during the lethal removals of the winter of 2017-2018 is high.

Because the probable extinction of this herd is due to inadequate regulatory mechanisms and the inability or refusal to follow recommendations of scientific studies and stated policies, the Fish and Wildlife Service should rescue the herd by listing it as endangered, and because the extinction of the northern herd looms, given environmental changes, such as a severe winter from which this herd may not escape because it has lost the instinct to migrate due to culling the migratory, it should be listed as threatened. It is especially important to save the central herd because of its rich genetic diversity, which via genetic exchange of small numbers between both herds can contribute to avoiding genetic drift and inbreeding depression. Without the existence of the central herd, no beneficial introgression can occur.

A *cordon sanitaire* should be instituted in the Greater Yellowstone Ecosystem that prohibits the grazing of cattle on grasslands used in the past or at present by wild bison outside the park. Its border should mimic the pre-settlement, historical range of wild bison as shown in Figure 11.

Only by doing so can the disease of brucellosis be controlled from spreading out of the park, while maintaining a viable herd of wild bison and elk, both of which have the disease and pose a biohazard nationwide in the presence of cattle.

For works cited see second volume, "Petition citations."

Appendix A

James Horsley

February 13, 2017

Jodi Bush
Field Supervisor
U.S. Fish & Wildlife Service
Ecological Services
Montana Field Office
585 Shepard Way, Suite 1
Helena, MT 59601

Dear Ms. Bush:

Ron Vandervort, biologist, U.S. Fish and Wildlife Service, MS: ES, Unified Listing Team, Falls Church, VA, suggested that I contact your field station with regard to a concern of mine. As I am sure you know, an unprecedented number of wild bison native to Yellowstone National Park are scheduled for culling in a few days—up to 1,300 animals. The slaughter is being carried out by the Interagency Bison Management Plan. This culling has the potential of driving the species to extinction. So far, 400 have been captured at the Stephens Creek capture facility and are awaiting shipment to slaughterhouses. More will be trapped.

The only way to stop this now is through an emergency listing by the Fish and Wildlife Service pursuant to the Endangered Species Act. If this iconic herd survives this winter, long range protection, according to the petition, entails disbandment of the IBMP and putting the management of wild bison primarily under American Indian tribes, for wild bison in the Yellowstone region are a tribal trust resource, that is, a natural resource, either on or off Indian lands, retained by Indian tribes through treaties, obligating the United States government to protect them. Exposing them to extinction is not protection. Limiting the herd to 3,000 bison and killing only the migratory members of the herd, which is now the outcome of the law that established the IBMP, is not conserving the herd as a resource for the American Indian tribes nor the public at large, for it prohibits the growth of the herd as a wild herd and counters the operation of natural selection.

The science behind the need for this slaughter is appallingly deficient. In an attempt to list wild bison as endangered, I have submitted three petitions over the course of several years under the ESA. My third petition was submitted January 12, 2017. The book you now have in hand titled *Before the Secretary of the Interior: A Petition to Protect Yellowstone's Wild Bison from Extinction* is a copy of that petition. I have worked with numerous personnel with Montana Fish, Wildlife & Parks and the Montana Department of Livestock, as well as with biologists and geneticists, in its preparation over a course of several years since the filing of the second petition.

If in the next several weeks the weather warms, melts the surface layer of the snow cover, then freezes again, it could trigger a massive migration of wild bison because the resultant ice glaze will prohibit wild bison from obtaining forage by cratering. Those migratory herds will be trapped at Stephens Creek capture facility, then taken to slaughter. Over a thousand could die this way. The remainder, those that did not migrate down from the higher altitudes, could all die of winter-kill. The result could be extinction. It is the mission of the FWS to protect our wildlife from such catastrophic eventualities.

The final rules and regulations of 50 CFR Part 424 published in the Federal Register September 27, 2016, state:

> Petitioners may request listing on an emergency basis; however, the Services are only required to treat such requests as a regular listing petition, and to follow the statutory timelines for responding to the petition as a regular listing petition. At any time, if one of the Services determines that there is an emergency posing a significant risk to the well-being of a species, it is within that Service's discretion under Section 4(b)(7) whether to consider promulgating a regulation that takes effect immediately.

I interpret this to mean that your local office can make the determination of an emergency listing that has immediate effect if it sees fit to do so. From the perspective of this petition, the basis for an emergency listing is delineated in particular on page 2, as well as in Chapter 2 "Alert: Impending Blood Bath," page 113; Chapter 3 "Protection hinges on the species concept," page 118; and Chapter 26 "Keeping out of the Emergency Room," page 453.

If ever there is "an emergency posing a significant risk to the well-being of a species," namely Yellowstone's wild bison, it is now. I urge the FWS to make an emergency listing (240 days) before it is too late.

Such large-scale culling exposes this herd to loss of genetic diversity and as noted, given a severe enough winter, extinction. Under the IBMP thousands of wild bison have been culled while seeking forage at lower altitudes outside the park. Such artificial selection annually increases the risk of extinction because only the migratory herd is killed, a sub-group that contains the genetic trait of migration, a trait necessary for the survival of at least a remnant of this wild species during a harsh winter.

It is important to preserve this trait so wild bison can survive without human assistance. These animals are the survivors of the great buffalo slaughter of the late 1800s, which reduced the vast herds covering the plains from millions to a mere 25 animals—those hiding out in the region that is now the park. The ancestors of this herd came to Yellowstone 10,000 years ago from the Old World. This is the only herd that has remained on the land to which it migrated. It is this herd from which all other bison in the nation have descended. Except for the Yellowstone herd, all others are now behind fences or range-restricted. Only the Yellowstone herd migrates. But it is this survivalist instinct that has become its death sentence, for migration puts them in proximity to cattle just outside the park. Ranchers want this pristine habitat all to themselves and their cattle.

While the FWS's findings of the first two petitions I submitted denied listing wild bison, the petitions achieved a critical first step: The findings determined the herd was a distinct population segment (DPS), essentially a subspecies. The next and final step is to show they are endangered. The FWS has argued in both their findings that while the herd may be a DPS, the herd is sufficiently abundant and will not go extinct. I have argued, however, that the migratory sub-group is not abundant, but rather is being systematically reduced to a point exposing the herd to extinction. The FWS states genetic traits, such as those governing migration, don't count in making a listing decision and discount the importance of this sub-group. According to the FWS in personal communication to me:

> One thing we considered at great length is your concern over the preservation of the "wildness" trait (as expressed through migratory behavior) in the context of the purpose of the Endangered Species Act (Act) in conserving species (as defined in the Act). The Act is not designed to conserve behaviors/traits (see accompanying petition, 2017, p. 129).

This flawed decision stems from an inappropriate application of the biological species concept to the preservation of wild bison, when instead it should be a more adequate species concept, such as the phylogenetic or ecological species concept.

One of the reasons for the length of this last petition is to comply with the intent of the final rules and regulations of 50 CFR Part 424, which state:

> Under the revised regulations, requests for agency action must contain electronic or hard copies of supporting materials, or appropriate excerpts or quotations from those materials, to qualify as petitions. Therefore, the

> Services are not required to consider claims for which cited source materials are not included with the petition. The Services will review this information to ensure compliance with the provisions set forth in this rule, and will take into consideration the extent to which the source materials included with the petition support a complete, balanced presentation of the facts, in any 90-day findings on petitions.

To facilitate easier reading and a balanced presentation of this complex issue, I have chosen to include in the narrative "excerpts and quotations" of cited source materials (about 400 references, including scientific papers, reports, maps, charts and books), instead of providing them separately as electronic or hard copies.

Another reason is that I have had to counter the shifting positions and bad science of the members of the IBMP. For example, after the petition was submitted, I noticed that the National Park Service, a member of the IBMP, had just dropped the threat of brucellosis as the major reason to prevent wild bison from migrating and now claims it must kill these animals because they might over-graze the park and die of winter-kill. So, the public is being asked to spend $3 million a year to keep bison from dying of starvation, thumbing its nose at Mother Nature, survival of the fittest, natural selection and good fiscal sense. This is sort of a euthanasia program for the animal kingdom. Don't believe that something this idiotic is going on? Visit National Park Service's blog: "Questions & Answers about Bison Management - National Park Service."

The spread of brucellosis out of the park, however, is still a major problem because *both* elk and bison have that disease—yet elk are allowed to migrate and mingle with cattle. This is a biohazardous disease that could spread nationally to other cattle herds if not contained. My second and now my third petition argue it makes no sense to keep only bison away from cattle when elk are equally infected. For that reason, the petition argues that the only sensible solution to this epidemiological problem is to remove cattle from grazing outside the park's perimeters and allow bison to migrate just as elk do now.

In the blog cited above, the NPS states why bison are treated differently than other wildlife when they leave the park. It states:

> Bison are not allowed to move freely outside Yellowstone due to fears they might transmit brucellosis to cattle . . . and out of concerns about competition with cattle for grass, human safety, and property damage. Elk are also infected with brucellosis, but their movements outside the park are not restricted. State governments control the management of wildlife outside Yellowstone (unless a species is federally listed as threatened or endangered).

Apparently realizing its hypocritical stance, the National Park Service has now made over-grazing, instead of brucellosis, the *lead* reason for killing bison. Thomas Pringle, a molecular biologist on the genomic team for the University of California at Santa Cruz, noted:

> This has nothing whatsoever to do with proper management of the YNP bison herd. I challenge the whole concept that bison or any other native species needs genetic or any other kind of 'management' . . . No one proposes a cull of a native species in a national park for the species' benefit—this is all about two cowardly controversy-avoiding agencies kowtowing to the local cattle industry . . ." (*Before the Secretary of the Interior*, 2017, pp. 10 and 107).

The Multiple-Use Sustained-Yield Act directs "the achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable resources of the national forests without impairment of the productivity of the land." By destroying wildlife to protect invasive cattle in the Greater Yellowstone Ecosystem, especially characteristic of those portions of the ecosystem in Montana, and by spending millions in tax dollars to do that, is not sustained yield. Rather, it is sustained loss. By violating the precepts of the Multiple-Use Sustained-Yield Act, the IBMP is standing in the way of economic growth and job creation for the area (especially those associated with the potential for increased regulated bison hunting opportunities), needlessly draining away public funds to protect the business of cattle ranching in our national forests. In the process, it is tragically exposing wild bison to extinction.

The petition recommends abolishing the IBMP and putting in its place a citizens' group that includes American Indian nations in a decision-making capacity. At present, tribes have only a token presence on the IBMP. American Indians have a symbiotic relationship to bison and for millennia preserved the species. By protecting wild bison and allowing the herds to grow, the FWS will ensure that their greater numbers will assure their survival through genetic diversity, including their ability to migrate. Wild bison should be recognized as having great value for the region. What is valued is protected.

I urge the FWS to make a decision to protect from extinction our newly-designated national mammal at this critical time.

My best,

James Horsley