Petition to list plains bison as threatened under the ESA.

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Summary: I petition to list wild plains bison (*Bison bison bison*) as threatened under the Endangered Species Act of 1973 (ESA), as amended, in order to conserve the subspecies and the ecosystems upon which plains bison depend. I find that each of the four major ecotypes of plains bison in the United States is likely to become endangered in the foreseeable future and that each ecotype is not sufficiently abundant or distributed, nor properly managed, to fulfill stated purposes of the ESA.

While the number of plains bison in wild and conservation herds has not declined in about 70 years, there are numerous threats to the future of wild plains bison that are not apparent in the total number of animals. Wild plains bison are threatened with loss of potential habitat, introgression with cattle genes, loss of genetic diversity, domestication and loss of wildness, disappearance of ecological effectiveness, and lack of effective, coordinated and persistent state and federal programs to restore the subspecies.

Should the Fish and Wildlife Service contend that listing plains bison is not warranted, I request that each major ecotype of wild plains bison be listed as threatened, as a significant distinct population segment (DPS), under the ESA in order to conserve the ecotypes and the ecosystems upon which these ecotypes depend.

I suggest four major ecotypes of plains bison be considered as significant DPS's to retain allelic diversity of plains bison in the future, so that bison may again fulfill their evolved ecological role as a keystone interactive species across examples of significant portions of the subspecies' historic range. I submit that restoration of wild bison has languished for decades. Listing is necessary to establish an agency, the U. S. Fish and Wildlife Service, with authority to provide guidance, coordination across jurisdictions, and persistence that will be needed for a long-term, incremental restoration program.

"The Services understand the Act to support interrelated goals of conserving genetic resources and maintaining natural systems and biodiversity over a representative portion of their historic occurrence." (Fed. Register 61(26):4723).

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Prehistory: During the ice ages, species of bison immigrated from Asia to North America where they lived among a highly diverse ungulate fauna of about 50 species (Kurten and Anderson 1980). In the late Wisconsin-early Holocene, most of these ungulates became extinct, leaving 12 species to fill abundant empty niches across the continent (Martin and Klein 1984). Consequently, at the time of European contact, most native ungulates, including bison, had very large geographic and ecological ranges. Bison occurred in many different ecosystems from Alaska and much of Canada to Mexico, and from eastern deciduous forests to the Great Basin and Columbia Plateau (Fig. 3.1 in Boyd 2003). However, since the Pleistocene extinctions occurred only about 12,000 years ago, there was not sufficient time for bison to become highly adapted or specialized for using many of the ecosystems across a range where they succeeded at least in part due to lack of competition from more locally adapted mammals (Martin 1970).

At the time of European contact, bison were most abundant and presumably most productive in the North American Great Plains, especially the northern Great Plains. This environment is most similar to the habitats across which bison immigrated to North America from Asia. These facts indicate that the Great Plains are the naturally-associated environment of North American bison, that is, the Great Plains are the kind of environment in which most of the species' evolution occurred, the kind of environment to which the species is best adapted; and the kind of environment in which the full genetic potential of the species may be realized. This prehistory is necessary to fully understand the significance of four major ecotypes of plains bison as Distinct Population Segments for conservation purposes.

Recent History: Trends in bison numbers and distribution since the advent of European man in North America have been reviewed by Boyd (2003), Freese et al. (2007) and Sanderson et al. (2008). Three hundred years ago plains bison numbered in the tens of millions across much of North America and were essential to the ecology of grassland ecosystems (Shaw 1995, Table 1 in Sanderson et al. 2008). Numbers were reduced to near-extinction with the only remaining wild plains bison in Yellowstone National Park. Outside the Park, private, rather than public, efforts conserved a few remaining bison. Through a variety of efforts, the continental bison population recovered substantially. Early efforts provided public/conservation herds. However commercial herds of bison, primarily for meat production, have increased such that at least 95% of the current bison population is now under private commercial management leading to domestication (Boyd 2003).

Meanwhile, private efforts to maintain wild bison continue. Private herds of The Nature Conservancy are notable examples. However, most private-conservation

herds have fewer than 500 animals. Probably all are classified as domestic livestock by their respective states.

Thirty-five herds of plains bison, summarized in Boyd (2003) are owned by federal, state or local agencies. Publicly owned conservation herds of wild bison on public lands are necessary to secure benefits of the subspecies to all citizens, including esthetic, ecological, educational, historical, recreational, and scientific values. However, in contrast to the accelerating numbers of privately owned bison, the number of bison in public/conservation herds has remained unchanged at about 20,000 animals since about 1930 (Fig. 1 in Freese et al. 2007).

Current programs for conservation of wild plains bison are inadequate, as discussed below under Listing Factors. For plains bison, the threat is not numerical extinction. The threat is from hybridization with cattle, loss of allelic diversity, domestication, loss of wildness due to anthropogenic selection overwhelming a limited range of natural selection, resulting in genomic extinction of wild plains bison, and also ecological extinction. This process is well underway and, to some extent, affects every herd of plains bison in the United States.

Rationale for listing and recovery:

1. **Geographic Limits.** This rationale is limited to the status of, and opportunities for restoration of, wild plains bison within historic bison range in the contiguous 48 states, west of about 95^{o} longitude. East of this line, the landscapes are intensively developed and used, such that opportunities for restoring large herds of wild plains bison over necessarily large ranges seem gone. Restoration of plains bison in Canada is left to Canadians. Bison conservation problems and opportunities, and conservation policies, are significantly different in Canada.
2. **Unoccupied Range.** Sanderson et al. (2008) estimate that the current range of bison is likely <1% of historic range, and this is probably true for plains bison as well. I therefore contend that wild plains bison are threatened over a significant portion of their range.

   I reject any rationale (Solicitor's opinion to Director, U. S. Fish and Wildlife Service, memorandum of March 16, 2007) that a species does not warrant listing as threatened or endangered when the remaining <1% of historic range is occupied by relict populations that, in total, have not recently declined. I reject this rationale because:
   A. it could apply to the last few animals of a species, an absurd conclusion that is not consistent with findings and purposes of the ESA.
   B. with respect to plains bison, it is inconsistent to promote conservation of 90-95% of the allelic diversity of bison while confining them to a future within the narrow natural selection

occurring in <1% of historic range, perhaps in only one population large enough to prevent genetic drift that is unrelated to natural selection. This is not safeguarding the future evolutionary legacy of the subspecies. In this respect, I contend that it is the obligation of the Secretary of Interior to determine what amount and diversity of historic range must be occupied by wild plains bison in order to allow continuing adaptation and evolution of the subspecies. Such continuing adaptation and evolution are biologically important to the subspecies, and necessary to preserve and create sufficient genetic diversity for reasonable purposes of future generations of the Nation and its people. (See additional discussion under "Ecotypes of plains bison as distinct populations", below.)

C. limiting the listing decisions under the ESA to only the currently occupied range of a species forces arbitrary decisions in circumscribing what is occupied range. (How large must the space between existing herds or populations be, to be "unoccupied range"?) Listing decisions should be based more on achieving purposes of the ESA, not on such arbitrary decisions.
D. for plains bison, and other species, this rationale would ignore conservation needs of the ecosystems upon which 99% of the historic populations of the subspecies once depended. This is inconsistent with a stated purpose of the ESA.
E. for plains bison, and other species, this rationale would severely limit public access for realizing the esthetic, educational, historic, recreational and scientific values of wildlife that may persist at unreasonable distances from citizens' homes. It would fail to safeguard the Nation's wildlife heritage for the benefit of <u>all</u> citizens.
F. I contend that the Secretary of Interior has latitude in defining "significant" portion of range in these contexts, consistent with achieving the purposes of the ESA.

Since wild plains bison are gone from a significant portion of their historic range, no regional DPS of plains bison, as defined below, currently has a population of sufficient size and distribution to assure retention of current genetic diversity in the long term; or to assure continued adaptation and evolution of the DPS to regional and changing environments; or to allow plains bison to function ecologically as an effective keystone, interactive subspecies, thereby providing and safeguarding the genetic and ecological value of wild plains bison for the benefit of all citizens.

3. **Commercial herds, private conservation herds, and wild bison.** Privately owned <u>commercial herds</u> do not contribute to restoration of wild bison. These animals are selectively bred, mostly mixed with cattle genes (Polziehn et al. 1995, Ward et al. 1999, Halbert et al. 2005), removed from natural selection, and most are in small herds in small pastures. They are not legally classified as wildlife under state laws. Their significant roles in

grassland ecosystems are limited or non-existent (Sanderson et al. 2008). Commercial herds of bison do not provide adequately for conservation of native grassland ecosystems. They are not necessarily secure in the long term. They are usually inaccessible to the public and they do not provide or safeguard benefits to all citizens.

Nine private conservation herds may contribute animals for restoration of wild plains bison (Boyd 2003). However, one herd is outside native range and all but two private herds are less than 500 animals. Their genetic constitutions are uncertain; natural selection is replaced by roundups with selective culling and/or with augmentations, leading to domestication. Most herds have unnatural sex ratios and are vaccinated for diseases. Three herds are rotated through pastures (Boyd 2003). Public access to these animals is limited. At least one TNC website notes that demonstrating how bison can be produced with cattle is an objective of management and this could compromise conservation objectives, especially the objective of allowing natural selection to operate. In all, private conservation herds are a step toward restoration of wild bison, but they do not constitute restoration of wild plains bison with all the public values of wild bison, including ecological values.

Several large herds of wild plains bison, subject to natural selection on diverse, large reserves of mostly public land will be necessary to restore the subspecies and fulfill the purposes of the ESA. These purposes include conservation of grassland ecosystems upon which plains bison depend, and safeguarding for the benefit of all citizens, present and future, the Nation's legacy in wild plains bison.

4. **Herd-size requirements for genetic security of wild bison.** How much of the original gene pool of plains bison has been lost is unknown. It is likely that significant genetic potential, representing adaptations to local and regional environments is no longer available for use in plains bison restoration. Today, the genetic integrity of wild plains bison is threatened by genetic drift in small populations, and by anthropogenic, rather than natural, selection leading to genomic extinction of wild plains bison (Freese et al. 2007).

   Gross et al. (2006), using population/genetic modeling, estimated that 1000 managed bison are needed to provide 90% probability of retaining 90% of allelic diversity for 200 years. However, Gross et al. (2006) noted that their models show high variation of results during the 2nd century of simulation, and suggested caution in their application. Freese et al. (2006) concluded that, considering the importance of the Yellowstone herd, a more prudent goal would be to retain 95% of the existing allelic diversity over 200 years. This will require maintaining about 2000 managed bison, according to the models of Gross et al. (2006). I contend

this more prudent approach is justified for additional herds that should be established, not just for Yellowstone bison.

Genetic diversity may be retained in relatively small bison herds through active genetic management, involving selective culling and transfer of animals among herds in an artificial metapopulation. However, this approach compromises or eliminates other values of wild bison in that animals are routinely captured and handled for genetic and disease sampling. Natural selective processes – including the development of disease resistance - are subverted, and hunting may not be allowed because it could be contrary to selective culling.

The future of genetic diversity of wild plains bison will also depend upon the diversity of habitats available to allow expression of adaptive bison traits. A diversity of bison habitats is needed to provide a diversity of natural selection, so that sufficiently large herds of bison may continue to adapt and evolve.

To my knowledge, FWS has not proposed herd-size or range-size standards for preventing gradual loss of genetic diversity of plains bison in the future. To prudently maintain genetic diversity of wild plains bison under natural, rather than manipulated conditions, I contend that several populations of at least 2000 animals on diverse natural landscapes will be required.

5. **Hybrid populations of plains bison with cattle genes**. Of 32 wild plains bison herds on native range in the 48 states, only 7 were considered free of cattle genes in 2003 (Boyd 2003, Tables 1-4), however 24 herds remained untested at the time. Freese et al. (2007) state that only 6 significant public herds of plains bison in the US and Canada do not show cattle gene introgression, with only 2 of these having been sufficiently sampled for statistical confidence. At best, only 1.5% of plains bison today are free of cattle gene introgression (Freese et al. (2007).

   Restoration of plains bison should be initiated with animals most likely to be free of cattle genes. This severely restricts options, probably for many years. Meanwhile, plains bison herds with limited cattle gene introgression should be retained and managed to conserve their genetic diversities, especially because some herds contain unique alleles (Roffe, T., personal comm.). Intensive genetic management, possibly with techniques not yet developed, may some day be used to rid these herds of cattle genes so they may contribute to restoration of wild plains bison.

6. **Disease issues of plains bison**. Bison in the Greater Yellowstone Ecosystem are infected with non-native *Brucella abortus*, resulting in the disease brucellosis. This disease is regulated by USDA Animal, Plant

Health Inspection Service (APHIS). Consequently, bison entering Montana from Yellowstone National Park are managed, not as wildlife, but as a disease threat by the state Department of Livestock.

Brucellosis is endemic in wildlife of the Yellowstone Ecosystem, including in many thousands of elk, as well as bison and probably other wildlife. No serious, detailed plan for eradication of the disease, with cost estimates has been proposed. I believe eradicating *Brucella* from the Yellowstone Ecosystem is impracticable. If eradication is possible, it will require draconian methods that will be very costly and publicly unacceptable.

Brucella transmission from bison to livestock has not been demonstrated in field conditions. It might occur only during February to mid-June (Cook et al. 2004, Aune et al., n. d.). Thus, the risk of unlikely *Brucella* transmission from bison to cattle can be controlled by spatial and temporal separation of bison and fertile cattle during part of each year. This is the most practical and economic approach for bison restoration in the Greater Yellowstone Area, including Grand Teton National Park. Given the potential for risk management through cattle management, there is abundant potential bison range in Montana for expansion of the Yellowstone Park herd and to provide needed winter and calving range for the Park herd. Much of this potential range is public land or private land with no cattle where bison are known to be welcome.

Outside the Greater Yellowstone Ecosystem, remaining bison are considered *Brucella*-free. Moreover, several Yellowstone bison have been processed through a quarantine program and are considered *Brucella*-free animals available for transplant.

Bison may also be impacted by tuberculosis, malignant catarrhal fever and Johne's disease. Opportunities for restoration or expansion of plains bison herds may be limited somewhat by needs to prevent contact with cattle or domestic sheep that may carry these diseases. However, this issue need not prevent restoration of bison, as evidenced by several bison herds already in cattle country with few, if any, problems.

Most herds of wild plains bison are frequently captured and vaccinated for various diseases. I consider most, if not all, this activity to be unnecessary since vaccinations are not used in the management of several large bison herds, and I am not aware of frequent or serious disease results in bison or in adjacent livestock. I oppose unnecessary use of vaccinations in wild bison because it subverts natural selection for disease accommodation and it requires capture and handling of the animals, promoting domestication of wild plains bison.

7. **Ecological extinction of plains bison.** "The plains bison is for all practical purposes ecologically extinct within its original range." (Freese et al. 2007:4). "The majority of bison no longer play the significant roles they once did in grasslands and other ecosystems." (Sanderson et al. 2008:254).

   Bison are a highly interactive species in grasslands. They create and maintain a mosaic of vegetative composition and structure, recycle and concentrate nutrients, interact with hydrological and soil processes, provide food for predators and scavengers including birds and small mammals, modify impacts of prairie fire, discourage woody plant invasion, and provide nest materials (wool) for birds and small mammals (Knapp et al. 1999; Freese et al. 2007; Sanderson et al. 2008, Table 1; and references in these papers). Domestic cattle are not ecological surrogates for bison. "Research at Konza Prairie in Kansas and in Utah indicates that the abundance and richness of annual forbs and the spatial heterogeneity of biomass and cover are higher in sites with bison than in sites with cattle." (Freese et al. 2007). Bison are a keystone, interactive species in grasslands and FWS policy attempts to reflect the important ecological role of a species in determining significance of a discrete population (Fed. Register 61, No. 26:4723).

   The need to restore large examples of ecologically intact grasslands in the 48 states is indicated by the numerous grassland species listed as threatened or endangered under the ESA and by the well documented decline of the nation's grassland birds (Sauer et al. 1995, National Audubon Society, 2008; North American Bird Conservation Initiative 2009).

   There is no specific criterion to define ecological extinction. The significance of ecological interactions of bison will decline as the numbers of bison decline, as the size of their range declines, and as their access to a diversity of seasonally-used habitats declines. Therefore, significant ecological restoration of plains bison will require, at a minimum, several large herds roaming free over large ranges with a variety of habitat types.

   To my knowledge, FWS has not proposed herd-size or range-size standards sufficient to retain a significant ecological role for plains bison. I suggest that herds of at least 2000 bison, each on a diverse range of at least 500 sq. miles are needed for ecological restoration of wild plains bison.

8. **Coexistence with livestock.** In 1896, buffalo hunter Vic Smith said, "The stockmen wanted the bison exterminated so the cattle could have the grass." (Smith 2009:220). Today, the most widespread and significant barrier to plains bison restoration is the presence of livestock on both

public and private historic bison range, and the strong, well-funded and politically connected opposition to bison restoration from the livestock industry. As a result, bison are not being restored on federal lands despite a mandate to provide for diversity of plant and animal communities in the National Forest Management Act and a mandate to take into account the long-term needs of future generations for wildlife in the Federal Land Policy and Management Act. Wild bison are not allowed on some private lands where they are welcome by landowners - due to state restrictions promoted by the livestock industry.

Due to potential impacts of bison on agricultural crops and livestock, and due to potential safety concerns, wild bison should not be forced upon any private landowner. Montana's law (81-2-121, Montana Code Annotated), facilitating removal of wild bison from private lands where bison are not welcome, is appropriate. However, restoration of plains bison should include expansion of public bison onto private lands adjacent to bison-occupied public lands, where bison are welcome on the private lands. Although wild bison will require large blocks of land, these bison ranges will have to be exterior-fenced to accommodate needs of some adjacent landowners.

Much restoration of plains bison must proceed on large blocks of land that are >90% publicly owned. Opportunities exist on public lands managed by the U. S. Departments of Interior and Agriculture, often mixed with state public lands. However, almost all these public lands are grazed by private livestock in publicly subsidized grazing programs. Many ranchers depend upon these grazing allotments for their livelihoods. In addition, probably all these large blocks of mostly public land contain inholdings of private land where bison are not now welcome. Abrupt closure of grazing allotments to restore bison and native prairie would cause economic hardships for individuals and for local communities. Such disruptions of people's lives and local economies are not contemplated and are not considered politically feasible. A long-term, incremental conversion of lands from livestock grazing to bison and native prairie is envisioned. This conversion should involve fair, mutually acceptable agreements between public and private interests. Agreements may include trading grazing allotments, vacating grazing allotments, purchase of grazing rights, and purchase or trade of lands. Both public and private funding may be involved.

This long-term, incremental approach will require enduring federal and state commitments to restoration of plains bison and the ecosystems upon which they depend. Agencies must persistently seek opportunities to expand bison range within carefully selected areas where plains bison restoration is most feasible.

9. **Needed coordination of long-term, incremental efforts.** Long-term conservation strategies for bison have been developed by non-government organizations and by the U. S. Department of Interior (Boyd 2003, Freese et al. 2007, Redford and Fearn 2006, Sanderson et al. 2008, USDI 2008). These strategies indicate that reestablishment of ecologically significant, viable and self-sustaining populations of wild plains bison within their associated ecosystems will require long-term, incremental efforts coordinated across very many state, federal, Tribal and private agencies and organizations. FWS is the only agency mandated to provide this persistent coordination - for species listed under the ESA. Without listing, such coordination has been and will be voluntary, intermittent, poorly funded, and very likely ineffective.

10. **Need for control and take of listed bison.** Plains bison will have to be controlled and confined to large designated bison ranges during the restoration process. Fences are being used successfully to control bison while allowing passage of other wild ungulates on commercial bison ranches. Ultimately, bison numbers will have to be controlled, preferably with an emphasis on public hunting; and this take may be necessary for many herds before the subspecies, or any DPS, is delisted. Therefore, a listing document should include a request from the Secretary of Interior for state conservation plans, under Section 10 of the ESA, which will include permitted take of threatened bison, and possibly habitat, as necessary to enhance survival and propagation of ecologically significant populations.

LISTING PETITION

Ecotypes of plains bison as discrete, significant populations: I do not contend that the major ecotypes of plains bison described below are genetically distinct. Genetic distinctiveness of these ecotypes was lost during the great bison decline and with frequent translocations of animals.

The four major ecotypes of plains bison are physically separated. Their persistence is necessary to capture and represent most of the environmental variability found within the range of the subspecies and to ensure that the adaptive capabilities of plains bison are conserved. Establishing at least one large wild bison population within each ecoregion would provide redundancy and resiliency needed to provide a margin of safety for possible catastrophic events, and for global warming.

Gross et al. (2006) and Freese et al. (2007) provided a high and generally accepted standard for retaining 90-95% of allelic diversity of bison. This legacy of allelic diversity is bequeathed to us from past evolution of bison in a diversity of environments, each with local and varying natural selective forces. Allelic diversity is necessary for the continued adaptation of bison to new and changing environments (Allendorf 1986) and is considered important to the long-range

survival of a species (Gross et al. 2006). Thus, the value of retaining allelic diversity of bison is generally accepted.

But, if allelic diversity of wild bison is to be maintained in the future, there must be at least one sufficiently large herd of bison in each of several wild environments with distinct natural selective forces. In contrast, limiting the future of plains bison to a limited array of natural selective forces in only one environment will assure adaptation to one local environment (specialization) and limit genetic and epigenetic diversity of plains bison in the future.

I contend that the appropriate range of natural environments needed to retain satisfactory genetic diversity of plains bison in the long term is contained in four major ecoregions of historic bison range: northern Great Plains, southern Great Plains, Rocky Mountains and Great Basin/Colorado Plateau. Each ecoregion contains a discrete ecotype of plains bison today, based on bison behavior and ecological relationships, as well as physical separation. Loss of any ecotype would result in a significant gap in the range of plains bison. Each ecotype can become more genetically distinct in the future (unless swamped by managed transplants across ecoregion boundaries). In this way, each ecotype is significant to the genetic future of plains bison. Restoring and conserving these four ecotypes of plains bison will "support interrelated goals of conserving genetic resources and maintaining natural systems over a representative portion of (plains bison) historic occurrence." (Fed. Register 61, No. 26:4723).

Each ecotype of plains bison lives and functions within a distinct vegetation/climate zone, an ecological setting unique for the subspecies. (Many books have reviewed the ecoregions and climatic zones of North America – c.f. Ricketts et al., 1999, Here I provide the barest essentials of an argument that these areas are discrete.) Many ecosystems within these vegetation/climate zones upon which bison depend, or once depended, are in great need of conservation. Bison behavior, including food habits, social habits, movement patterns, and relations to plants, other animals, and microorganisms are unique for each ecotype. With natural selection, sufficiently large populations of plains bison will again adapt genetically and behaviorally to each regional vegetation and climate. In time, the full genetic potential of plains bison will be realized, providing ecological, scientific and perhaps commercial value. For example, genetic adaptations to diseases (Seabury et al. 2005) and to climate could provide genetic materials for use in commercial bison, and even in domestic cattle, for dealing with climate change or disease problems.

A discrete set of the American people will, by proximity, have reasonable access to bison in each ecoregion, for realizing educational, historical, recreational and scientific values of bison. Recreational values would include state-resident fair-chase hunting for some and non-resident hunting for others.

1. **Northern Great Plains ecotype.** The Northern Great Plains is the naturally-associated environment of plains bison, as noted above.

Compared to other environments, plains bison are best adapted to the northern Great Plains. They will be most consistently productive in this environment and will be easiest to conserve there, even with effects of global warming. Northern Great Plains bison provide resiliency and redundancy for the subspecies.

The northern Great Plains have a unique flora and flora. Prominent vegetation types of the northern Great Plains include northern shortgrass (*Fescue*) prairie, northern mixedgrass prairie and pine/juniper parklands. Less prominent types are local herbaceous wetlands, shrubby draws, badlands and riparian vegetation along rivers and streams. In Montana, South Dakota and Wyoming, extensive grasslands are intermixed with low hills and small mountains with conifer trees, a condition not found elsewhere in plains bison range. The climate of the northern Great Plains includes relatively short summers and long winters with frequent snow and occasional severe blizzards. Bison are expected to adapt behaviorally to the unique vegetation, phenology, topography and climate of the northern Great Plains. Genetic adaptations to this environment will be maintained and amplified through natural selection. Without wild northern Great Plains bison, the full adaptive capabilities of the subspecies are not conserved.

Species of concern in the northern Great Plains ecosystem upon which plains bison depend include: sage grouse, Eskimo curlew, piping plover, burrowing owl, Baird's sparrow, black-tailed prairie dog, black-footed ferret, swift fox and many others.

Over 4.5 million Americans live in five states containing major portions of the northern Great Plains. Conserving at least one large herd of wild plains bison in this area would assure this population will have reasonable access to bison for realizing values of the subspecies, as envisioned in the ESA.

2. **Southern Great Plains ecotype.** Southern Great Plains bison provide resiliency and redundancy for the subspecies.

   The southern Great Plains have a unique flora and fauna. Prominent vegetation types include southern shortgrass, mixedgrass and tallgrass prairies and oak and juniper savannahs. Less prominent types are local herbaceous wetlands, playas, sandsage shrubland and riparian vegetation along streams and rivers. The climate of the southern Great Plains includes relatively short winters and long, hot summers with monsoon rainfall in some areas. Bison are expected to adapt behaviorally to the unique vegetation, phenology, and climate of this area. Genetic adaptations to the southern Great Plains will be maintained and amplified through natural selection. Without wild southern Great Plains bison, the full adaptive capabilities of the subspecies are not conserved.

Species of concern in the southern Great Plains ecosystem upon which plains bison depend include: lesser prairie-chicken, sharp-tailed grouse, long-billed curlew, burrowing owl, Baird's sparrow, black-tailed prairie dog, black-footed ferret, swift fox, meadow jumping mouse, plains leopard frog and many others.

Over 34 million Americans live in five states containing major portions of the southern Great Plains. Conserving at least one large herd of wild plains bison in this area would assure this population will have reasonable access to bison for realizing values of the subspecies, as envisioned in the ESA.

3. **Rocky Mountains ecotype.** Rocky Mountain bison provide resiliency and redundancy for the subspecies.

   The Rocky Mountains have a unique flora and fauna. Prominent vegetation types expected to be used by bison are mountain and foothill grasslands, sagebrush, mountain shrubs and aspen. Less prominent types include riparian vegetation along streams and rivers, forest parklands and alpine tundra. Extreme topographic variation allows for considerable bison migration. Rocky Mountain climates include medium-to-long winters and medium-to-short summers. Snow accumulation can be large, but is mediated by topography, elevation and aspect. Bison are expected to adapt behaviorally to the unique vegetation, phenology, topography and climate of this area. Genetic adaptations to the Rocky Mountains will be maintained and amplified through natural selection. Without wild Rocky Mountain bison, the full adaptive capabilities of the subspecies are not conserved.

   Species of concern in Rocky Mountain habitats used by bison include: Sage grouse, Gunnison's sage grouse, Brewer's sparrow, golden eagle, white-tailed prairie dog, Gunnison's prairie dog and many others.

   Over 8 million Americans live in four states containing major portions of the Rocky Mountains within historic bison range. Conserving at least one large herd of wild plains bison in this area would assure this population will have reasonable access to bison for realizing values of the subspecies, as envisioned in the ESA.

4. **Great Basin/Colorado Plateau ecotype.** Great Basin/Colorado Plateau bison provide resiliency and redundancy for the subspecies.

   This region has a unique flora and flora. Prominent vegetation types expected to be used by bison include mountain and foothill grasslands, palouse prairie, sagebrush, and juniper parklands. Less prominent types

include riparian vegetation along streams and rivers, and forest parklands. Numerous mountain ranges offer opportunities for bison migration. Great Basin/Colorado Plateau climates include moderate winters and hot summers. Lack of precipitation results in limited and highly seasonal vegetative production. As a result, historic bison populations were sparse in this area. Herds appear to have been easily eliminated by native Americans once they acquired horses. Bison are expected to adapt behaviorally to the unique vegetation, phenology, topography and climate of this area. Genetic adaptations to the Great Basin/Colorado Plateau will be maintained and amplified through natural selection. Without wild bison in this ecoregion, the full adaptive capabilities of the subspecies are not conserved.

Species of concern in Great Basin/Colorado Plateau habitats include: sage grouse, Gunnison's sage grouse, golden eagle, long-billed curlew, Utah prairie dog, Gunnison's prairie dog, white-tailed prairie dog, black-footed ferret, pygmy rabbit, kit fox and many others.

Over 12 million Americans live in four states containing major portions of the Great Basin/Colorado Plateau within historic bison range. Conserving at least one large herd of wild plains bison in this area would assure this population will have reasonable access to bison for realizing values of the subspecies, as envisioned in the ESA.

Listing Factors for plains bison: The stable trend of plains bison numbers in "conservation herds" since the 1930s (Fig 1 in Freese et al. 2007) does not, by itself, support listing plains bison as a threatened subspecies. Problems indicating that wild plains bison are likely to become endangered in the foreseeable future are more insidious. Eleven of these problems are listed in columns 2-12 of Tables 1-4. They lead to loss of genetic diversity, loss of genetic and epigenetic wild traits, and loss of ecological effectiveness of wild plains bison. Of 32 plains bison herds on native range in the United States, 29 herds have from 4 to 10 of these problems (mean = 7 problems/herd). The only herds with sufficient range for ecological effectiveness are the Yellowstone herd and the perhaps the Henry Mountains herd, and the latter is too small for maintaining its genetic diversity. Wild plains bison are threatened by domestication, loss of wildness, and by genomic extinction in the foreseeable future. They are already in danger of ecological extinction. I contend that wild plains bison are threatened because:

1. **Loss and modification of plains bison habitat continues**. The majority of historic plains bison range, especially the most productive areas with the best soils, is now developed, especially as cropland or grazing land, and is unavailable for bison restoration. Most of the remaining native prairie is privately owned and not near any large block of public land where bison restoration is a possibility. Bison habitat in the Rocky Mountains and in the Great Basin/Colorado Plateau likely never was

widespread and has already been impacted by activities listed in the next paragraph and by permanent flooding with dam construction.

Opportunities for restoration of wild plains bison are thus much restricted today. However land development and degradation of potential plains bison habitat continues, on both public lands and on nearby private lands. These activities include cattle grazing, often with unnatural grazing systems that alter vegetation and animal communities. Other ongoing impacts include conversion of prairie to dryland or irrigated cropland, tree invasion, wetland drainage altering stream flows and groundwater, lack of fire resulting in altered vegetation, subdivision of land with housing or other construction, and development of energy, minerals and petroleum resources.

With the possible exceptions of cattle grazing and dam construction, all of the above activities affecting potential plains bison habitat are expected to increase in the foreseeable future. Thus, delay in initiating a focused, coordinated and funded program to restore habitat for wild plains bison will only increase costs and decrease opportunities for success.

2. **Existing federal regulatory mechanisms for bison conservation are inadequate**. Examples of inadequate federal regulations and programs include, but may not be limited to:
   A. Interagency Bison Management Plan. The IBMP for Yellowstone bison was finalized in 2000. In 9 years, there has been no progress in maintaining a free-ranging herd of bison, one of the plan's objectives. Moreover, bison have recently been extirpated without restoration from the Eagle Creek Bench near Gardiner, Montana, from the upper Gallatin Canyon south of Big Sky, Montana, and from eastern Idaho. Some bison are handled as livestock within Yellowstone National Park and especially outside the Park in Montana, where the state Department of Livestock has bison management authority. In 2008, 1434 bison were sent to slaughter. In the name of brucellosis risk-management, bison are not allowed on their historic habitat where there are no cattle during the season when *Brucella* transmission is possible. Due to bison control, the long-term genetic diversity of Yellowstone bison is in jeopardy. Regulations and policies of the Animal, Plant Health Inspection Service (APHIS) and of the state of Montana (MCA 81-2-120) limit possibilities for plains bison restoration and conservation in that portion of the Greater Yellowstone Ecosystem in Montana.
   B. Department of Interior Bison Conservation Initiative (2008). This initiative is a good beginning toward plains bison restoration. However, only one of eight priorities addresses needed increases in herd sizes and numbers of herds. Emphasis throughout the initiative is on establishing interagency communications on bison

conservation, and on managing genetics and diseases of bison. The Bureau of Land Management's role, beyond representation on a Working Group, is underemphasized in the initiative, despite BLM's control of significant habitat where plains bison may be reintroduced. The initiative does not commit the U. S. Forest Service, including the large National Grasslands, to anything.

Most important, (1) this initiative provides no standards of herd size or range size for bison restoration; (2) does not provide strong incentives for states to become more involved in restoration of plains bison; and (3) does not assure persistent, long-term efforts to conserve plains bison throughout changes in state and federal political climates and administrations. Listing under ESA regulations would provide these needed, persistent state and federal efforts.

C. CMR National Wildlife Refuge Planning. Only two of four plan alternatives consider bison reintroduction. One alternative would "consider" bison reintroduction, and the 4th alternative, the draft proposed action, would restore bison only "when habitat is available" (from livestock competition?) and when "accepted by the public." (CMR National Wildlife Refuge Planning Update, Issue 3, 2008). A stronger commitment to bison reintroduction on the CMR NWR and adjacent BLM lands would result under ESA regulations after listing of plains bison.

D. National Grasslands. Seven National Grasslands with potential for plains bison restoration and recovery include: Thunder Basin NG, WY; Buffalo Gap NG, SD; Fort Pierre NG, SD; Little Missouri NG, ND; Kiowa, Rita Blanca NG, NM, OK, TX; Comanche NG, CO and Black Kettle NG, OK. The Nebraska National Forest, NE, and the Custer National Forest, MT also have potential for bison restoration. Numerous policy, administrative and funding issues impede the incorporation of biodiversity issues into National Grassland programs (Olsen 1997). Likewise, reestablishment of bison is not a priority for the National Forests.

A cursory review of Forest Service and National Grassland websites indicates there was considerable review of National Grassland policy ongoing during the late 1990s. This activity that might develop a multiple-use framework to include restoration of significant areas with native prairie ecosystems, including wild plains bison, seems to have ceased.

3. **Existing state regulatory mechanisms for bison conservation are inadequate**. A cursory review of state websites indicates that state programs are inadequate for bison restoration:

A. At least 6 states legally define bison as “livestock” or by a similar term: Colorado, Minnesota, North Dakota, Kansas, Wyoming, Oklahoma.
B. In states with endangered species listings, at least 7 states do not list bison as threatened or endangered: Minnesota, Montana, South Dakota, Nebraska, Colorado, Texas, New Mexico. These states either ignore bison as wildlife, or consider wild bison as extirpated.
C. Bison are not included on state lists of “species of concern” in at least 8 states: Minnesota, Missouri, South Dakota, Wyoming, Colorado, Oklahoma, Texas, Utah.
D. Bison are not listed as a priority species in the comprehensive wildlife conservation plans of at least 13 states: Colorado, North Dakota, South Dakota, Kansas, Minnesota, Missouri, Nebraska, New Mexico, Oklahoma, Texas, Wyoming, Idaho, Utah.

While all states may have comprehensive wildlife conservation plans, I found a commitment to conservation and reintroduction of bison only in the Montana plan. Yet Montana’s plan is largely unfunded and there are no specific proposals for restoration of bison. Bison leaving Yellowstone National Park are controlled by the state Department of Livestock in Montana and none are allowed outside the Park during most of the year. Montana accepts bison in the National Bison Range as “display animals” in an “exhibition park”, not as animals for conserving the subspecies (MCA 87-1-711 and 712). Knowles (2001) recommended testing acceptance of wild bison in Montana with herds of 50 animals in each of four areas. Eight years later, the state has not initiated this limited process. “Disease-free” bison recently available from quarantine pens for transplant in Montana have not yet found a home.

Utah, where bison are a big-game species, may be the only state with an active program to expand the range of wild plains bison. However, bison are not listed as a sensitive species in Utah and are not considered a species of concern in Utah’s Comprehensive Wildlife Conservation Strategy. The future of Utah’s commitment to restoration of wild bison is therefore uncertain.

Two of Utah’s 3 bison populations can contribute marginally, at best, to conservation of plains bison. The Antelope Island herd has but 600 animals, with no potential for expansion, contains cattle genes, is subjected to annual roundups and anthropogenic selection and is considered to be on “peripheral” historic range (Boyd 2003). The new Book Cliffs herd seems to have been introduced into a part of historic range that may have very limited habitat quality for bison, since this area was not even considered as

potential bison habitat in the Utah GAP analysis (Utah GAP Analysis, USDI National Biological Service, 1997).

Most western states are ignoring their trust responsibility to maintain bison as a native wildlife species. State programs are inadequate for restoration of wild plains bison.

4. **Existing private programs to conserve plains bison are inadequate**. The Nature Conservancy is commended for its efforts to conserve plains bison. However, the largest TNC herd is 1500 bison and 6 TNC herds have <500 animals. Genetic cattle introgression into TNC bison was uncertain in 2003 (Boyd 2003). Most important, TNC herds face a preponderance of anthropocentric selection in that 4 herds have rotational grazing systems, 6 have no predators, at least 4 have skewed sex ratios; and all have roundups, vaccinations, and annual contrived culling programs (Boyd 2003).

5. **Plains bison face genetic restriction and modification, with loss of wildness and genomic extinction.** Neither the National Park Service nor the Fish and Wildlife Service have science-based quantitative management objectives for conserving the genetic diversity of bison (Gross et al. 2006:7, Freese et al. 2007:6).

   I contend, above, that a herd of at least 2000 animals, with predominately natural selection, is required to provide genetic security for the wild plains bison genome within one herd. Only the Yellowstone National Park herd, with 2900 animals at this time, fulfills this requirement. However, the Yellowstone herd consists of at least 2 subpopulations with differing genetic compositions (Halbert 2003, Gardipee 2007) and differing age structures and timing of parturition (Gogan et al. (2005) suggesting the operation of different factors of natural selection. Neither subpopulation is large enough to forestall loss of allelic diversity. Both subpopulations are being managed with non-random anthropogenic selection in all years and significant levels of such selection in some years (Interagency Bison Management Plan reports, 2008). Relaxation of these population restrictions and population control methods is not likely in the foreseeable future due to legal requirements and policies, primarily in Montana, for managing the small risk of *Brucella* transmission from bison to cattle.

   Beyond Yellowstone, only 3 herds of plains bison have even 1000 animals (Boyd 2003). The Custer State Park herd in South Dakota has 1100, with no room for expansion; has genetic introgression from cattle; is managed with roundups and selective culling resulting in an unnatural sex ratio and otherwise subverting natural selection. Animals are vaccinated and rotated among fenced pastures (Boyd 2003). Two TNC herds, Medano-Zapata Ranch in Colorado and Tallgrass Prairie Preserve in Oklahoma,

each have 1500 animals with room for expansion. However these two herds had not been genetically tested for cattle introgression and are subject to anthropogenic selection. The Medano-Zapata herd is maintained with an unnatural sex ratio; and the Tallgrass Prairie herd has no natural predators. Both herds are vaccinated for diseases (Tables 2, 3; Boyd 2003). The conservation goals for TNC bison, vis-à-vis demonstrating commercial benefits of producing bison, are uncertain.

Of 32 plains bison herds on native range in the United States, including those discussed above, 27 are subjected to roundups, 26 have selective culling, 18 have no predators, 14 are artificially rotated through pastures, 14 are supplementally fed in at least some years, at least 14 have skewed sex ratios, and 20 are captured and vaccinated for 1 or more diseases (Tables 1-4). This is the preponderance of anthropogenic selection leading toward domestication and genomic extinction of wild plains bison.

Some amelioration of the loss of genetic diversity of plains bison may be achieved with frequent transplants of animals among herds in managed metapopulations. However, this technique does nothing to reduce the preponderance of anthropogenic selection in bison herds and may contribute to such selection.

With current numbers and sizes of plains bison herds, and current management practices, including anthropogenic selection and genetic drift, genomic deterioration of truly wild plains bison is underway (Tables 1-4), and genomic extinction of wild bison is likely in the foreseeable future. Moreover, there are not sufficient numbers and sizes of wild plains bison herds, ranging across a diversity of landscapes with a diversity of natural selective forces, to allow continued evolution and adaptation of the plains bison genome. Such continued evolution is needed to retain and create the genetic diversity of wild plains bison necessary to preserve this heritage for future generations of Americans, as noted above.

6. **Few plains bison herds are not hybridized with cattle**. As of 2003, only 7 plains bison herds, with 6,419 animals, had been tested and found free of cattle genes (Boyd 2003, but additional testing has occurred since 2003, Roffe, T., personal comm.). However, the largest two of these herds, with 3600 bison, in Yellowstone and Grand Teton National Parks, are infected with *Brucella* and therefore are not readily available for transplant stock. Seven herds, including the large Custer State Park herd with 1100 animals are known to have cattle introgression. Seventeen herds had not been tested as of 2003 (Boyd 2003, Tables 1-4) but, based on results elsewhere, it is likely that some, at least, of these have cattle introgression.

7. **Disease and disease-risk management threaten wild bison.** The Yellowstone Park herd is the largest population of wild plains bison within historic range. It is the only herd where some animals have persisted in a wild state since historic times. It has no genetic introgression from cattle and is the only herd subjected to natural selection in a complete ecosystem, with all native predators. For purposes of conservation of plains bison, these are important and rare or unique positive aspects of the Yellowstone herd.

   However, Yellowstone bison are infected with non-native *Brucella abortus.* While brucellosis is, at most, a minor direct threat to Yellowstone bison, management of the herd to prevent a minimal risk of *Brucella* transmission to cattle severely limits the value of the Yellowstone herd for plains bison conservation and restoration.

   Yellowstone bison are at times captured, retained in a pasture, handled like livestock, and culled. Other animals are vaccinated for brucellosis. Outside the holding pasture, bison movements and distribution are artificially controlled. This process subverts natural selection, may enhance transmission of disease in the holding pasture, alters the natural age structure of the herd, and limits Yellowstone bison to numbers that are not sufficient to retain genetic diversity of Yellowstone's two subpopulations in the long term.

   For the other 31 herds of wild bison on native range in the United States, disease management with vaccinations is notably inconsistent. Twenty herds are vaccinated for disease(s); while 11 herds are not (Boyd 2003). Vaccinating subverts natural selection for disease accommodation and requires capture and handling of the animals, promoting domestication.

8. **Lack of ecologically significant populations.** Above (see Rationale) I proposed a standard of 500 sq. miles of diverse habitat for plains bison range size. Only 1 herd of plains bison, the Yellowstone National Park herd, clearly meets this standard. The Henry Mountains herd, on 469 sq. miles of range, approaches my range-size standard for achieving ecological significance. However the range of this herd is intensively managed, limiting the herd's ecological significance in maintaining natural mountain grasslands and other habitats, with their associated plants and animals.

   Every other herd of plains bison on native range in the United States exists on <300 sq. miles of habitat, with 27 of 32 herds on <100 sq. miles (Tables 1-4). Twenty-one of these 32 herds are rotated through pastures and/or are supplementally fed, and at least 14 have skewed sex ratios, compromising their ecological roles in natural ecosystems (Tables 1-4).

9. **Abundance of threatened, endangered and declining species in the grassland ecosystems upon which bison depend**. "Dramatic declines in grassland and aridland birds signal alarming neglect and degradation of these habitats." In the contiguous United States, there are more threatened or endangered bird species, and other bird species of conservation concern in grasslands than in any other terrestrial ecosystem (N. American Bird Conservation Initiative 2009). As birds are indicators of the health and integrity of ecosystems, it is clear that the ecosystems upon which bison depend have not been well conserved, which is a purpose of the ESA.

   Federally listed species that would benefit from establishing large reserves for conservation of wild plains bison include: Attwater's prairie-chicken, grasshopper sparrow, piping plover, black-footed ferret and Utah prairie-dog. Other species of concern (on state, Forest Service and/or BLM lists) that would benefit include sage grouse, Gunnison's sage grouse, lesser prairie-chicken, sharp-tailed grouse, long-billed curlew, golden eagle, Eskimo curlew, burrowing owl, Baird's sparrow, Brewer's sparrow, black-tailed prairie dog, white-tailed prairie dog, Gunnison's prairie dog, swift fox, kit fox, meadow jumping mouse and plains leopard frog.

Listing factors for major ecotypes of plains bison.

1. **Northern Great Plains ecotype.** In this ecoregion, the largest herd of wild plains bison, with 1100 animals, is in Custer State Park, South Dakota. This number is insufficient for genetic security and continued evolution. The herd has cattle gene-introgression. It has access to only 111 sq. miles of range and animals are bi-annually rounded up and rotated among pastures. The herd is vaccinated for disease and is managed with a skewed sex ratio. Anthropogenic selection compromises or overwhelms natural selection. There appears to be no room for expanding the range of the Custer State Park herd (Boyd 2003).

   The second largest herd of wild plains bison in the Northern Great Plains is 850 animals contained within 110 sq. miles on the T. Roosevelt National Park. However, the herd consists of 2 units, 600 and 250 animals within 2 separate units of the Park. While the Park is surrounded by abundant federal land, expansion of this herd and bison range is considered not possible under current federal policy. Periodic roundups with anthropogenic selections occur (Boyd 2003).

   The third largest herd of wild plains bison in this ecoregion is the Badlands National Park herd, with 750 animals on 100 sq. miles. This herd and range are considered "expandable". Infrequent roundups occur and animals are vaccinated for brucellosis; degree of anthropogenic selection is uncertain (Boyd 2003). The Badlands NP herd may have an important future in conserving the genetic and ecological future of wild plains bison,

although the limits of expansion are unknown and the badlands habitat may be unusual, not representing the northern Great Plains ecoregion very well.

Ten other herds of wild plains bison in the northern Great Plains have 500 or fewer animals (Table 1). At least one of these (Fort Niobrara) has cattle genes; (Boyd 2003). Nine have roundups; all are subject to anthropogenic culling; 8 have no predators; 5 are supplementally fed; 4 have contrived rotational grazing; at least 5 are managed with a skewed sex ratio; and 7 are vaccinated for diseases (Table 1; Boyd 2003).

Cattle introgression was known in 2003 for only 2 herds, but 8 herds were untested at the time (Boyd 2003).

No wild plains bison herd in this ecoregion achieves my standard of 2000 animals on at least 500 sq. miles. All, or almost all, herds are managed in ways that subvert natural selection (Table 1). Thus, domestication and genomic extinction are well underway and certain with prevailing conditions and in the foreseeable future. Ecological extinction is nearly complete.

Opportunities for expanding the range of wild plains bison in the northern Great Plains are compromised almost everywhere by competition from cattle grazing, including unnatural grazing systems that alter vegetation and animal communities. Other ongoing threats include conversion of prairie to dryland or irrigated cropland, tree invasion, wetland drainage with altered stream flows and groundwaters, lack of the natural benefits of fire, and subdivision of land with developments, especially near recreation areas. In some areas energy, mineral and petroleum development may be problems.

Federal and state programs for conserving plains bison are inadequate, as noted above. Bison are not listed as a priority species in the Comprehensive Wildlife Conservation Strategies of Minnesota, Nebraska, South Dakota, North Dakota or Wyoming. Limitations of Montana's listing of plains bison in the state's Comprehensive Wildlife Conservation Strategy are described above, under "Existing state programs are inadequate".

2. **Southern Great Plains ecotype.** The largest plains bison herd in this ecoregion is the TNC's Tallgrass Prairie herd with 1500 animals on only 23 sq. miles, but with potential for expansion. Cattle introgression into this gene pool was unknown in 2003 (Boyd 2003). The herd has no predators; there are annual roundups, culling of animals, and vaccinations for disease (Table 2). I suggest that, at this density on so small a range, the full range of natural behavior of plains bison may not occur.

Wichita Mountains NWR has the 2nd largest herd of plains bison in the southern Great Plains, with 565 bison on 67 sq. miles with no room for expansion (Boyd 2003). The herd appears free of cattle genes. Coyote predation occurs. However, natural ecological relationships of this herd are compromised with annual roundups, rotations through pastures and periodic culling.

The remaining 7 plains bison herds in this ecoregion have from 40 to 320 bison, each on less than 7 sq. miles (Table 2). None experience predation; all have roundups; at least 4 have anthropogenic culling; 4 are supplementally fed; at least 4 have skewed sex ratios; 5 are vaccinated for diseases; and 3 herds have cattle genes while the others had uncertain cattle introgression in 2003 (Table 2; Boyd 2003).

No wild plains bison herd in the southern Great Plains approaches my standard of at least 2000 bison on at least 500 sq. miles. All herds are managed with considerable anthropogenic, rather than natural, selection (Table 2). Domestication and genomic extinction are well underway with prevailing conditions and in the foreseeable future. Ecological extinction is nearly complete.

Federal and state programs for conserving wild plains bison in the southern Great Plains are inadequate, as noted above. Bison are not listed as a priority species in the Comprehensive Wildlife Conservation Strategies of Colorado, Kansas, Missouri, Oklahoma or Texas.

3. **Rocky Mountain ecotype.** The most valuable herd of wild plains bison in the United States exists in Yellowstone National Park. The herd, currently at 2900 animals, roams over 3,596 sq. miles (Boyd 2003). However, bison are not allowed access to some critical winter and calving ranges outside the Park, due to restrictions of the Interagency Bison Management Plan and laws and policies in Montana, for alleviating the small risk of *Brucella* transmission to livestock.

   Yellowstone bison have no known cattle genes. This is the only wild herd that has occupied its range continuously throughout historic times. All native predators are present in the Park. Yellowstone bison are the only wild plains bison meeting my standard of at least 2000 animals on at least 500 sq. miles of range. But all is not well with this herd. Because there are two subpopulations within the herd, it is not genetically secure, as noted above. (New genetics research on the Yellowstone herd is expected to be reported in summer, 2009.) In the name of brucellosis risk management, some bison are captured, confined, fed, and culled in some or most years. In this way, natural selection is being compromised. Historic range outside the Park has been lost in recent years, as noted

above. In contrast, only a small number (25 in the first year) of bison, treated as livestock, will be allowed outside the Park's northern boundary for a limited time each year (Royal Teton Ranch Agreement, IBMP and Montana FWP). While brucellosis risk management limits the size, distribution, genetic security and value of this herd today, subdivision and development of housing and commercial enterprises are even more serious threats to the future of Yellowstone bison winter and calving ranges outside the Park in the future.

The 2nd largest herd of plains bison in this ecoregion is TNC's Medano/Zapata herd, of 1100 animals on 70 sq. miles in Colorado. There is potential for expansion of this herd and/or range (Boyd 2003, Roffe, T. personal comm.). However, introgression with cattle genes was uncertain in 2003. Natural selection of the herd is being compromised by annual roundups and culling. The herd is vaccinated and has a skewed sex ratio (Table 3, Boyd 2003).

The 3rd largest herd of plains bison in the Rocky Mountains is in Grand Teton National Park and the National Elk Refuge, Wyoming. There are 700 bison on 290 sq. miles, with no room for expansion. The herd is apparently free of cattle genes, but is supplementally fed, compromising natural selection.

There are 400 plains bison inside the 29 sq. mile National Bison Range in Montana, with no room for expansion. Cattle genes are present in the herd. There are annual roundups, rotational grazing, and culling that replace natural selection with anthropogenic selection.

The remaining 2 plains bison herds in the Rocky Mountains are essentially display herds of 26 animals each, on very small fenced ranges (Table 3). Both herds are supplementally fed; are rotated among pastures, have skewed sex ratios; are vaccinated and are rounded up for selective culling. Cattle gene introgression was uncertain for these 2 herds in 2003 (Boyd 2003).

Of 6 plains bison herds in this ecoregion (Table 3), only the Yellowstone herd achieves my standard of at least 2000 animals on at least 500 sq. miles. But the Yellowstone herd has special problems that have not been solved, as noted above, and the genetic security of this herd is questionable. For the other 5 herds in the ecoregion, domestication and genomic extinction are underway due to anthropogenic selection and due to insufficient range and habitat variation to allow an array of behavioral and genetic adaptations to develop and be maintained. Bison are ecologically effective in YNP and perhaps at the Medano/Zapata Ranch, but ecological significance elsewhere is questionable or non-existent.

Opportunities for range expansion or bison restoration in the Rocky Mountains are limited and declining. In some areas, competition with livestock is a problem. Especially in this ecoregion, subdivision and recreational development of potential bison habitat, mostly in the valleys, is a long-term threat that will make bison restoration less possible and more expensive in the future.

Federal and state programs for conserving wild plains bison in the Rocky Mountains are inadequate, as noted above. Bison are not listed as a priority species in the comprehensive Wildlife Conservation Plans of New Mexico, Colorado, Wyoming or Utah.

4. **Great Basin/Colorado Plateau ecotype.** This ecoregion has only 1 established herd of wild plains bison within what is clearly native range. The Henry Mountains, UT, herd has 279 bison on 469 sq. miles of habitat. (Boyd 2003 lists the range of the herd at 1000 sq. miles; however the UT Div. of Wildlife Resources provides 469 sq. miles in its on-line description of the herd.) Bison numbers are limited by having to share the range with cattle, however there is potential for bison expansion. No cattle genes should occur in the herd, due to its origin with animals from Yellowstone National Park (Boyd 2003). Extensive artificial habitat management is practiced on the range (Utah DWR).

   The larger Antelope Island herd of plains bison exists on a 44 sq. mile island considered “peripheral” to historic range (Boyd 2003). This herd, with no room for expansion, has cattle genes and is annually rounded up for culling – anthropogenic selection. A skewed sex ratio is maintained and bison are vaccinated for diseases.

   Utah has recently established a plains bison herd in the Book Cliffs area, with 15 animals in an initial transplant. Two herds in Arizona are outside of historic plains bison range (Boyd 2003). The herd at Bear River State Park, WY is merely a display herd of 8 animals (Boyd 2003).

   No wild plains bison herd in the Great Plains/Colorado Plateau ecoregion meets my standard of at least 2000 animals on at least 500 sq. miles of range. The Henry Mountains herd has persisted for over 60 years, but must be losing genetic diversity due to genetic drift, as no augmentations have occurred (Boyd 2003). Ecological values of the Henry Mountains herd are compromised by sharing the range with cattle and by extensive habitat management creating somewhat artificial ecosystems.

   While Utah is attempting to expand the range of wild plains bison, the subspecies is not listed as a priority species in the Comprehensive Wildlife Conservation Plans of Utah, Colorado or Idaho.

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