

Re: Yellowstone bison 90-day draft

Bison x



Gober, Joy <joy_gober@fws.gov>

6/19/15

to Jennifer

Jennifer,

I thought it looked fine. I had a few minor, for-what-they're-worth comments, which I've attached. Good luck with the other critters you're working on.

Joy

On Thu, Jun 18, 2015 at 4:24 PM, Servis, Jennifer <jennifer_servis@fws.gov> wrote:
Hi Joy,

Thanks again for being willing to look over the finding draft and share your knowledge of the bison. The draft attached here takes mostly from the November 2014 petition, but I will be adding notes from the March 2015 petition as well. It doesn't look as though the newer petition includes any additional information or claims that the 2014 petition doesn't cover already so the finding will not likely change.

Please give comments on any aspect of the finding (thoughts I missed or overemphasized, language, style, etc...). I'm trying to learn as much about the process as possible so your input is much appreciated! Feel free to make track changes and/or we can talk via email or over the phone - whatever works best for you.

Thanks again,

Attachments area

Federal Docket No. FWS-HQ-ES-201X-XXXX

90-DAY FINDING ON A PETITION TO LIST THE YELLOWSTONE BISON AS THREATENED OR ENDANGERED UNDER THE ENDANGERED SPECIES ACT

Background

Section 4(b)(3)(A) of the Act requires that we make a finding on whether a petition to list, delist, or reclassify a species presents substantial scientific or commercial information indicating that the petitioned action may be warranted. We are to base this finding on information provided in the petition and supporting information submitted with the petition.

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)).

Petition History

On November 14, 2014, we received a petition dated November 13, 2014, from the Western Watersheds Project and Buffalo Field Campaign, requesting the Yellowstone National Park bison be **listed** as threatened or endangered under the Act. The petition clearly identified itself as such and included the requisite identification information for the petitioner, required at 50 CFR 424.14(a).

On March 2, 2015, we received a secondary petition dated March 2, 2015, from Mr. James A. Horsley, requesting that the Yellowstone National Park bison be listed as threatened or endangered under the Act. The petition clearly identified itself as such and included the requisite identification information for the petitioner, required at 50 CFR 424.14(a). In a March 24, 2015, letter to the petitioner, we responded that we reviewed the information presented in the petition and did not find that the petition warranted an emergency listing.

Comment [GJ1]: Did both petitioners receive letters from us?

This finding addresses both above petitions as they request the same action for the same entity. The petition dated November 13, 2014 will be referred to below as the primary petition and the petition dated March 2, 2015 will be referred to below as the secondary petition.

Evaluation of Petition to **List** the Yellowstone bison

When citation lists are provided, the use of the “+” sign to string a series of citations together indicates that the information in these citations, when combined, provide substantial information.

Species and Range

Does the petition identify an entity that is eligible for listing (i.e., is the entity a species, subspecies, or DPS)?

☒ Yes

☐ No

If yes, list common name, Scientific name, and Range. If no, please explain.

Yellowstone National Park (YNP) bison Distinct Population Segment (DPS), subspecies *Bison bison bison*, Yellowstone National Park. Referred to below as YNP bison.

- Freese *et al.* 2007, p. 178
- Gates *et al.* 2005, pp. 93, 245
- Halbert and Derr 2007, p. 5
- Ward *et al.* 1999, p. 54
- Ward 2000, p. 20

Information in the Petition

Factor A

1. Does the petitioner claim the entity warrants listing based on the present or threatened destruction, modification or curtailment of the species habitat or range (Factor A)?

☒ Yes

☐ No

- a. If the answer to 1 is yes:

Do the sources cited in the petition provide substantial information to support the claim?

☐ Yes

☒ No

If yes, indicate for which purpose(s) present or threatened destruction, modification or curtailment of the species habitat or range (e.g., logging, agriculture, overgrazing, etc.) is a threat and list the citations with page numbers for each purpose. If no, please indicate for which purpose(s) and explain.

Range curtailment

The petition correctly notes that bison historically occupied approximately 20,000 km² including area within the northern Greater Yellowstone Area. Presently, 3,175 km² within the boundaries of Yellowstone National Park (YNP) serves as principle YNP bison habitat (Plumb *et al.* 2009, pp. 2377, 2379). In addition, movement of YNP bison beyond the boundaries of YNP is prevented through non-lethal and lethal measures primarily implemented to control the spread of brucellosis from YNP bison to cattle livestock on private lands beyond YNP. Additional information on disease management is provided under Factor C. The petition states 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 find that restriction of range is likely not a limiting factor for the continued existence of YNP bison. Since its conception in 2000, the Interagency Bison Management Plan (IBMP) has conducted annual winter culls that restrict YNP bison from occupying cattle grazing land outside YNP, while maintaining the conservation goal of 2,500 – 4,500 animals (Plumb *et al.* 2009, p. 2385; National Park Service 2015, unpaginated). Most recent population counts by the Park Service recorded 4,865 bison prior to the 2015 winter cull (Geremia *et al.* 2014, p. 1). Therefore, we do not find that range curtailment is a threat to the YNP bison at this time.

Livestock grazing

The petition argues that livestock grazing is directly and indirectly impacting bison through the alteration of plant communities, soil characteristics, and other habitat elements, as well as the development of infrastructure such as fencing and roads associated with livestock management. The area of land where YNP bison and livestock grazing range overlaps beyond the northern border of YNP is minimal, as most YNP bison range remains within YNP. Further, no information in the petition or the sources it cites describe the extent of habitat degradation caused by livestock grazing in this area of overlap, which is needed to assess the degree of risk to YNP bison.

Lastly, the petition notes concern for disease transmission from livestock to YNP bison and this threat is addressed under Factor C.

Development and infrastructure

The petition states that the historic range of the bison has changed due to cultivation, cattle ranching, commercial bison ranching, natural resource extraction, and urban expansion. The petition lists a number of residential areas and the current bison capture and quarantine facility that lay outside YNP, but within IBMP management

zones that have been recently developed. These land use changes occurred outside of YNP and information concerning the extent to which this development outside park boundaries is posing a threat to the YNP bison was not found within the petition or the sources it cites.

Invasive species

Non-native plant invasions are a major threat to the Greater Yellowstone Ecosystem (Olliff *et al.* 2001, p. 347). As the petitioner rightly notes, non-native plants can alter native plant communities and soil properties, and impact ungulate foraging. A number of non-native plants found in YNP were mentioned in the petition. However, only *Euphorbia esula* was cited as having a negative impact on foraging bison by reducing the foraging value of bison habitat in North Dakota (DiTomaso 2000, p. 257). Neither the petition nor the sources it cites provides information of the extent to which this plant or others mentioned are a threat to foraging bison in YNP. The stable population size of the YNP bison does not suggest reduction of foraging value of habitat by non-native plants is a threat to the status of the YNP bison.

Therefore, we find that the information provided in the petition does not present substantial scientific or commercial information indicating listing of the YNP bison may be warranted due to Factor A.

b. If the answer to 1 is no:

Do sources cited in the petition provide substantial information indicating the entity may warrant listing based on factor A, even though the petitioner does not make this claim?

☐ Yes

☐ No

If yes, indicate for which purpose(s) present or threatened destruction, modification or curtailment of the species habitat or range (e.g., logging, agriculture, overgrazing, etc.) is a threat and list the citations with page numbers for each purpose. If no, please explain.

c. Provide additional comments, if any.

Factor B

2. Does the petitioner claim the entity warrants listing based on overutilization for commercial, recreational, scientific, or educational purposes (Factor B)?

☒ Yes

☐ No

- a. If the answer to 2 is yes, overutilization for which purposes does the petitioner claim are a threat such that listing may be warranted (check all that apply):

☐ Commercial

☒ Recreational

☐ Scientific

☐ Educational

☐ Other: Threat *(Overutilization for a purpose other than one of the above four categories should be addressed in Factor E)*

Comment [GJ2]: Hunting is recreational, but how would we categorize culling? I'm not sure if it is commercial (to protect cattle from disease) or scientific (to maintain bison numbers at 2,500-4,500); maybe both? I think you cover it very well in the narrative below, but maybe check more boxes here?

- b. If the answer to 2 is yes:

Do the sources cited in the petition provide substantial information to support the claim?

☐ Yes

☒ No

If yes, indicate for which purpose(s) overutilization is a threat and list the citations with page numbers for each purpose. If no, please indicate for which purpose(s) and explain.

Hunting

The petition argues hunting during the annual winter cull is 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. YNP bison are hunted when they 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 petition claims genetic viability may be degraded by a loss of unique genetic qualities (particularly the ability to migrate) through disproportionate culling of migratory animals. The 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...” (p. 36). The petition cites Pringle’s (2011) 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). 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). Only one bison from YNP analyzed in Pringle’s study had haplotypes that contain the possibly deleterious mutations (Pringle 2011, p. 14). 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). 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. Lastly, there is no evidence at this time that indicates culling animals migrating from YNP (i.e. artificial selection) will eliminate a genetic basis for the migratory behavior and continual migration each year suggests this behavior persists.

Plumb *et al.* (2009, p. 2383) suggests movement of YNP bison beyond YNP boundaries began when the Central/Western herd surpassed a population size of 1,500 and the Northern herd surpassed 550. These numbers are well below mean estimates of herd population sizes limited by food resources (~ 2,400 and ~3,800 for Northern and Central/Western herds, respectively). 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). 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.

The petition also indicates the ratio of bulls to cows killed each winter is not conserved through years. The petition does not discuss particular threats related to unequal sex ratios, however IBMP annual culling guidelines involve taking approximately equal numbers of males and females and sex composition surveys are conducted so as to optimize culling goals for the current population structure (Geremia *et al.* 2014, pp. 2, 17).

Finally, the petition suggests that 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) indicate that the YNP bison consists of two subpopulations that are genetically distinct, but not isolated (p. 8). 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). Therefore, the petition rightfully 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). The petition cites Hendrick (2009, p. 419) 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.

However, White and Wallen (2012, p. 751) 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, it is estimated that approximately 60-70% of the genetic makeup of YNP bison are not from the original 25 that survived the bottleneck (Hedrick 2009, p. 415). 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) 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.”

Comment [GJ3]: Good!

Therefore, we find that the information provided in the petition does not present substantial scientific or commercial information indicating listing of the YNP bison may be warranted due to Factor B.

- c. If the answer to 2 is no:

Do sources cited in the petition provide substantial information indicating the entity may warrant listing based on factor B, even though the petitioner does not make this claim?

☐ Yes

☐ No

If yes, indicate for which purpose(s) overutilization is a threat and list citations with page numbers for each purpose. If no, please explain.

d. Provide additional comments, if any.

Factor C

3. Does the petitioner claim the entity warrants listing based on disease or predation (Factor C)?

☒ Yes

☐ No

a. If the answer to 3 is yes:

Which does the petitioner claim is a threat such that listing may be warranted (check all that apply)

☒ Disease

☒ Predation

b. If the answer to 3 is yes:

Do the sources cited in the petition provide substantial information to support the claim?

☐ Yes

☒ No

If yes, indicate which (disease, predation, or both) is a threat and list the citations with page numbers for each. If no, please indicate disease and/or predation and provide an explanation.

Disease

The petition discusses the direct impacts of hemorrhagic septicemia and malignant catarrhal fever on bison herds in the past and argues that the diseases pose a threat to YNP bison. In 1965, an outbreak of hemorrhagic septicemia occurred among a herd of bison in Montana and following vaccination, there were no further signs of the disease (Heddleston and Wessman 1973, p. 306). However, as the petition notes, there have been no recent reported cases of hemorrhagic septicemia in YNP and no information in the petition or the sources it cites suggest an outbreak is immanent.

Malignant catarrhal fever has impacted bison herds in the past, causing high mortality rates; however, no outbreaks have occurred in YNP. The disease can be spread from sheep to bison and the petition cites concerns for YNP bison-sheep interactions because sheep are ranching within the northern Greater Yellowstone Ecosystem and 3 YNP bison bulls were seen comingling with domestic sheep in 2013 on private land approximately half a mile from the YNP boundary. Outbreaks of malignant catarrhal fever should be monitored closely to prevent its spread to YNP. However no recent reports of the disease have been made concerning YNP bison or sheep in nearby ranches, so we do not consider the disease to be a threat to the YNP bison at this time.

The petition discusses both direct and indirect impacts of brucellosis disease on YNP bison. Brucellosis is a bovine disease most known for causing pregnant females to abort and can be transmitted interspecies. Estimates of the percentage of YNP bison infect with brucellosis range widely from 10% to 70% depending on the type of testing technique (Meagher and Meyer 1994, p. 646; Gates *et al.* 2010, p. 33). It is generally considered to have only minimal direct effects on bison and the YNP bison population does not appear to suffer from a portion being infected as their numbers are stable or increase each year (Meagher 1973, p. 70; Meagher and Meyer 1994, p. 646; Geremia *et al.* 2014, p. 2).

The annual cull managed by IBMP is implemented to prevent the spread of brucellosis from YNP bison to domestic cattle grazing on adjacent land and is thus an indirect impact of disease on YNP bison. In the winter, YNP bison seek lower elevation areas where food sources are more abundant. These areas often extent beyond YNP boundaries into land used for cattle grazing. 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.

The primary concern stated in the petition with regards to culling as disease management is the range and population size limits placed on YNP bison. However, the petition does not provide evidence to support that IBMP management activities are a threat to the status of the species such that the species may warrant listing as threatened or endangered. 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; National Park Service 2013, p. 14). 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.

Other concerns listed in the petition related to indirect impacts of IBMP disease management include loss of genetic viability and subpopulation integrity, and these impacts are discussed under Factor B.

Comment [GJ4]: And E?

Predation

The petition states that bison have few predators other than man, citing only grizzly bear and gray wolves as natural predators. Neither the petition nor the sources it cites provide information on the extent to which grizzly bear predation is a threat to bison and suggests grey wolf predation “is not considered a significant concern at this time.”

Therefore, we find that the information provided in the petition does not present substantial scientific or commercial information indicating listing of the YNP bison may be warranted due to Factor C.

c. If the answer to 3 is no:

Do sources cited in the petition provide substantial information indicating the entity may warrant listing based on factor C, even though the petitioner does not make this claim?

☐ Yes

☐ No

If yes, indicate which (disease, predation, both) is a threat and list citations with page numbers for each. If no, please explain.

- d. Provide additional comments, if any.

Factor D

4. Does the petitioner claim the entity warrants listing based on the inadequacy of existing regulatory mechanisms (Factor D)?

☒ Yes

☐ No

- a. If the answer to 4 is yes:

Do the sources cited in the petition provide substantial information to support the claim?

☐ Yes

☒ No

If yes, list the citations with page numbers. If no, explain.

We consider plans and initiatives to be voluntary agreements that provide guidance for better managing wild plains bison, rather than regulatory mechanisms. Therefore, we discuss the Interagency Bison Management Plan (IBMP) under Factor C, because it focuses on disease. The IBMP is a cooperative effort developed by the National Park Service, USDA-Forest Service, USDA-Animal & Plant Health Inspection Service, Montana Department of Livestock, and Montana Fish Wildlife & Parks. Thus, concerns in the petition regarding disease control by these organizations are addressed with regards to IBMP under Factor C. We evaluate the inadequacy of existing regulatory mechanisms from the standpoint of the other factors. If there is not substantial information that listing YNP bison may be warranted due to another factor, then the regulations affecting that factor cannot be considered inadequate.

Comment [SJA5]: Some language taken from 2011 90-day for wild plains bison when discussing IBMP for Yellowstone bison under this factor. Does this make sense?

Comment [SJ6]: Seems OK. Is the IBMP the only thing the petitioners discussed under Factor D? If there were others, mention them at least in this section.

Comment [GJ7]: The petition also mentions the States. You could probable use some language from 2011 90-day as well, where it is applicable. Idaho, Montana, and Wyoming all give bison dual status (considered domestic livestock if commercial herd and wildlife if conservation herd).

- b. If the answer to 4 is no:
Do sources cited in the petition provide substantial information indicating the entity may warrant listing based on factor D?

☐ Yes

☐ No

If yes, list citations with page numbers. If no, please explain.

- c. Provide additional comments, if any.

Factor E

5. Does the petitioner claim the entity warrants listing based on other natural or manmade factors affecting its continued existence (Factor E)?

☒ Yes

☐ No

- a. If the answer to 5 is yes:
Identify the other natural or manmade factors claimed by the petitioner to be a threat such that listing may be warranted.

Genomic extinction

Climate change

- b. If the answer to 5 is yes:
Do the sources cited in the petition provide substantial information to support the claim?

☐ Yes

☒ No

If yes, indicate for which other natural or manmade factors are a threat and list the citations with page numbers for each factor. If no, please indicate for which factor(s) and explain.

Genomic extinction

Genomic extinction refers to situations in which “hybrids are fertile and may displace one or both parental taxa through the production of hybrid swarms” (Allendorf and Luikart 2007, p. 429). The petition states “bison are at extremely high risk of genomic extinction because of domestication and anthropogenic selection, and hybridization with cattle”. However, Freese *et al.* (2007, p. 178) remark that “while many public bison herds harbor evidence of domestic cattle nuclear gene introgression, the amount of introgression across the genome of each individuals herd appears to be fairly low, with introgression rates ranging from 0.56% to 1.80%.” The petition rightly notes that the YNP bison herd is one of only a few with no evidence of cattle introgression (Ward *et al.* 1999, p. 54; Ward 2000, p. 20; Freese *et al.* 2007, p. 178; Halbert and Derr 2007, p. 5). This important characteristic of the YNP bison makes conservation of the herd important to the overall preservation of the bison genome. Thus, breeding with cattle and bison from other herds is prevented. We find that YNP bison are not at risk of genomic extinction because there is no evidence of cattle introgression and potential introgression is prevented.

In addition the petition calls for “protection under the Endangered Species Act to avoid further loss of genetic diversity, loss of evolutionary potential, and [to] conserve potential genetic contributions to plains bison restoration” and these concerns as they relate to the YNP bison are discussed under Factor B.

Climate change

The petition argues that climate change will result in decreased precipitation, increased temperatures, widespread drought conditions, and reduced snow pack in YNP. However, no information is provided in the petition or the sources it cites that such climate factors will occur to an extent that YNP bison will be negatively impacted within the foreseeable future.

Koons *et al.* (2012, p. 479) indicated that climate changes may alter density-independent and density-dependent factors that influence foraging and dispersal behaviors of bison in the Henry Mountains, Utah. Based on these findings, the petition suggests as the climate dries, more YNP bison will move out of the park. However, no evidence was provided in the petition or the sources it cites that indicate, given the

unique topography of YNP, that dispersal out of the park is likely as a result of drought conditions.

In addition, the petition suggests decreased snow pack will lead to YNP bison dispersal into Grand Teton National Park, joining the Jackson bison herd, and rendering YNP bison at risk of breeding with these cattle-introgressed bison. However, neither the petition nor the sources it cites indicate under what extent of snow pack reduction these dispersal patterns are likely to occur and if snow pack will reach those levels.

Comment [GJ8]: Should we also mention that topography may also be limiting dispersal south.

Lastly, bison historically occupied an extensive range (from Canada to Mexico, and from the Rockies to Florida to New York) and tolerated a variety of climatic conditions (Boyd and Gates 2006, p. 16). This suggests YNP bison are likely to be flexible with any climate changes that may occur within the foreseeable future.

Therefore, we find that the information provided in the petition does not present substantial scientific or commercial information indicating listing of the YNP bison may be warranted due to Factor E.

c. If the answer to 5 is no:

Do sources cited in the petition provide substantial information indicating the entity may warrant listing based on factor E, even though the petitioner does not make this claim?

☐ Yes

☐ No

If yes, identify the other natural or manmade factor(s) and list citations with page numbers for each. If no, please explain.

d. Provide additional comments, if any.

*Proceed to the **Petition Finding** section and the remaining sections to complete the Petition Review Form.*

Petition Finding

Based on our review of the petition and sources cited in the petition, we find that the petition does not provide substantial scientific or commercial information indicating that the petitioned action may be warranted.

Author

The primary authors of this notice are the staff members of the **Region 6 Ecological Services Regional Office**, U.S. Fish and Wildlife Service.

FOR FURTHER INFORMATION CONTACT: Justin Shoemaker, Senior Listing Biologist, Ecological Services, Region 6, 1511 47th Avenue, Moline, IL 61265; telephone 309-757-5800 ext. 214.

Date: _____

Noreen Walsh

Regional Director, Region 6,
U.S. Fish and Wildlife Service

References

Allendorf, F.W. and G. Luikart. 2007. Conservation and the Genetic of Populations. Blackwell Publishing, Malden, MA.

Boyd, D.P. and C.C. Gates. 2006. A brief review of the status of plains bison in North America. *Journal of the West* 45:15-21.

DiTomaso, J.M. 2000. Invasive weeds in rangelands: species, impacts, and management. *Weed Science* 48:255-265.

Freese, C.H., K.E. Aune, D.P. Boyd, J.N. Derr, S.C. Forrest, C.C. Gates, P.J. Gogan, S.M. Grassel, N.D. Halbert, K. Kunkel, and K.H. Redford. 2007. Second change for plains bison. *Biological Conservation* 136:175-184.

Gates, C.C., C.H. Freese, P.J. Gogan, and M. Kotzman. 2010. American bison: status survey and conservation guidelines. IUCN.

Geremia, C., R. Wallen, and P.J. White. 2014. Population dynamics and adaptive management of Yellowstone bison, *available at* http://www.ibmp.info/Library/OpsPlans/BisonPopulationDiseaseModel_Final_Winter2015.pdf (last visited June 2015).

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.

Halbert, N.D. and J.N. Derr. 2007. A comprehensive evaluation of cattle introgression into U.S. Federal bison herds. *Journal of Heredity* 98:1-12.

Heddleston, K.L. and F. Wessman. 1973. Vaccination of American bison against *Pasteurella multocida* serotype 2 infection (hemorrhagic septicemia). *Journal of Wildlife Disease* 9:306-310.

Hendrick, P.W. 2009. Conservation genetic and North American bison (*Bison bison*). *Journal of Heredity* 100:411-420.

Koons, D.N., P. Terletzky, P.B. Adler, M.L. Wolfe, D. Ranglack, F.P. Howe, K. Hersey, W. Paskett, and J.T. Du Toit. 2012. Climate and density-dependent drivers of recruitment in plains bison. *Journal of Mammalogy* 93:475-481.

Meagher, M.M. 1973. The bison of Yellowstone National Park. Government Printing Office, Scientific Monographs 1. National Park Service, Washington D.C.

Meagher, M.M. and M.E. Meyer. 1994. On the origin of brucellosis in bison of Yellowstone National park: A review. *Conservation Biology* 8:645-653.

National Park Service. 2013. Yellowstone National Park Natural and Cultural Resources Vital Signs.

National Park Service. 2015. Frequently asked questions: bison management, *available at* <http://www.nps.gov/yell/learn/nature/bisonmgntfaq.htm> (last visited June 2015).

Olliff, T., R. Renkin, C. McClure, P. Miller, D. Price, D. Reinhart, and J. Whipple. 2001. Managing a complex exotic vegetation program in Yellowstone National Park. *Western North American Naturalist*. 61:347-358.

Plumb, G. E., P. J. White, M. B. Coughenour, and R. L. Wallen. 2009. Carrying capacity, migration, and dispersal in Yellowstone bison. *Biological Conservation* 142:2377–2387.

Pringle, T.H. 2011. Widespread mitochondrial disease in North American bison. *Nature Precedings*, *available at* <http://precedings.nature.com/documents/5645/version/1/files/npre20115645-1.pdf> (last visited June 2015).

Ward, T.J. 2000. An evaluation of the outcome of interspecific hybridization events coincident with dramatic demographic decline in North American bison. Ph.D. Dissertation, Texas A&M University, College Station.

Ward, T.J., J.P. Bielawski, S.K. Davis, J.W. Templeton, and J.N. Derr. 1999. Identification of domestic cattle hybrids in wild cattle and bison species: a general approach using mtDNA markers and the parametric bootstrap. *Animal conservation* 2:51-57.

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.