Management of Bison in the National Wildlife Refuge System
Genetic Conservation

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Background:

Bison were nearly extirpated in the late 1800s. Ecologically, bison have been extinct since that time, with remnant populations managed by various private and governmental agencies. Recently bison conservation organizations and agencies, recognizing this ecological extinction, have focused on landscape level conservation and restoration efforts. Restoration initiatives include the central Montana prairies extending to and including lands in southern Saskatchewan, proposals to have free-ranging bison across multi-jurisdiction landscapes in Colorado, and large restoration efforts on privately held lands in Oklahoma and elsewhere. Led by non-governmental conservation organizations such as World Conservation Union (formerly International Union for the Conservation of Nature; IUCN), American Prairie Foundation, and The Nature Conservancy, these organizations have focused on Department of Interior (DOI) bison resources as potential foundation stock. A large-scale genetics project, conducted from 1999 – 2002, assessed the bison resources managed by the US Fish and Wildlife Service (FWS) and National Park Service (NPS) and found these were the best genetic representatives of historic bison populations, containing wide diversity and very low levels of cattle gene introgression. Currently about 7000 bison (winter 2007 estimate) are managed in 5 National Parks. The bulk of these bison (about 5000) are not available for conservation efforts because of regulated diseases of livestock. FWS manages about 1300 bison across several Refuges excluding brucellosis-infected bison that winter on the National Elk Refuge (n=1000; included with NPS total above as the National Elk Refuge/Grand Teton Nation Park herd; NER/GRTE).

In recognition that Department of Interior agencies (NPS and FWS) had genetically significant but limited and isolated bison population resources, had similar management issues, and had a need to coordinate across the agencies to address management, a DOI bison management group was formed about 6 years ago. That group meets annually and addresses conservation, diseases, and tribal relations issues as they relate to DOI bison. The group provides non-binding guidance to managers and serves as a forum for discussion of relevant topics. The last 3 years, genetic conservation has been the primary emphasis, and outside researchers and non-governmental organizations involved in bison conservation and restoration efforts have been invited participants at the meeting.

FWS and NPS, however, do have unique roles in bison conservation given their differing national missions and management capabilities. In 2005, FWS bison managers and biologists outlined six purposes for having bison on a National Wildlife Refuge (NWR). Of all the purposes, "Bison Conservation" was identified as one of national scope and thus applicable to the National Wildlife Refuge System (NWRS). This plan addresses bison conservation within the FWS, expands the concept to include "Restoration", and accepts as implicit that the conservation purpose is the highest priority for the NWRS for the management of bison. Consequently conservation becomes the

highest priority for bison management at any Refuge with a significant number of bison. This plan provides guidance for FWS Refuges in the conservation of bison to meet DOI consensus goals for bison and for Refuges to fulfill a national role in the landscape conservation and restoration efforts.

Implicit in conservation of a species is conservation of the genome, or genetic foundation of the species. We propose that the NWRS adopt a goal of conserving extant bison genetics currently managed by FWS and providing foundation genetic stock for potential landscape restoration efforts. Landscape restoration efforts will be lengthy processes involving a multitude of stakeholders and lands under different jurisdictions. Except in very rare isolated situations, Refuges are unlikely to provide significant land base to such efforts, and we therefore propose the national bison conservation goal focus on providing bison resources as seed stock.

Current Status:

As of spring 2007, the FWS pre-calving bison population of 1300 is currently distributed across 8 Refuges: National Bison Range (NBR, n=300), Ft. Niobrara NWR (FTN, n=350), Witchita Mountains NWR (WM, n=530), Sully's Hill National Game Preserve original herd now located at FTN (SUL, n=39), Sully's Hill National Game Preserve (SH, n=7), Neil Smith NWR (NS, n=39), Rocky Mountain Arsenal (RMA, n=16), and Charles M. Russell NWR (CMR, n=3).

In the absence of selection, gene frequency will vary from generation to generation in populations where parents have a limited number of offspring due to chance reproduction of a few more or a few less individuals of a given genotype. In large populations this is less of an issue because variation is small and tends to balance out over time. In small populations, however, the effect is greatly magnified resulting in loss of alleles. Gross and Wang (2005) modeled the effects of population size on "genetic drift" for the NPS and concluded that a population of 400-1000 was needed to have high confidence of retaining 90% of a herd's genetic diversity over 200 years. They further pointed out that bison breeding behavior was unlikely to match model assumptions so that the minimum number was closer to 1000. Further studies suggested that if a population is to retain enough plasticity to adapt to future selective pressures on a natural landscape, a minimum population size of 2000 is needed.

None of the FWS herds meets a minimum criterion of 1000-2000 animals with the exception of NER/GRTE, and this population is precluded from current involvement in conservation and restoration efforts due to the presence of brucellosis, a U.S. regulated livestock disease. In addition, a small founder population for NER/GRTE may mean the genetic foundation of this population is restricted. Clearly, individually FWS herds are at risk for significant genetic drift and loss of diversity. Studies conducted by Texas A&M University (TAMU) and University of California, Davis (UCD) suggest that the level of diversity in FWS herds is adequate at present time and similar to NPS herds.

These genetic analyses also analyzed for cattle gene introgression (hybridization) and detected introgression at a very low level (<1.5%) in all herds except the SUL and NER/GRTE herds (data incomplete). Conservation of a species, and thereby its genetic foundation, implies exclusion of alien alleles. Yet herds with low levels of cattle alleles also contain unique bison alleles that contribute significantly to bison genetic diversity and need to be part of the bison conservation effort.

We propose that in order to achieve the FWS goal of bison conservation, we must meet two sometimes competing objectives:

1. Conserve and retain as much bison genetic diversity as possible.
2. Minimize or at least not exacerbate the level of cattle gene introgression.

FWS Bison Conservation Plan:

FWS Refuges are individually relatively small tracts of land. Combined with the need to manage for other wildlife species, prevent habitat degradation and keep bison populations well within long term carrying capacities, bison populations on individual refuges are limited. Annual culling is necessary to stay within these parameters, yet can lead to rapid loss of genetic diversity.

A mechanism to address the Service-wide conservation goal within the resources and capacities of individual refuges is metapopulation management. A metapopulation is "a collection of spatially divided subpopulations that experience a certain degree of gene flow among them" (Allendorf and Luikart 2007). Key elements of metapopulation management within the context of FWS herds include:

1. Genetic monitoring is implicit: Monitoring must be done at some interval to assess the status (genetic diversity and degree of hybridization) of FWS bison, the extent of drift within herds, and the response to management actions to affect gene frequency.
2. Individual animal identification is essential: Because culling and "gene flow" (i.e. translocation) will need to be done to mitigate the effects of drift, we need to know who has what genes before culling or translocating a particular animal. This does not mean every animal in a herd needs to be identified, but only identified animals would be used in gene flow management actions. Unmarked culled animals represent an unknown genetic loss to the herd.
3. Coordination among all units is required: Each herd is one component of the metapopulation and cannot act completely independently of other units. While Refuges will individually cull, consideration needs to be made for conserving genes needed in the metapopulation.
4. Management may need adjustment: Criteria for removal of animals from a Refuge need to first consider the genetic consequences. Culling known hybrids may not be a sound management action. Feedback between management and monitoring, and adapting appropriately are essential. Assessments for bison carrying capacities need to be completed, and the relative priority of bison vs other Refuge goals need to be reviewed.
5. Funding needs have to be addressed: Are there other sources of funds for genetic monitoring and metapopulation management?

Accomplishments to date:

We have taken initial steps to conserve the bison genetics in FWS herds and mitigate adverse situations:

1. No cattle genes were found in the SUL herd, the only herd in the FWS without any detectable cattle gene introgression. Because this herd is extremely small (39) and the risk of drift large, and we did not want to mix this herd with any hybridized herd, the bison were relocated to FTN. FTN can provide adequate

space for the herd to expand. The herd is retained isolated from the extant FTN herd and will not be culled. Long-term concerns: The herd currently has reasonable diversity given its size but the risk of founder effect and drift is large. Yet if introductions are needed in the future to improve diversity they would need to be made from other herds not known to be hybridized until we have a technique to identify individual animal hybrid status.

2. NBR herd contains the largest number of private alleles at markers used to estimate diversity. The NBR herd has the highest estimated diversity of all the FWS herds due to these many alleles not occurring in other FWS herds. These unique and low prevalence alleles needed to be relocated to other sites so that all these unique aspects aren't held in a one location. 39 bison were relocated to NS, 16 to RMA and 7 to SH. Long-term concern: additional animals may need to be relocated to ensure sufficient conservation of the unique genetics found at NBR.

Proposed Next Steps:

Several steps need to be taken to address bison conservation on a NWRS level. Some of these are near term, others longer term. The FWS bison management group may identify further actions.

1. Consultation: Input from geneticists relevant to the specific makeup of the FWS metapopulation is needed. We have already initiated some of this within the Wildlife Health Office.
    a. What constitutes an adequate monitoring program (frequency, sample size and cohorts sampled)?
    b. What level of diversity or rate of drift indicates the need for gene flow into a herd? How much gene flow?
    c. How do we accomplish bison gene flow and minimize cattle gene flow?
    d. Given the current data, what is the most effective culling strategy?
2. Status: Reassess the genetics of herds, especially small herds, to estimate the rate of genetic drift. Most of the data on FWS herds comes from 1999 to 2002.
3. Data management: Develop and maintain a metapopulation database for genetic conservation. This is already partially addressed at the Wildlife Health Office but needs to include new Refuges, and include eventual gene flow among Refuges.
4. Land base: Identify new Refuges that may be appropriate for participation in the metapopulation management so as to increase the FWS carrying capacity for bison long term. The goal is to have a metapopulation of 1600 to 2000 animals.
5. Refuge Assessment: Each Refuge involved in the metapopulation needs to assess its natural resources and priorities, and identify a long-term carrying capacity for bison in the context of meeting all Refuge purposes. This is essential to optimize use of existing bison Refuges and estimate the potential size of our metapopulation.
6. Management: Culling needs to consider individual animals and what genes they are known to carry. Unique, rare and low prevalence bison genes should be conserved, even if found in animals with known cattle alleles, simply to maximize conservation of bison genetic diversity. All other things equal and since culling must be done, bison carrying known cattle alleles otherwise having bison genes well represented in the population can be candidates for culling. Some Refuges

need to start from the beginning with marking individual animals and assessing their genetic makeup (e.g. WM).

7. Apply adaptive management techniques: Use monitoring data to decide when to introduce new genes and to assess the effectiveness of the action. Adapt as indicated.
8. Funding: Identify funding for the monitoring and management actions needed that are beyond the scope of individual refuges.