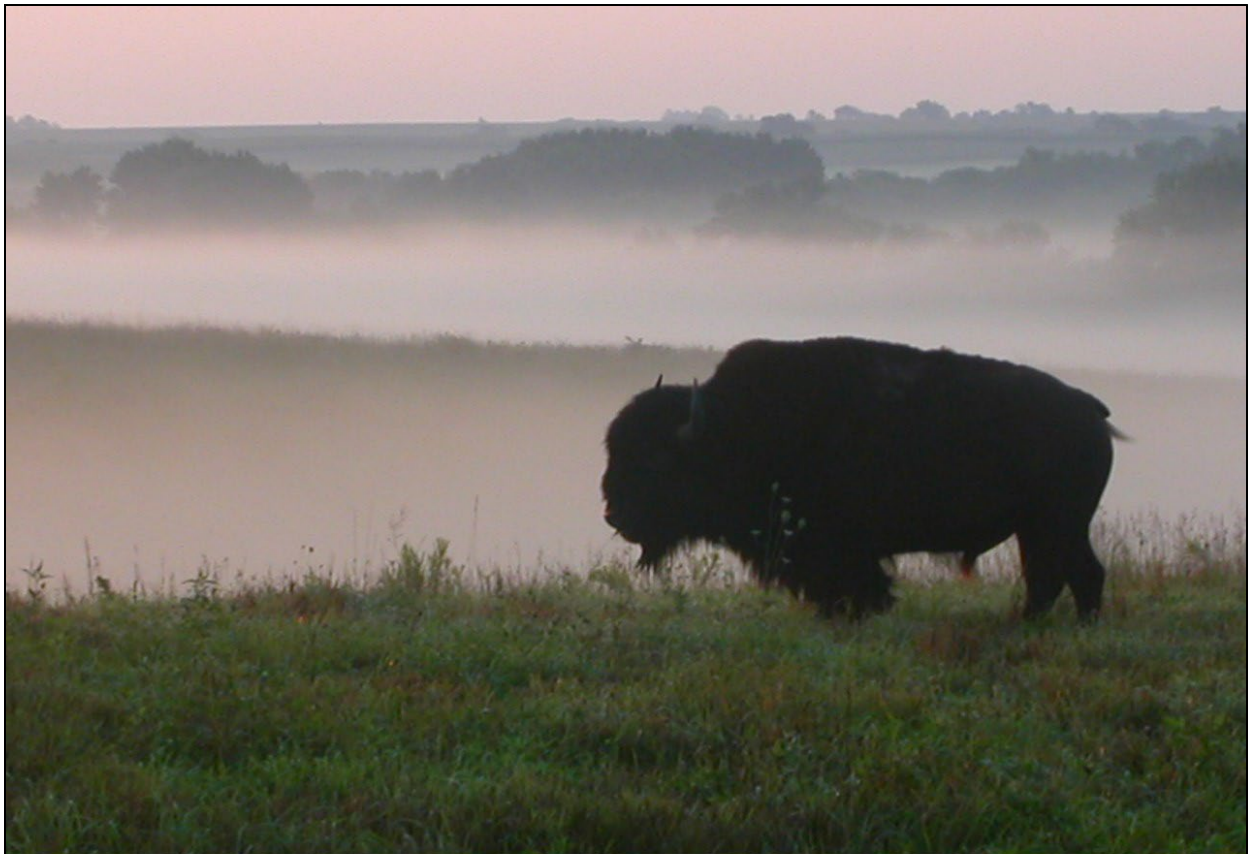

Neal Smith National Wildlife Refuge

Best Management Practices Handbook for the Conservation of Range-Limited American Plains Bison

Supplements 701 FW 8, Range-Limited American Plains Bison Management

National Wildlife Refuge System
April 2024

Contents

I. Purpose

The purpose of this handbook is to provide guidance and best management practices for fenced, range-limited American plains bison (*Bison bison bison*) in the National Wildlife Refuge System (NWRS) of the U.S. Fish and Wildlife Service (Service). The handbook supplements Service Manual chapter 701 FW 8, Range-Limited American Plains Bison Management.

While North American bison are no longer threatened with extinction after demographic recovery from near decimation in the late 1800s, loss of genetic variation combined with artificial husbandry practices threaten the ecological restoration of the species. Six Federal herds established between 1907 and 1919 are the foundation of contemporary conservation bison, requiring science-based management to conserve the species as native North American wildlife.

The Department of the Interior (Department) defines a "wild bison" as a member of a herd with large enough population size to prevent loss of genetic variation and with low levels of cattle or subspecies introgression, subject to some of the forces of natural selection, including competition for breeding opportunities (Dratch and Gogan 2010).

> *NOTES: References that appear in parenthesis are listed in section V of this handbook. We have linked this first reference to that section so that the reader is familiar with its location, but we do not link subsequent references.*
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> *Definitions for some of the terms used in this handbook can be found in 701 FW 8, section 8.5.*

We intend for the guidance in this handbook to promote standardized NWRS range-limited herd management practices that are consistent with the value of bison as wildlife appropriate for use in landscape scale restoration efforts.

A. Current Status of National Wildlife Refuge System Bison

The Service manages approximately 1,200 plains bison in five range-limited NWRS herds established between 1907 and 2007, excluding the Jackson Bison Herd, which is infected with brucellosis and is managed jointly by Grand Teton National Park and the National Elk Refuge (Fish and Wildlife Service and National Park Service 2007). These five herds are at Fort Niobrara National Wildlife Refuge (NWR), Neal Smith NWR, Wichita Mountains NWR, White Horse Hill National Game Preserve, and Rocky Mountain Arsenal NWR. Additionally, a very small display herd is managed at Charles M. Russell NWR. All five NWRS bison herds are managed within the historic range of plains bison. The Rio Mora NWR is not included in the five herds because it is not managed by NWRS, which has no management authority for this herd. NWRS bison have cultural and historic significance and contribute to habitat management, education, and recreation for the public. While each refuge has a locally unique role within the NWRS bison conservation program as defined by refuge-establishing purposes and detailed within each refuge's Comprehensive Conservation Plan, conservation of bison is the single over-arching purpose that all refuges with bison share as the highest priority.

In May 2020, the Department announced a renewed vision for bison conservation, detailed in the Bison Conservation Initiative 2020, emphasizing wild, healthy, genetically diverse herds that support ecological and cultural restoration through shared stewardship. As part of the Department's bison metapopulation, NWRS bison are a critical genetic resource, contributing significant and unique components to the Department's bison herd genome. Because the role of natural selection is reduced in range-limited bison populations managed within ecological carrying capacity, consistent science-based management is essential to maintaining the conservation value of NWRS bison herds to support bison restoration (Hartway et al. 2020).

Genetic diversity provides the foundation for adaptive capacity. Low genetic diversity results in reproductive failure, poor recruitment, and lack of disease resistance—obstacles that have plagued many species conservation efforts (Halbert et al. 2004, Giglio et al. 2016). Although population size is the most important factor in the rate of genetic diversity loss, most refuges are limited in size and are therefore unable to maintain population numbers high enough to independently conserve bison (Gross and Wang 2005, Hedrick 2009). Managing all bison refuges together as a metapopulation allows all herds to contribute to long-term conservation of bison. Periodic movement of bison among refuges supports gene flow across the entire NWRS bison population, and such a Servicewide approach is consistent with the National Wildlife Refuge System Improvement Act of 1997 to effectively deliver conservation.

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II. Goals and Objectives

The goal of the NWRS bison conservation and management program is to conserve and help restore bison as native North American wildlife by:

> *Maintaining a healthy, self-sustaining bison population that is viable over the long term, from which bison may be used in landscape scale restoration efforts, conserving genetic diversity and minimizing cattle gene introgression, and minimizing anthropogenic selection and allowing the forces of natural selection to operate to the extent possible.*

While bison are no longer threatened with extinction, loss of habitat, loss of genetic variation, and artificial husbandry practices threaten the ecological restoration of bison as native North American wildlife.

The timeframe of this goal supports a desired state of stability over the long term, generally considered by most population and genetics models to include the next 200 – 500 years, which calls for the implementation of best management practices at all levels consistently and as soon as possible. The rationale supporting the following bison conservation and management objectives are referenced and discussed in subsequent sections, along with strategies and methods for evaluation.

The Service's objectives are to:

A. Allow as many of the forces of natural selection to operate across the largest population and geographic scales possible to support evolutionary processes and adaptation at an ecologically appropriate scale for bison (Dratch and Gogan 2010, Gates et al. 2010), while meeting refuge and NWRS bison conservation goals and objectives within the limitations of range-limited herd management.

B. Manage habitat and herd distribution for a healthy bison population (Department of the Interior 2008, Department of the Interior 2020), while meeting refuge objectives for biological integrity, diversity, and environmental health. Service employees may use habitat management activities, such as prescribed fire, to achieve these objectives as appropriate. The Service's Wildlife Health Office Bison Herd Health Program Lead should conduct evaluations to support consistent wildlife and environmental health objectives as outlined for bison within the Department (Jones et al. 2020).

C. Maximize conservation of genetic diversity to the extent possible through use of scientifically supported strategies associated with population management activities. Recent studies suggest that conservation of at least 87% of gene diversity over 200 years may be achievable for most individual herds within the NWRS metapopulation (Giglio et al. 2018, Giglio et al. 2016). Management as a metapopulation, by ensuring exchange of bison (and/or bison genetic material), will further contribute to bison genetic diversity conservation (Hedrick 2009, Gates et al. 2010, Hartway et al. 2020).

D. Minimize cattle gene introgression as a secondary priority to diversity conservation, ensuring that introgression, measured using science-based genomic methods, is not exacerbated by metapopulation movements (Dratch and Gogan 2010, Gates et al. 2010).

E. Increase the NWRS bison metapopulation to a minimum of 2,000 animals (overwintering population size) to decrease loss of diversity through genetic drift (Hedrick 2009) by proactively exploring opportunities to increase the size of existing herds, as well as establishing new herds through creative partnerships, as appropriate (Department of the Interior 2020).

F. Work with a variety of partners to develop and implement a continental Department of the Interior bison metapopulation management strategy that mitigates diversity loss within individual herds through small, periodic bison translocations that introduce new genetic material to each herd, while minimizing introgression and disease risks (Hartway et al. 2020, Department of the Interior 2020).

III. Managing Existing Herds of Wild, Healthy Bison

A. Natural Selection and Domestication

Recognizing that bison lack full recovery as free-ranging wildlife, increasing emphasis has been placed on allowing evolutionary forces of natural selection and adaptation to function as much as possible. A recent U.S. Department of Agriculture (USDA) National Animal Health Monitoring System survey of private bison herds found that skewed age and sex ratios were common in ranched herds, with most herds managing for bulls no more than 3 years old. The use of artificial selection and husbandry practices also includes vaccination, intensive veterinary care, and interactions with other domestic animal species (Parker et al., 2016). Bison managed under such artificial conditions are not subject to natural selection processes such as mate competition, disease resistance, and natural forage utilization, and such artificial selection affects survival and/or reproduction, leading to management-driven alteration of genetic composition over several generations. Such changes are consistent with domestic animal management, but not wildlife management (Lott 1998, Gates et al. 2010).

Although natural selection is limited on most refuges supporting range-limited bison, the Service has implemented several changes to historic management in the past decade to minimize artificial selection. These changes support increased opportunity for natural selection processes in refuge herds and they include: allowing all animals in the herd to compete for mating; allowing mature animals to age, reproduce, and die naturally; allowing natural calf mortality to occur by retaining all calves in the herd over the first winter; and allowing natural disease processes to play a larger role in survival and reproduction. With limited habitat available for NWRS bison, population management through animal removal is required, and selection of animals for removal must be done using the best available science to support conservation of genetic diversity.

Service employees must not base management of bison within the NWRS on behavior or phenotype. Employees should not remove animals for perceived aggressiveness, pressuring fences, or if they sustain non-lethal injuries. When selecting animals to remove from a herd, employees should be guided by the best available science by participating in the NWRS bison conservation and management program under the direction of the NWRS Bison Conservation Coordinator.

> *"A wild bison is a member of a herd with large enough population size to prevent loss of genetic variation and with low levels of cattle or subspecies introgression, subject to some of the forces of natural selection, including competition for breeding opportunities."*
>
> Department of the Interior Bison Genetics Report (Dratch and Gogan 2010)

Managing escapes outside the refuge boundary is dependent on the situation, but any contact with domestic bison or cattle outside the refuge requires euthanasia of escaped bison to prevent disease introduction into the refuge herd. Employees must contact the Service's Wildlife Health Office for additional guidance regarding humane euthanasia criteria and protocols.

Some refuges historically provided supplemental winter forage to bison to maintain artificially high densities, but the Service has discontinued this practice in light of the potential to affect evolutionary adaptation to using natural winter forage. The Service should manage NWRS herds to remain within ecological carrying capacity, and both fecal parasite counts and body condition scores should be used, in addition to habitat condition assessments, as indicators to determine if population size, density, or distribution needs to be adjusted. Service employees should only use supplemental feeding in the most extreme circumstances, such as in response to a wildfire that consumes the majority of available forage, and only for the shortest duration possible to protect the bison genetic resource.

Artificial selection pressures also include bison injury due to anthropogenic causes. Bison injured during capture and handling may suffer decreased reproductive success, resulting in decreased genetic contribution to the herd genome. Such artificial selection based on animal tolerance of high-stress handling in facilities can rapidly lead to domestication of the herd. Details on low-stress handling training and techniques to be used by NWRS units supporting bison are provided in the sections below. These techniques must be employed in consultation with the NWRS Bison Conservation Coordinator and the NWRS Bison Herd Health Program Lead.

B. Socialization and Behavior

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The full extent of natural socialization and behavior is not yet understood because most bison are confined on ranges below optimum size (Kohl et al. 2013), but we have learned much from herds under varying levels of natural selection. Based on livestock models, refuges historically considered older animals to be non-reproductive, but recent studies suggest that bison older than 15 have a 36% chance of producing offspring in any given year (Mooring and Penedo 2014). Aggression, mate competition, and associated bull mortality are important components of bison natural selection and social structure, including the potential for injuries suffered during the breeding season. Managing for an even sex ratio with a full age structure also conserves genetic diversity by maximizing generation time and effective population size (Gross and Wang 2005, Dratch and Gogan 2010). Based on these factors, NWRS bison herds should include a wide age structure to support natural processes and behaviors, including mate competition and natural variation in reproductive potential. Older bison should be allowed to remain in the herd until they die naturally unless humane euthanasia is required. Employees should contact the Service's Wildlife Health Office for additional guidance regarding euthanasia criteria and protocols.

Similarly, refuges should avoid segregation of small, seasonal "display" herds. Allowing all individuals in the herd to remain together supports normal socialization and behaviors while also allowing full mate competition to occur during breeding season. Segregating animals for display purposes also requires Animal Care and Use Committee review to ensure that animal welfare standards are met. Further information regarding this review process is available from the Service's Wildlife Health Office.

C. Habitat and Use of the Landscape

Cross-fencing and manufactured water resources are sometimes perceived as negative influences to maintaining the wild character of bison, and existence of these alterations to the landscape may affect bison movement and distribution (Kohl et al. 2013). Although some studies suggest that historic movements of bison may have varied depending on habitat type and quality, and that all bison did not regularly undertake large-scale geographic movements (Widga et al. 2010), it is likely that the optimum acreage to allow for natural movement and behaviors is larger than most existing NWRS units can provide.

Use of cross-fencing and installation of manufactured water resources may have a positive effect on habitat quality by increasing bison distribution across an entire management unit, resulting in decreased parasitism, increased vegetation resilience, and reduced impact to heavily used preferred areas of the available habitat. Such management activities may also increase the ability of the refuge to achieve conservation objectives for other species. Some refuges currently use managed grazing rotation programs, while others allow bison to roam freely within the entire management boundary with only minimal influence in the form of habitat management activities like prescribed fire. Rotational grazing management programs are often based on livestock models, and bison-specific studies are needed to better define the ecological characteristics of "healthy grazed bison habitat" across different landscapes, including how grazing affects the needs of other wildlife species.

Since bison are no longer free to roam vast geographic areas, the Service has historically provided mineral supplementation on many refuges. However, in an effort to move away from traditional livestock husbandry practices that may affect micronutrient metabolism, as well as due to concerns associated with altering natural bison distribution and increasing animal densities, some refuges have discontinued mineral supplementation. Evaluating diversity of soil types and vegetation uptake relative to mineral requirements, as well as monitoring long-term health impacts, may be required to provide support for or against mineral supplementation at each individual refuge with bison.

Because we cannot predict what future environments will be like that will require bison to adapt, diversity in habitat and vegetation management across refuges may ultimately conserve a diversity of bison behaviors and adaptations. Some bison behaviors and adaptations may not have been present throughout bison evolutionary history, but may yet be adaptive under future selection forces. However, employees should make every effort to minimize artificial influences of human origin to the extent possible while still meeting refuge objectives. Managing herd sizes well within ecological carrying capacity, including utilizing options such as periodic habitat exclusion after voluntary herd moves instead of more intensive grazing rotation programs, can provide significant benefits to bison, refuge habitats, and other wildlife species.

D. Components of an Intact Ecosystem

Relationships between predator and prey in large, ecologically intact systems, as well as those of sympatric and co-dependent species, are poorly understood due to the sheer magnitude of landscape change from human activities in the past century. Nevertheless, many plant and wildlife species have significant ecological relationships with bison and/or the habitats they occupy. Sanderson et al. (2008) summarized decades of research documenting that bison are a keystone species in highly complex ecosystems. Unfortunately, large predators such as wolves (*Canis lupus*) and grizzly bears (*Ursus arctos*) are not year-round residents on most NWRS bison conservation units due to the small size of the units, surrounding land use patterns, and/or lack of social tolerance. It is not possible in most cases to restore small isolated NWRS units to the level of a fully functioning ecosystem at a landscape scale, but refuges should restore species assemblages known to historically co-exist with bison to the extent possible while meeting other management objectives as outlined in the refuge's Comprehensive Conservation Plan and associated step-down plans.

> *"Low-stress bison handling is an animal-centered, behaviorally-correct, psychologically-oriented, ethical and humane method of working animals that is based on mutual communication and understanding, not coercion."* (Hibbard and Locatelli 2012)

E. Animal Welfare and Population Management

The welfare of an animal, which includes its physical and mental state, has been defined as the Five Freedoms. The Five Freedoms were originally described in a British government report on livestock husbandry in 1965, and they are now internationally recognized in the World Organization for Animal Health (OIE) Terrestrial Animal Health Code, Chapter 7.1, Introduction to the Recommendations for Animal Welfare, Guiding principles for animal welfare (2015). The Five Freedoms are:

1. *Freedom from Hunger and Thirst:* by ready access to fresh water and a diet to maintain full health and vigor.
2. *Freedom from Discomfort:* by providing an appropriate environment, including shelter and a comfortable resting area.
3. *Freedom from Pain, Injury, or Disease:* by prevention or rapid diagnosis and treatment.
4. *Freedom to Express Normal Behavior:* by providing sufficient space, proper facilities, and company of the animal's own kind.
5. *Freedom from Fear and Distress:* by ensuring conditions and treatment that avoid mental suffering.

While animal welfare concerns do not generally apply to recreational use (such as for observation and photography) of free-roaming wildlife, range-limited NWRS bison numbers would rapidly outgrow the available habitat if the Service did not manage bison population size. Consistent with Federal regulations and policy (50 CFR 30.1, 50 CFR 30.1, 701 FW 5) and genetic recommendations to conduct regular, consistent population control that results in stable population sizes (Gross and Wang 2005, Hartway et al. 2020), the Service will remove a portion of NWRS bison offspring exceeding ecological carrying capacity most years. Live bison capture and removal assists in the restoration of herds on Tribal lands, supports conservation efforts of partners, such as States and nonprofit bison conservation organizations, and ensures that the ecological needs of other species are met on NWRS units, which are of limited size (Department of the Interior 2020). To offer live excess bison to our partners, employees gather the animals and bring them into handling facilities, always considering the welfare of each bison at each point during this capture and handling process. Bison are naturally gregarious, and the portion of each herd handled varies across refuges from around 40 to 90%. Mature animals that are reluctant to be moved towards the handling facility should be left alone to remain in the field.

Low-stress bison handling is an animal-centered, behaviorally correct, psychologically-oriented, ethical and humane method of working animals that is based on mutual communication and understanding, not coercion (Hibbard and Locatelli 2012). Low-stress handling techniques should be used to separate animals by age, sex, and behavior early in the capture and handling process to prevent intraspecific injury. Small groups of bison are more easily handled than larger groups. Conducting bison capture and handling activities using the absolute minimum required number of personnel is key to reducing animal stress and injury. Appropriate position and posture of personnel is also essential to facilitating safe and efficient bison movement through a facility by minimizing stress that in turn maximizes responsiveness of the animal. Stimuli must begin at the lowest level possible by simply opening up access to the area to which the animal needs to move and allowing time for the bison to recognize and move into that area without additional stimuli. Use of additional visual stimuli, including modifying personnel posture, may be added only if needed. Personnel may use flags as additional visual stimuli, but only if animals do not respond to modified personnel position and/or posture. Personnel may also add audio stimuli, including the voice, rattles, or other noise, if lower-level stimuli are ineffective. Tactile stimuli should be reserved for use only when absolutely necessary. Personnel should introduce each additional stimulus only after the animal has had adequate time to respond to the first efforts. To minimize animal stress and ensure personnel safety, only those trained and able to demonstrate proficiency in low-stress handling techniques are allowed to participate in NWRS bison capture and handling activities. The number of people allowed in or near the handling facility must be restricted to the minimum required to achieve capture and handling objectives. The NWRS Bison Conservation Coordinator or the NWRS Bison Herd Health Program Lead can provide training resources and materials to support employee training and annual refresher needs.

Service personnel identify animals by using subcutaneous radio-frequency identification (RFID) microchips, sometimes also called pit tags, inserted at the base of the ear of each bison when it's first captured as a calf. This method of identification provides long-term, reliable identification, with less than 2% average annual tag loss. By identifying animals early in the handling process, employees minimize the number of animals directed to the squeeze chute for disease surveillance sampling or removal from the herd through donation. A small, metal “brite tag” approved by USDA as part of the national identification system is required for interstate animal transport. Branding is not acceptable due to concerns over humane treatment of the animals (Wallace et al. 1995) and is not needed to support animal identification because we use microchip technologies. The Service’s Wildlife Health Office has also developed temporary external identification hair color marks that can be applied either within the handling facility or remotely delivered in the field. These temporary identification marks last at least 90 days.

Refuges supporting bison should modify their handling facilities and streamline their protocols to reduce handling stress and promote bison welfare with the following activities:

1. Limit captures to younger age classes for herd health sampling activities associated with annual population management. Calves may be handled to collect genetics and health samples and for microchip insertion. Most yearlings, and some 2- or 3-year old animals, are handled as part of the annual population management process for removal from the herd; these animals should be prioritized for sampling as part of the health surveillance program to minimize handling of adults.
2. Leave weak or injured animals in the field, if possible. If weak or injured individuals are unintentionally gathered with other animals, they must be released out of the facility as soon as possible without physical restraint.
3. Animals for which identification and/or genetic information is unknown, such as older bulls with a damaged or missing microchip, may be sampled using a small remotely delivered tissue biopsy to better inform herd genetic composition, but they should not be physically restrained to insert new identification.
4. NWRS bison should be selected from the herd for donation prior to capture using science-based methods to minimize relatedness and inbreeding within the herd. The destination of each bison is pre-loaded into a handheld computer system to facilitate rapid animal sorting upon entry to the handling facility to reduce stress and the potential for injury.
5. While public viewing of bison capture and handling operations has been encouraged historically, low-stress handling protocols require that Service personnel carefully review such display activities and take appropriate mitigation measures to minimize stress on bison. Additional information on animal capture, handling, and display is available from the Service’s Wildlife Health Office.
6. If it is not possible to donate live bison to support conservation efforts of Tribes and other partners due to lack of appropriate facilities, contact the Bison Herd Health Program Lead in the Service’s Wildlife Health Office for guidance to support disease testing for bison donation using humane lethal removal.

F. Health Management

Wildlife health is determined by the resilience and sustainability of a species to native pathogens and parasites (Stephen, 2014; Jones et al., 2020). Some level of disease and parasites is part of natural selection in a normally functioning ecosystem, but the risks from emerging infectious diseases such as *Mycoplasma bovis* (Janardhan et al. 2010, Woodbury 2012), combined with the risks of well-known introduced livestock diseases such as bovine brucellosis and tuberculosis, require strong health surveillance protocols for NWRS bison. Additionally, management as a metapopulation requires adherence to a variety of interstate transport regulations that frequently change from year to year in response to changes in the animal health landscape within each State.

The Service's Wildlife Health Office provides wildlife health management services for the NWRS, including bison disease surveillance and response and long-term data collection to provide high confidence in the disease status of each herd. At the time of this handbook's publication, all five range-limited NWRS bison herds are free from reportable diseases for livestock, and disease status is monitored annually through a herd health surveillance and monitoring program. Consistent with the paradigm shift to managing bison as wildlife, veterinary interventions (such as vaccination and disease-specific treatments) are no longer routinely applied. The Service's Bison Herd Health Program Lead may consider mitigation for the exacerbation of an existing disease condition due to handling or other management activities if a large portion of the herd is affected and if the Program Lead expects little to no additional stress to the animal as a result.

> *"Wildlife health is determined by the resilience and sustainability of a species to native pathogens and parasites."*
>
> DOI Bison Health History and Status Report (Jones et al. 2020)

Disease surveillance should be conducted throughout the year and includes the following:

1. Morbidity and mortality surveillance is a very effective way to evaluate disease status. Methods include general animal health observations performed during routine refuge management activities, along with conducting necropsies on mortalities found in good post-mortem condition. The Bison Herd Health Program Lead provides guidance on targeted sampling options that are appropriate for situations where post-mortem condition or other issues prevent a full necropsy, including surveillance for specific pathogens of concern such as *Mycoplasma bovis*.

2. Body condition should be scored during the handling process using standard criteria that the Bison Herd Health Program Lead establishes. If a herd's average body condition score decreases, further evaluation of herd health, habitat condition, animal densities, and distribution is necessary.

3. Fecal parasite counts should be evaluated annually relative to population density and distribution from fresh fecal samples that refuge personnel collect in the field during the summer. If necessary, the Project Leader may implement habitat management activities, such as the use of prescribed fire, to modify animal distribution. The Project Leader, working with the Bison Herd Health Program Lead, may consider anthelmintic treatment to reduce excessive parasite burdens, but only if habitat management options have failed to do so.
4. During annual population management captures, young bison that are handled for genetic sampling or for surplus removal are tested for exposure to several diseases, which must include specific tests required for interstate transport. This annual surveillance generally results in statistical detection probabilities for disease at 7% prevalence with 90% confidence in most cases, but surveillance detection goals may vary from year to year depending on the health of surrounding wildlife, livestock, or on other factors driven by regional animal health concerns. A small number of additional adult animals may occasionally be handled for specific disease sampling based on clinical presentation, body condition, or past disease test results. Herd-specific information detailing disease surveillance history and current health status is available for all of the Department's bison herds, with an emphasis on preventing disease transmission among herds through bison translocations to augment genetic diversity (Jones et al. 2020).

Livestock trespassing onto Service lands increases the chance of disease introduction into Service herds, with some domestic species posing a significant risk to bison. Laws and regulations related to fencing, livestock owner responsibility, and liability vary from State to State. However, to protect the health of Service bison herds, refuge personnel must maintain refuge fencing to minimize contact between livestock and bison. If livestock are found trespassing on Service lands, personnel should try to prevent contact and co-mingling until the livestock owner can remove the livestock according to State law and regulations. Refuge personnel may use low-stress techniques to maintain separation between Service bison and livestock, and they may also need to install temporary and/or electric fencing to prevent co-mingling.

The NWRS Bison Herd Health Program Lead considers disease response on a case-by-case basis in coordination with other appropriate State and Federal health authorities, depending on the disease(s) involved, severity of the outbreak, transmission cycles that may involve vectors and/or area livestock, and risk to the bison genetic resource. The Bison Herd Health Program Lead considers potential responses using habitat management techniques first, including encouraging animal distributions that reduce density. Unless the bison genetic resource is at risk, use of veterinary treatments is generally reserved to allow disease resistance to develop naturally in NWRS bison herds.

G. Conservation Genetics

There is considerable debate about the relative value of natural selection to genetic diversity in managed populations (Lacy 2000). Genetic drift leads to the loss of diversity, and small populations that have already suffered from the effects of a bottleneck followed by genetic drift are especially susceptible to inbreeding depression, leaving them less able to adapt to changing environmental conditions through natural selection. Inbreeding depression results in reproductive failure, poor recruitment, and lack of disease resistance (Halbert et al., 2004, Giglio et al. 2016, Hartway et al. 2020). Conservation of genetic diversity plays a significant role in conservation of species (Giglio et al. 2016, Hartway et al. 2020), especially when the existing evolutionary forces of selection on refuges may be significantly different from that of historic, or even future conditions (Lacy 2000). Programs that emphasize conservation of genetic diversity strive to ensure adaptive plasticity that will improve survival of future populations under a variety of environmental and management conditions. Furthermore, since at least some forces of natural selection continue to occur on many refuges, refuge personnel should allow natural processes to have the maximum effect possible on NWRS bison populations, as described in the sections above.

Halbert and Derr (2008) detailed the patterns of genetic diversity in U.S. Federal bison herds using microsatellites, and these microsatellite panels have been adopted as standard by the Department (Dratch and Gogan 2010, Hartway et al. 2020). While genetic diversity of NWRS herds is currently above the threshold at which inbreeding effects become apparent (Halbert et al. 2004, Halbert and Derr 2008, Hartway et al. 2020), careful management of Federal herds is essential to ensuring long-term species conservation (Hedrick 2009, Gates et al. 2010, Hartway et al. 2020). Geneticists recommend maintaining an even sex ratio, minimizing variation in population size, maximizing effective population size, and maximizing generation time as indirect methods to mitigate the effects of genetic drift (Gross and Wang 2005, Dratch and Gogan 2010). The NWRS Bison Conservation Coordinator will work with refuge personnel to implement these science-based recommendations.

Recent modeling work suggests that using genetic data to support population management efforts results in maintaining higher levels of genetic variation than selecting bison for surplus randomly. Including only the indirect methods described above, within 200 years heterozygosity may decline below 0.5, and within 500 years more than 1/3 of gene diversity may be lost in herds if random removal is used as the primary population control strategy (Giglio et al. 2016, Giglio et al. 2018, Hartway et al. 2020). The rate of diversity loss varies between herds, and herds with higher initial diversity have a higher rate of loss (Giglio et al. 2018). Conservation of bison genetic diversity is best achieved using genome-wide estimates of mean kinship derived from these microsatellites. Loss of only ¼ of gene diversity over 500 years is an achievable goal using these methods to minimize relatedness among individuals retained within the herd (Giglio et al. 2016, Giglio et al. 2018). Animals with the highest mean kinship values are genetically over-represented in the population (Ballou and Lacy 1995) and are therefore most appropriate for surplus to minimize inbreeding (Giglio et al. 2016). With technical support from the NWRS Bison Conservation Coordinator, NWRS units supporting bison will continue to minimize inbreeding within refuge bison herds using science-supported methods until improved genetic diversity conservation can be realized through expanded, science-based metapopulation management of the Department's bison.

More than 150 years of intentional cross-breeding between bison and cattle has resulted in a variety of hybrid animals, and the American Beefalo continues to be a popular breed today. As a result of these hybridization experiments that began in the late 1800s, cattle gene introgression is common in domestic bison, while low levels of introgression have been detected in most Federal herds (Halbert and Derr 2008, Dratch and Gogan 2010, Hartway et al. 2020, Stroupe et al. 2022). Currently, NWRS bison are tested for the presence of cattle introgression in both nuclear and mitochondrial DNA (mtDNA). Due to the potential metabolic effects of cattle mtDNA in bison (Hedrick 2009, Derr et al. 2012), geneticists recommended removal of a small number of bison with known cattle mtDNA introgression from NWRS bison herds more than a decade ago. No mtDNA introgression has since been detected in NWRS bison.

Some recent conservation efforts have emphasized cattle gene introgression as a primary element in bison conservation programs, taking priority over conservation of genetic diversity. However, two factors make this emphasis inappropriate for NWRS bison. First, preliminary results suggest that the existing 15 marker microsatellite panel is poorly sensitive compared to newer genomic techniques, such as using single nucleotide polymorphisms (SNPs), to the extent that estimation of the amount of introgression in individual animals cannot be made with confidence (Hedrick 2009, Dratch and Gogan 2010, Hartway et al. 2020). While some introgressed individuals can confidently be identified, other individuals could have higher total amounts of introgression that are undetected with this small microsatellite panel. Secondly, this emphasis could result in significant loss of bison genetic diversity since cattle gene introgression is widespread in public herds (Gates et al. 2010). Geneticists agree that conserving diversity is the highest genetic priority and that low, existing levels of introgression present in most Federal conservation herds are not likely to be significant for bison conservation (Hedrick 2009, Gates et al. 2010).

Genetic diversity provides the foundation for adaptive capacity on the evolutionary pathway of bison

Rocky Mountain Arsenal National Wildlife Refuge

H. Metapopulation Management

Maintaining the NWRS bison genetic foundation across several diverse geographic locations reduces the risk of total loss of genetic resources at any one location from a natural event or other disaster. Distribution of animals with diverse genetics across diverse landscapes under an NWRS bison metapopulation model also results in a broad range of natural selection forces acting on a large population genetic foundation. While the NWRS currently has only about 1,200 bison, the Department's herds combined total about 4,000 bison, excluding those affected by brucellosis (Department of the Interior, 2014). Although the full extent of gene flow in historic herds of bison roaming across the Great Plains is unknown (Shaw 1995), conserving genetic diversity is essential to the long-term viability of this species. Expansion of the existing NWRS conservation and metapopulation management program to include other Departmental herds could greatly improve the success of long-term bison conservation efforts (Hartway et al. 2020).

However, some geneticists have suggested that protection of "lineages" is important (Halbert and Derr 2008). We define lineages as the differences between herds that are representative of historical conservation efforts and confirmed by genetic analysis (Dratch and Gogan 2010). Although some adaptation to the local environment at NWRS units is possible, this adaptation is not measurable, nor genetically distinguishable from historic management artifact. There is no evidence that lineages represent local adaptation with biological conservation value, and lineages most likely reflect differences based on genetic drift combined with anthropogenic management artifact (Hedrick 2009, Freese et al. 2007, Davies et al. 2022). Furthermore, recent modeling of potential Departmental herd management scenarios demonstrates that limiting bison translocations to support conservation of lineages results in significant loss of genetic diversity compared to translocations optimized by genetic distance (Hartway et al. 2020).

To prevent further loss of species integrity due to cattle gene introgression, the NWRS adopts a "don't make it worse" strategy to ensure that cattle gene introgression in refuge bison is not exacerbated by metapopulation movements. Any herds with high levels of cattle introgression, including bison with cattle mtDNA, do not meet the Department's definition of "wild bison" (Dratch and Gogan 2010) and are not appropriate to use for NWRS bison herd genetic augmentation. Translocations that introduce novel cattle gene segments into a herd may not be appropriate unless loss of genetic diversity is a significant threat without inclusion of animals containing those segments. As new genomic technologies become available, improved detection and quantification of cattle gene introgression will better characterize the impact of historic hybridization experiments between cattle and bison. The conservation of bison is best achieved by restoring gene flow among the Department's herds through strategic, occasional translocation of a small number of animals (Hartway et al. 2020); however, until better information is available, an intentional and cautious approach to bison metapopulation management is warranted to protect the success of bison conservation gained over the last century.

The Service may use multiple criteria to evaluate NWRS bison herd genetic augmentation, including translocations from within the NWRS or from other conservation herds. In addition to a variety of social, economic, and logistical factors, criteria that the NWRS Bison Conservation Coordinator evaluates include:

1. Contribution of new genetic variation to the recipient herd or to the NWRS bison metapopulation;
2. Risk of disease introduction into the recipient herd and/or risk of disease impacts to translocated animals, including potential risk mitigation through the use of assistive reproductive technologies;
3. Risk of detectable novel cattle gene introduction to the recipient herd;
4. Need for genetic augmentation based on current data, herd size, and time since last translocation;
5. Cost of transport (including risk of injury to transported animals); and
6. Frequency and probability of future opportunities for similar translocations.

IV. Ecological Restoration and Considerations for Establishing New Herds

Creating new large herds has long been recognized as key to the functional conservation of bison and the ecosystems upon which they depend. With the genetic and behavioral plasticity to survive landscape change, disease, and increasing human disturbance, bison are uniquely positioned for successful restoration as native North American wildlife. The NWRS takes advantage of this unique opportunity to help secure the success of future conservation and restoration efforts by adopting best management practices that contribute to the goals outlined in the 2020 Department of the Interior Bison Conservation Initiative:

A. Supporting wild, healthy bison as native North American wildlife;

B. Conserving bison genetic diversity by restoring gene flow through metapopulation management;

C. Recognizing that shared stewardship is essential to achieve bison conservation and restoration goals;

D. Restoring the ecological role of bison on appropriate large landscapes; and

E. Restoring the cultural connection between bison and Tribes, while promoting the unique status of bison as an American icon for all people.

A century of conservation success brought bison back from the brink; we must now secure the genetic, ecological, and cultural future of this species.

Contribution to the goals outlined in the Department's Bison Conservation Initiative should be met through the science-based management practices for NWRS bison described in this handbook. Donation of healthy, genetically diverse NWRS bison above refuge ecological carrying capacity supports the Department's goals to assist in the restoration of bison herds on conservation partner lands, with special emphasis on restoring conservation herds to Tribal lands. The Project Leader ensures appropriate habitat evaluation to establish an ecological carrying capacity that includes the needs of other wildlife species on the refuge. Within that capacity, the NWRS Bison Conservation Coordinator will select young bison for donation to best support the genetic conservation goals of the NWRS. Donation of NWRS bison above ecological carrying capacity for any purpose, including to establish or augment conservation herds—whether on Departmental lands or lands of Tribes, States, or other conservation partners—should be accomplished through the NWRS bison donation process using a Servicewide, equitable, and transparent review process that the NWRS Bison Donation Program Facilitator manages, with support from the NWRS Bison Conservation Coordinator and the NWRS Bison Herd Health Program Lead. The Service's Bison Donation Request Form, FWS Form 3-2555 (OMB Control No. 1018-0190), is available by sending an email to nwrs_bison_donations@fws.gov or on the Service's public-facing forms collection online.

The modern and renewed vision for bison conservation is complex and includes many stakeholders and partners. This renewed vison includes management of existing herds to conserve genetic diversity, promoting natural processes that define the evolutionary pathway of bison, and supporting the establishment of new herds to achieve ecological restoration of bison as wildlife. Managing bison as wildlife also aligns with Service and Departmental goals to honor the cultural and conservation connections between Tribes, Indigenous Peoples, and bison, including efforts to recognize and incorporate Indigenous Knowledge (IK) along with scientific and technical information.

V. References

Aune, K, Jorgensen, D. and C. Gates. 2017. Bison bison. The IUCN Red List of Threatened Species 2017: e.T2815A45156541. http://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T2815A45156541.en.

Ballou, J. D. and R. C. Lacy. 1995. Identifying genetically important individuals for management of genetic variation in pedigreed populations. In: Ballou J.D., Foose T.J., Gilpin M. (eds) Population management for survival and recovery. Columbia University Press, New York, NY. Pp. 76-111.

Coder, G. D. 1975. The national movement to preserve the American buffalo in the United States and Canada between 1880 and 1920. Dissertation. The Ohio State University, Columbus, Ohio.

Davies G, McCann B, Jones L, Liccioli S, Penedo MC, Ovchinnikov IV. 2022. Genetic variation of the mitochondrial DNA control region across plains bison herds in USA and Canada. PLoS ONE 17(3): e0264823. https://doi.org/10.1371/journal.pone.0264823

Department of the Interior. 2008. Bison Conservation Initiative. Unpublished Report, Assistant Secretary for Fish and Wildlife and Parks U. S. Department of the Interior Washington, DC. 11pp.

Department of the Interior. 2014. DOI bison report: Looking forward. Natural Resource Report NPS/NRSS/BRMD/NRR—2014/821. National Park Service, Fort Collins, Colorado.

Department of the Interior. 2020. Bison Conservation Initiative 2020.

Derr, J.D., P.W. Hedrick, N.D. Halbert, L. Plough, L. K. Dobson, J. King, C. Duncan, D. L Hunter, N. D. Cohen and D. Hedgecock. 2012. Phenotypic effects of cattle mitochondrial DNA in American bison. Conservation Biology 26 (6): 1130-1136.

Dratch, P. A., and P. J. P. Gogan. 2010. Bison Conservation Initiative: Bison Conservation Genetics Workshop: report and recommendations. Natural Resource Report NPS/NRPC/BRMD/NRR—2010/257. National Park Service, Fort Collins, Colorado.

Fish and Wildlife Service and National Park Service. 2007. Final bison and elk management plan and environmental impact statement: National Elk Refuge, Grand Teton National Park, and John D. Rockefeller, Jr. Memorial Parkway. Volume 1. Denver, CO: U.S. Department of the Interior, Fish and Wildlife Service. 605 pp.

Flores, D. 1991. Bison ecology and bison diplomacy: the southern plans from 1800 to 1850. The Journal of American History 78:465–485.

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

Gates, C.C., C.H. Freese, P.J.P Gogan and M. Kotzman. 2010. American Bison: Status Survey and Conservation Guidelines. IUCN.

Giglio, R.M., Ivy J.A., Jones, L.C. and E. Latch. 2016. Evaluation of alternative management strategies for maintenance of genetic variation in wildlife populations. Animal Conservation 19: 380-390.

Giglio, R.M., Ivy J.A., Jones, L.C. and E. Latch. 2018. Pedigree-based genetic management improves bison conservation. Journal of Wildlife Management doi:10.1002/jwmg.21433.

Gross, J. and G. Wang. 2005. Effects of population control strategies on retention of genetic diversity in National Park Service bison (Bison bison) herds. Final Report, Yellowstone Research Group, USGS-BRD. United State Geological Survey, Bozeman, Montana, USA.

Halbert, N.D. and J.D. Derr. 2007. A comprehensive evaluation of cattle introgression into US federal bison herds. Journal of Heredity 98(1):1-12.

Halbert, N.D. and J. D. Derr. 2008. Patterns of genetic variation in US federal bison herds. Molecular Ecology 17:4963-4977.

Halbert, N.D., Raudsepp, T., Chowdhary, B.P. and J.D. Derr. 2004. Conservation genetic analysis of the Texas State Bison Herd. Journal of Mammalogy 85(5):924-931.

Hardy, Sylvia. 2008. Between Domestication and Wildness: A Study of North American *Bison bison* on Contemporary Private Herd Ranches in Maine, Massachusetts and Missouri. Washington University Undergraduate Research Digest, Vol. 3 (2): 26-35.

Hartway, C., Hardy, A., Jones, L., Moynahan, B., Traylor-Holzer, K., McCann, B., Aune, K. and G. Plumb. 2020. Long term viability of Department of the Interior bison under current management and potential metapopulation management strategies. Natural Resource Report NPS/NRSS/BRD—2020/2097. National Park Service, Fort Collins, Colorado. 115 pp.

Hedrick, P.W. 2009. Conservation genetics and North American bison (Bison bison). Journal of Heredity. 4: 411–420.

Hibbard, W., and L. Locatelli. 2012. Low-stress livestock handling: Mapping the territory. Stockmanship Journal 1(2): 10-30.

Isenberg, A. C. 2000. The destruction of the bison: an environmental history, 1750–1920. Cambridge University Press, New York, New York.

Janardhan, K.S, Hays, M., Dyer, N., Oberst, R.D. and B.M. DeBey. 2010. Mycoplasma bovis outbreak in a herd of North American bison (Bison bison). Journal of Veterinary Diagnostic Investigation 22:797–801.

Janiskee, B. 2010. On bison science, bison politics, and the rebisoning of the west. National Park Traveler.

Jones, L.C., J.G. Powers, and S.J. Sweeney. 2020. Department of the Interior: History and status of bison health. Natural Resource Report NPS/NRSS/BRD/NRR – 2020/2201. National Park Service, Fort Collins, Colorado.

Kohl, M.T., Krausman, P.R., Kunkel, K. and D.M. Williams. 2013. Bison versus cattle: are they ecologically synonymous? Rangeland Ecology and Management 66: 721-731.

Lacy, Robert C. 2000. Should we select genetic alleles in our conservation breeding programs? Zoo Biology 19: 279-282.

Latch, E.K. and J.A. Ivy. 2018. Final Project Report: Evaluation of culling strategies that incorporate cattle gene introgression. Technical report to US Fish and Wildlife Service, Natural Resource Program Center, Wildlife Health Office. May 7, 2018. 21 pp.

Lott, D.F. 1998. Impact of domestication on bison behavior. In: L. Irby and J. Knight (ed.), International symposium on bison ecology and management in North America, pp.103-106. Montana State University, Bozeman.

Mooring, M.S. and M.C.T. Penedo. 2014. Behavioral versus genetic measures of fitness in bison bulls (Bison bison). Journal of Mammalogy 95(5): 913-924.

Parker, M., Patyk, K and S. Sweeney. 2016. Bison 2014: Highlights from the National Animal Health Monitoring System's first national study of health and management practices on U.S. ranched-bison operations. Poster: The 65th International Conference of the Wildlife Disease Association, Cortland, NY, August 4.

Sanderson, E.W., Redford, K.H., Weber, B., Aune, K., Baldes, D., Berger, J., Carter, D., Curtin, C., Derr, J., Dobrott, S., Fearn, E., Fleener, C., Forrest, S., Gerlach, S.C., Gates, C.C., Gross, J., Gogan, P.J., Grassel, S., Hilty, J.A., Jensen, M., Kunkel, K., Lammers, D., List, R., Minkowski, K., Olson, T., Pague, C., Robertson, P.B. and Stephenson, B. 2008. The ecological future of the North American Bison: Conceiving long-term, large-scale conservation of wildlife. Conservation Biology 22:252-266.

Shaw, James H. 1995. How many bison originally populated western rangelands? Rangelands 17(5):148-150.

Stroupe, S., Forgacs, D., Harris, A., Derr, J.N., and Davis, B.W. 2022. Genomic evaluation of hybridization in historic and modern North American Bison (*Bison bison*). Scientific Reports 12, 6397.

Traylor-Holzer, K. 2017. Draft Report: Population Viability Analysis of Bison DOI Populations. Submitted to IUCN SSC American Bison Specialist Group, August 2, 2017. IUCN SSC Conservation Planning Specialist Group. 30 pp.

Wallace, J., D. Lalman and S. Dewald. 1995. Livestock branding in Oklahoma. Oklahoma Cooperative Extension Service, Oklahoma State University. ANSI-3255.

Widga, C, Walker, J.D., and L. D. Stockli. 2010. Middle Holocene Bison diet and mobility in the eastern Great Plains (USA) based on δ13C, δ18O, and 87Sr/86Sr analysis of tooth enamel carbonate. Quaternary Research 73: 449-463.

Woodbury M. 2012. Mycoplasma in bison. Western College of Veterinary Medicine, University of Saskatchewan, Saskatoon, Saskatchewan. S7N 5B4.

World Organization for Animal Health (OIE) Terrestrial Animal Health Code. 2015. Chapter 7.1 Introduction to the Recommendations for Animal Welfare, Guiding principles for animal welfare.