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Natural Resource Stewardship and Science

A Draft Decision Framework for the National Park Service Interior Region 5 Bison Stewardship Strategy

Natural Resource Report NPS/MWRO/NRR—2019/2046

ON THIS PAGE
Regular bison capture operations are needed to maintain desired population sizes in parks.
(NPS / VIDAL DAVILA)

ON THE COVER
A young bison calf stays close to its mother at Tallgrass Prairie National Preserve
(NPS / HEARTLAND INVENTORY AND MONITORING NETWORK ARCHIVES)

A Draft Decision Framework for the National Park Service Interior Region 5 Bison Stewardship Strategy

Natural Resource Report NPS/MWRO/NRR—2019/2046

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received formal peer review by subject-matter experts who were not directly involved in the process described in the report, and whose background and expertise put them on par technically and scientifically with the authors of the information. The peer review process adheres to the U.S. Geological Survey's Fundamental Science Practices for peer review and oversight.

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Executive Summary

The Department of the Interior Bison Conservation Initiative calls for its bureaus to plan and implement collaborative American bison conservation and to ensure involvement by tribal, state, and local governments and the public in that conservation. Four independently managed and geographically separated National Park Service (NPS) units in Interior Region 5 (IR5) preserve bison and other components of a formerly contiguous Great Plains landscape. Management of bison in IR5 parks has historically been specific to each park, and livestock and range management science informed much of the decision making. In the past two decades, NPS has shifted away from managing bison from this livestock-based perspective towards a wildlife stewardship approach, including ensuring their long-term adaptive potential and considering them as just one part of a complex ecosystem. This shift requires a more holistic and cooperative approach to stewardship that is challenging not only because of limitations in funding and fluctuations in leadership priorities, but also because of the constraints imposed by the parks' relatively small, fenced areas.

The IR5 NPS Bison Stewardship Strategy ("Strategy") will help the NPS to meet its responsibilities in cooperative stewardship of bison. The Strategy will serve to organize and consolidate the NPS's legal and policy responsibilities within a framework of collectively defined values and objectives to support the careful and transparent decision-making processes that both guide and transcend park-specific planning. This report describes a preliminary decision framework for the Strategy, including the context, the fundamental objectives, and a range of alternative strategies developed and considered through two workshops and a series of conference calls with NPS personnel, stakeholders, and outside experts with an interest in IR5 NPS bison stewardship. Although not the Strategy itself, this framework serves as the Strategy's starting point and identifies 14 fundamental objectives, falling in four major themes:

Persistence of Wild and Healthy Bison

1. Maximize the long-term persistence of bison in IR5 parks
2. Maximize the long-term adaptive capacity of bison in North America
3. Maximize the wildness of the bison herds
4. Maximize humane treatment of bison, while allowing natural processes to occur

Supporting Tribal Buffalo Culture

5. Improve relationships, trust, and communication with Tribes to enhance shared stewardship of bison within and beyond IR5
6. Maximize the number of live, healthy bison that can be transferred to tribal herds

Persistence of Native Ecological Communities and Processes

7. Maximize structural and compositional heterogeneity of native prairie plant communities across space and time within each park
8. Maximize the abundance and diversity of animal species of special concern
9. Minimize the loss of native grassland within each park

10. Minimize the abundance of exotic plants in the park landscape
11. Maximize riparian area and wetland integrity

Public Outreach

12. Maximize the number of healthy, wild bison that are visible to the public
13. Maximize the safety of visitors
14. Maximize public understanding of the past, present, and future of bison and Native Americans in the Great Plains

The terms “minimize” and “maximize” in these objectives describe the desired direction for each individual objective. Finding the right balance among these objectives and any others identified in further work is one of the central challenges in developing the Strategy. To that end, this report also demonstrates and describes potential methods for evaluating how well alternative strategies would achieve each of the fundamental objectives.

Acknowledgments

We thank the participants of the workshops and webinars for their input, insights, and dedication throughout the process that led to this document. John Gross, Katherine O'Donnell, Amanda Hardy, and Tom Olliff provided valuable suggestions for improvement of earlier versions of this document. The Department of Interior North Central Climate Adaptation Science Center and the National Park Service Focused Condition Assessment program funded this effort.

Introduction

Four National Park Service (NPS) units in Interior Region 5 (IR5) are home to American bison (*Bison bison*; hereafter "bison"[1]): Badlands, Theodore Roosevelt, and Wind Cave National Parks; and Tallgrass Prairie National Preserve. These parks are managed independently and are geographically separated, yet they preserve components of a formerly contiguous Great Plains landscape that was shaped by large-scale processes: weather, climate, fire, and large herds of nomadic bison.

The contiguous Great Plains landscape, along with its Native peoples and communities, has been permanently impacted by Euro-American colonization and development, and the vast bison herds and the unique people who depended on them were nearly extirpated. IR5 parks that preserve remnants of this landscape and help to maintain the influence of bison on natural and cultural landscapes in this region are therefore significant. Moreover, bison were established as the National Mammal in 2016, in part because they are a symbol of unity, resilience, and health for all Americans, thereby calling the NPS to a shared stewardship of bison.

As the Department of the Interior (DOI) Bison Conservation Initiative (Assistant Secretary for Fish and Wildlife and Parks 2008) states, bureaus must collaboratively plan and implement bison conservation to ensure involvement by tribal, state, and local governments and the public. Bureaus must adhere to legal authorities, including federal policies (e.g., National Environmental Policy Act, Federal Land Policy and Management Act, Endangered Species Act, National Historic Preservation Act, Treaties, and agency-specific mandates).

The IR5 NPS Bison Stewardship Strategy ("Strategy") will serve to organize and consolidate the NPS's legal and policy responsibilities within a framework of collectively defined values and objectives to support the careful and transparent decision-making processes that both guide and transcend park-specific planning. The Strategy will help the NPS to meet its responsibilities for the public trust, its mission, and its continued collaborative relationships with other DOI bureaus, Tribes, and other trusted partners and conservation allies in cooperative stewardship of bison.

This report describes a preliminary decision framework for the Strategy, including the context, the fundamental objectives, and a range of alternative strategies developed and considered through two workshops (September 5-6, 2018; April 16-18, 2019) and a series of conference calls with NPS personnel, stakeholders, and outside experts with an interest in IR5 NPS bison stewardship (Appendix A). The workshops and calls were facilitated by the authors of this report, using the

[1] NPS preferentially uses the common name "bison" for this species, and we follow that preference in this document. However, we occasionally use the common name "buffalo", which is preferred by many partner Tribes and is more commonly used by the public. Furthermore, we follow the Integrated Taxonomic Information System (www.itis.gov, accessed 16 August 2019) in not distinguishing among proposed subspecies (plains bison, *B. bison bison*, and wood bison, *B. bison athabascae*).

principles of structured decision making (Gregory et al. 2012). This decision framework is meant to serve as a starting point for the development of the Strategy but is not the Strategy itself.

Approach

Structured decision making (SDM) is a general term for carefully organized analysis of a problem to reach a decision that clearly focuses on achieving fundamental objectives (Gregory et al. 2012). Although not rigidly prescribed, the typical steps in SDM are as follows:

1. Define the problem: In this document, we begin by describing the socio-ecological, policy, and legal context within which the decision is being made, the principal entities participating in the decision making, the need for the Strategy, and the Strategy's purpose. That purpose serves as the problem statement, which we further qualify by describing the temporal scope of the Strategy.
2. Determine the objectives: We describe the fundamental objectives of the Strategy—the long-term goals the participating entities seek to achieve—and metrics appropriate for evaluating how well a specific plan of action would perform towards accomplishing those objectives.
3. Formulate alternatives: The Strategy will ultimately comprise a portfolio of actions consistent with achieving the fundamental objectives. Compiling a set of alternative strategies before evaluating their utility in achieving objectives can lead to creative solutions to a problem. We describe the range of alternative strategies participants created from a set of possible actions.
4. Determine consequences: Consequences of each alternative for each fundamental objective have not yet been evaluated. Instead, we describe options for completing this step and demonstrate how this step feeds into the next step.
5. Examining tradeoffs and optimizing outcomes: We conclude this document with a brief description of methods for completing this final step before participating entities decide the final content and implementation of the Strategy.

Context

American bison historically ranged from Canada to Northern Mexico and from the Appalachian Mountains to the Cascade and Sierra Nevada Mountains. However, the greatest numbers were concentrated on the Great Plains, where they were a keystone species. Through their grazing and other behaviors, bison influenced plant and animal species composition; the physical and chemical environment, including soil nutrient availability; spatial and temporal heterogeneity in vegetation structure; and a variety of ecosystem processes (Knapp et al. 1999). Furthermore, bison were the keystone of Plains Tribes' economy, culture, and spirituality. Many of the Northern Plains Tribes (most of the Tribes in the Dakotas, Montana, Nebraska, and Wyoming) were signatories of the 1851 and 1868 Fort Laramie Treaties. These Treaties gave those Tribes the right to access and hunt buffalo on and off their reservations in return for ceding land for European colonization.

Once estimated in the tens of millions (Shaw 1995), by the end of the 1800s the largest land mammal on the continent neared extinction (Hornaday 1889, Isenberg 2000) due to hunting and conversion of prairie ecosystems to agriculture. Consequently, the International Union for Conservation of Nature (IUCN), the global authority on the status of the natural world and the measures needed to safeguard

it, has placed bison on the IUCN Red List of threatened species (Aune et al. 2017). For the last 100 years, the DOI has served as the primary national conservation steward of bison. The bison was saved due to the dedicated efforts of private individuals and organizations that resulted in the establishment of several small federally managed herds dedicated to recovery (Coder 1975, Dary 1989, Dratch and Gogan 2010). Over the course of the 20th century, the DOI's bison conservation efforts focused on stabilizing the population and protecting its remaining genetic diversity, and after more than a century of conservation stewardship, bison are demographically secure. Today, DOI lands support approximately 10,000 bison in 19 herds across 12 states (DOI 2014).

While the species is no longer threatened by demographic extinction, most DOI bison continue to exist in small, range-restricted herds confined by fences and with few, if any, predators. They are further bound by socio-political concerns that limit long-term, large-scale ecological recovery of the species (DOI 2014). Recognizing these challenges, DOI chartered the Bison Conservation Initiative in 2008 to establish a framework for improved stewardship of the species within DOI. The framework emphasizes the restoration of bison to their ecological and cultural roles on appropriate landscapes by strengthening existing and building new partnerships with states, Native American Tribes, and other conservation partners. With management responsibilities for the majority of DOI bison (~7,700 bison in 10 herds in 8 park units), NPS is a key player in the Bison Conservation Initiative and in the ongoing recovery and shared stewardship of the species, on NPS lands and beyond.

A critical tool for bison management and stewardship is the ability to transfer bison from one location to another. NPS authority to transfer or otherwise dispose of wildlife, including bison, exists under 54 U.S.C. §100101 and 54 U.S.C. §100752. Additionally, Wind Cave National Park has authority to transfer or otherwise dispose of bison under 16 U.S.C. §141c and 16 C.F.R. Chapter 1, Part 10, §§1-4. Because NPS' purpose is to conserve and provide for the wildlife in its System units, bison in the IR5 parks are considered wildlife and not livestock. Tribes also consider bison on their reservations to be wildlife based on their shared history. However, Kansas, North Dakota and South Dakota—the states in which the four parks covered by the Strategy lie—legally designate bison as livestock outside the parks (Aune et al. 2010). This designation places some constraints on NPS bison management, particularly as it pertains to interstate transport of animals.

Given the government-to-government relationships the U.S. has with federally recognized Tribes, Alaskan Native groups, and Native Hawaiian organizations, Executive and Secretarial orders and DOI and NPS policy requires the establishment of regular and meaningful consultation and collaboration with tribal officials, from Tribes and intertribal organizations, in the development of Federal policies that have tribal implications, including bison stewardship. Therefore, a tribal organization focusing on bison restoration joined the four parks as one of the principal participating entities in the development of this draft decision framework.

Principal Participating Entities

Each park's unique history, reasons for establishment, environmental setting, and existing management plans constrain and influence current and future stewardship of bison. The brief summaries below provide the management context within each park and explain the roles of the other principal entities involved in the development and eventual implementation of the Strategy.

Badlands National Park

Badlands National Park (BADL), in southwestern South Dakota, was established as Badlands National Monument in 1939. The monument originally encompassed approximately 110,000 acres (44,534 ha) and was expanded by 133,000 acres (53,846 ha) in 1968. It was redesignated as Badlands National Park in 1978. The park's outstanding scenic values, its importance to the science of paleontology, and its natural resources were, and continue to be, its signature features. The 1968 expansion created the South Unit of the park, which comprises tribal lands that are part of the Pine Ridge Indian Reservation. Unless otherwise stated, in this document the term "park" refers only to the North Unit of Badlands National Park.

Badlands' landscape is dominated by two major features—northern mixed-grass prairie and badlands. The latter supports sparse or no vegetation and constitutes 40-45% of the park's area (Von Loh et al. 1999). Sage Creek and its tributaries run through the western portion of the park, but large parts of their courses flow only intermittently. Developed water sources predating the park's establishment are scattered throughout the park. Some of these water features, as well as a concentrated area of natural springs on the western edge of the park, support hydric vegetation types. The park contains 64,144 acres (25,969 ha) of designated Wilderness Area, the largest prairie wilderness in the United States. Black-tailed prairie dog (*Cynomys ludovicianus*) colonies cover a substantial portion of the Badlands landscape and are managed under the park's Prairie Dog Management Plan (NPS 2007). These colonies are characterized by vegetation substantially different from the surrounding prairie, and they host a population of the federally endangered black-footed ferret (*Mustela nigripes*). Other large herbivores in the park include bighorn sheep (*Ovis canadensis*), pronghorn (*Antilocarpa americana*), mule deer (*Odocoileus hemionus*) and white-tailed deer (*O. virginianus*). The park has both a prescribed fire program and, in the Sage Creek Wilderness area where prescribed fires have never been applied, a Wildland Fire Use policy (let wildfires burn if naturally started). The goals for the use of prescribed fires include facilitating resource management and research; simulating a natural ecological process; decreasing fuel load; and reducing potential for wildland fire damage of park resources, tribal interests, and adjacent lands. Prescribed fire resource management objectives generally focus on undesired plant species.

Since Euro-American colonization of the area in the latter half of the 1800's, much of the park was grazed by cattle until a fence was built and bison re-introduced in 1963-1964. At that time, 50 bison were brought from Theodore Roosevelt National Park and 2 from Fort Niobrara National Wildlife Refuge (Plumb and Sucec 2006). An additional 20 bison from Colorado National Monument were introduced to the park herd in 1983 (Dratch and Gogan 2010). Bison currently have access to approximately 84,000 acres (34,008 ha) of the park, much of this in designated wilderness. A current

management goal of the park is to maintain 500–700 bison, which was estimated to be about a third of the landscape's ecological carrying capacity when the geographical extent of the bison range was approximately 75% of its current size. Lacking predators and hunting, Badlands bison are managed by removing bison as the herd approaches or exceeds the population management goal; the bison that are removed have been distributed to the neighboring Oglala Sioux Tribe or to other Tribes through the InterTribal Buffalo Council (ITBC).

Tallgrass Prairie National Preserve

Tallgrass Prairie National Preserve (TAPR), established in 1996, is in southeast Kansas in the heart of the Flint Hills, the largest extent of tallgrass prairie left in North America. The 10,894-acre (4,411-ha) preserve is a public-private partnership under cooperative management with The Nature Conservancy (TNC). Portions of the preserve are leased to graze cattle, which are used as a prairie management tool and to represent the cattle ranching legacy of the area. The preserve exists within a private-lands landscape, and positive relationships with neighboring landowners are essential for carrying out management actions including managing bison and using prescribed fire. Bison were not specified in the park's enabling legislation but were reintroduced at NPS discretion in partnership with TNC. When appropriate, TNC employs bison as a conservation tool or conservation target. TNC aims to preserve unique bison species traits and to allow these native grazers to play as natural a role as possible in contemporary grassland systems.

The discretionary nature of the herd, as well as the role of TNC in ownership, management, and stewardship of the herd, permit greater management flexibility than at other IR5 parks. Bison from Wind Cave National Park (WICA) were reintroduced to the 1,100-acre (445-ha) Windmill Pasture, which supports up to 100 animals at a density determined using Natural Resources Conservation Service stocking rates in a strategy based on production grazing. TAPR and TNC are discussing the possibility of expanding the area available to bison in the next several years. The current bison herd is intensively managed compared to other IR5 parks, with regular captures and testing, vaccination, and random culling of young animals to maintain the health, 50:50 sex ratio, and genetic integrity (i.e., avoid cattle gene introgression) of the herd. TAPR is managed using an intensive patch-burning and rotational grazing system that mimics natural prairie disturbance regimes.

Theodore Roosevelt National Park

Theodore Roosevelt National Park (THRO) lies in western North Dakota. The 46,159-acre (18,688-ha) South Unit and 218-acre Elkhorn Ranch Unit were established in 1947 as Theodore Roosevelt National Memorial Park in honor of one of our country's most prominent conservation leaders. The 24,070-acre (9,745-ha) North Unit was added in 1948. In 1978, Congress redesignated the area as Theodore Roosevelt National Park and established the 29,920-acre (12,113-ha) Theodore Roosevelt Wilderness within the park's North and South Units. The 218-acre (88-ha) Elkhorn Ranch unit is maintained for its historical significance and will not be included in the Strategy. From 1934 to 1947 some of the area now in the park was managed for recreational purposes by state and federal agencies. Prior to this, most of the land was used extensively (and in some cases intensely) for cattle ranching.

The landscape is a complex mix of northern mixed-grass prairie, Little Missouri River Badlands, hardwood and juniper draws, and riparian floodplain vegetation (Von Loh et al. 2000). The Little Missouri River runs freely through both the North and South units, but it is shallow enough that most wildlife can freely cross it within the park boundaries. Intermittent tributaries to the river cross both the North and South units. Other large or major herbivores in the park include black-tailed prairie dogs, feral horses (South Unit), elk (*Cervus canadensis*; South Unit), bighorn sheep, pronghorn, mule deer, white-tailed deer, and a small herd (10 individuals) of longhorn cattle (North Unit). Since their reintroduction to the park in 1985, the target population of 100-400 elk was greatly exceeded in the late 2000's but is now maintained. The park has a wildland fire use policy and an active prescribed fire program; together, their goals are to improve ecological condition, reduce hazard fuels, and remove fuels adjacent to populated areas to protect lives and property.

Bison were reintroduced to the South and North Units in 1956 and 1962, respectively, and they have access to all areas in the fenced park (including campgrounds) except south of Interstate 94 in the South Unit and the facilities and housing area in the North Unit. The South Unit population was founded by 29 animals from the Fort Niobrara National Wildlife Refuge, and the North Unit population by 20 animals from the South Unit. In 2017, twelve bison were transferred from BADL to the North Unit, and researchers are studying the social interactions of these transplants with the resident herd. The park does not currently have a bison management plan, but population sizes in the North and South Units are targeted for 100-300 and 300-500 animals, respectively, based in part on a multi-species forage allocation model completed in 1993 (Westfall et al. 1993, Irby et al. 2002). Bison populations are managed through periodic removal; captured animals have been transferred primarily to Tribes, but also to states, zoos, other national parks, and other conservation herds.

Wind Cave National Park

WICA lies approximately 60 miles (100 km) southwest of BADL on the southeastern edge of South Dakota's Black Hills. It was established in 1903 to protect the park's namesake cave, which Lakota Tribes consider to be the origin of bison and their people. The park was initially 10,532 acres (4,264 ha) in size. Subsequent legislation altered the size and purpose of the park to include surface resources, including the 1912 establishment of the Wind Cave National Game Preserve within WICA's current boundaries. This legislation established the presence of bison, pronghorn, and elk in the park. In 1946, the park was expanded from 11,718 to 28,059 acres (4,744 to 11,360 ha) to maintain viable populations of big game animals. In 2011, the park expanded again, in part to eventually provide habitat for a larger bison population. The current size of the park is 33,847 acres (13,703 ha).

WICA lies on an ecotone from ponderosa pine (*Pinus ponderosa*) forest typical of the Black Hills to northern mixed-grass prairie typical of the surrounding plains (Cogan et al. 1999). The park was one of the first NPS units to develop an active prescribed fire program, which began in 1972 and continues today. This fire program is critical for maintaining healthy ponderosa pine and prairie systems and their balance on the landscape. Objectives of prescribed fires focus on reducing encroachment of ponderosa pine into grassland, reducing fuel loads in forested areas, and reducing non-native plant species. Three creeks enter the park from the west and north, but in most years these

creeks sink into the porous karst landscape after only a short stretch within the park. Natural springs, some of which have been altered by development, provide the only other sources of water for wildlife in the park. Riparian and other hydric vegetation occurs (or should occur) around these water features. Black-tailed prairie dogs and their associated vegetation type are an important feature of the park's landscape, and their colonies support a population of black-footed ferrets. Elk are the other major large herbivore in the park; their population has varied considerably, especially in recent years when various management actions have reduced it from at least 850 (in 2013) to approximately 235 animals in 2018.

The park's bison herd is descended from 14 animals donated by the New York Zoological Society in 1913 and six additional animals brought from Yellowstone National Park in 1916. The herd was first culled in 1923, and removal operations today are performed when necessary to maintain a population size of 350-500 animals, given a lack of predators and hunting within the park's fences. This size, together with an elk population of 350-400, was estimated to consume 25% of the park's forage production prior to the 5,556-acre (2,249-ha) park addition in 2011 (NPS 2006). Bison currently have access to nearly all the pre-2011 park, and planning is underway to expand their range into the property acquired in 2011. Bison removed from the herd have been transferred to Tribes, other conservation herds, state parks, and other national parks.

Bison Leadership Team

In 2013 the NPS Midwest Regional Office[1] and the superintendents of the parks described above established the Midwest Region Bison Leadership Team (BLT) to encourage collaborative decision-making among parks and to facilitate coordination with other NPS regions and with NPS national leadership. The BLT Vision Statement is:

> *In the 21st century, parks of the Midwest Region will collaborate with partners and stakeholders to conserve the genetic integrity of bison, manage bison as wildlife with minimal intervention by managers, and expand bison herds, including across land ownership boundaries, so that bison will once again be an ecological force on the Great Plains.*

The BLT promotes communication, cooperation, collaboration, and consistency regarding bison management in the IR5 parks. Voting members include the superintendents of BADL, WICA, THRO, and TAPR, and the Associate Regional Director for Natural Resources, or their delegates. Agate Fossil Beds National Monument and Scotts Bluff National Monument are non-voting members, and other parks in IR5 interested in restoring bison can also be non-voting members. Non-voting parks are promoted to voting members when their park restores bison. Park resource management program managers, wildlife biologists, or other staff may also be included in the BLT as appointed by their superintendents, and the BLT is currently considering expanding its non-voting

[1] We use the legacy (pre-August 31, 2019) names of administrative units here to adhere to the nomenclature when the BLT and its Vision Statement were established.

membership to include expertise from other NPS entities (e.g., a vegetation ecologist) and a representative of the InterTribal Buffalo Council. The Regional Office, usually represented by the Associate Regional Director for Natural Resources, has historically held a coordinating role for the group, with support from other staff from the Natural Resource Stewardship and Science (NRSS) program. The program manager of the Regional Office of American Indian Affairs serves as the BLT's principal liaison for and expert on NPS-Tribal relations.

Tribal Partners

Treaty obligations, Presidential Executive Orders, Secretarial Orders, and DOI policy compel NPS to consult with affected, federally recognized Tribes regarding Park actions. However, NPS IR5 goes further than these legal obligations in that it sees Native American Tribes as collaborative partners in the stewardship of bison. Historically, the National Park Service lands were the traditional homes of Native Americans and currently, as noted above, BADL shares land with the Oglala Lakota Nation on the Pine Ridge Indian Reservation. The individual park units have long-standing relationships with several Tribes in their areas, and the Strategy will not replace those relationships. As part of the Strategy, Tribes are an integral partner in the development of a long-range vision for bison on IR5 park lands.

Founded in 1990, the *InterTribal Buffalo Council* (ITBC) is a Federally-chartered Indian Organization under Section 17 of the Indian Reorganization Act (25 U.S.C. §5124). The membership of ITBC includes 67 Tribes, in 18 states, with a total of 55 bison herds. ITBC seeks to promote the social welfare of Native Americans and Native Alaskans by restoring bison to Indian lands to restore the cultural, spiritual, and traditional connections between buffalo and tribal people.

ITBC and many individual tribal governments have made significant efforts to build infrastructure and partnerships to support the expansion of bison across North America. Tribal lands account for 55 million acres (22 million ha) in North America, and ITBC membership accounts for 58% of that area; this represents a significant portion of land in the United States where bison are being restored. ITBC and their member Tribes work to restore the species to preserve their historical, cultural, traditional, and spiritual relationship for future generations.

ITBC is working with NPS to develop the Strategy, helping to represent its membership without diminishing the sovereign role of individual Tribes or NPS consultation obligations. ITBC has previously worked with NPS to transfer bison to Tribes and has developed detailed bison distribution policies. Distributing bison to Tribes prevents the unnecessary slaughter of IR5 bison and alleviates grazing pressure on park lands while simultaneously supporting a federal obligation to maintain treaty-secured access to bison for many Native American Tribes.

IR5 NPS Bison Stewardship Strategy Purpose and Need

Management of bison in IR5 parks has historically been specific to each park. Population goals were centered around park-level issues such as vegetation condition, visitor experience, and logistical issues, and livestock and range management science informed much of the decision making. In the past two decades, NPS has shifted its bison management from a livestock-based to a wildlife-oriented perspective, which focuses on ensuring their long-term adaptive potential and considering them as just one part of a complex ecosystem. This shift requires a more holistic approach to management—stewardship—that is challenging not only because of limitations in funding and fluctuations in leadership priorities, but also because of the constraints imposed by the parks' relatively small, fenced areas. Moreover, the BLT recognizes that single-park management is not sufficient for achieving its vision, which includes the common goals of maintaining genetic integrity, ecological processes, and natural behaviors, with humane and ethical treatment of bison at its foundation.

Parks and the BLT also recognize that bison stewardship in IR5 parks is necessary. In this region, bison are not accepted as wildlife allowed to roam freely across the landscape. Instead, various state and local statutes designate them as livestock that must be constrained. Thus, NPS units in IR5 must keep their bison herds fenced within their boundaries, thereby limiting park herds to whatever resources are available within the fence, isolating them from other herds, and likely modifying their wildness. Working together will allow the parks within IR5 to better address many of these challenges.

The Strategy will allow the BLT to identify and prioritize their objectives for bison and the natural and cultural landscapes of which bison are a part. These objectives transcend the boundaries of individual parks in IR5. An inclusive and thoughtful Strategy will provide guiding principles, not only for IR5's approach to bison stewardship in each park unit, but also for establishing and maintaining meaningful and consistent relationships with the full community of stakeholders. This includes providing consistent messaging in myriad outreach and educational activities to park visitors and other audiences. Tribal partners are central to these efforts, as the BLT, NPS IR5, and NPS national office support tribal connections to bison as well as their active leadership role in shared stewardship and management efforts.

Because park-level management can shift with changing leadership and public influence, a Strategy will consolidate decision-making processes across the BLT to focus on longer-term outcomes and acknowledge the collective leadership of the BLT. A longer-term Strategy will maintain stewardship focus on long-term desired future conditions for bison, their landscape, and their human and ecological communities. It is intended as a safeguard against decisions made for short-term convenience that could compromise long-term shared goals. A longer-term Strategy will also ensure the consideration of future scenarios, including climatic shifts and fluctuations, as well as the development and use of innovative approaches for tackling the most pressing stewardship and science needs.

Finally, a consolidated Strategy across IR5 parks will facilitate the efficient use of resources, including budget, staff, and time. Coordinating bison-related stewardship will enable parks to share

staff time and funds spent on contracting and financial assistance needs related to bison capture operations, infrastructure development and maintenance, and research. Enhanced communication through the Strategy will ensure that research projects can be designed to meet the information needs of all parks and that information delivery can be timed to coordinate with planning and decision-making schedules.

In summary, this decision framework was designed with the understanding that the purposes of the Strategy are (1) to more efficiently meet the stewardship and tribal trust responsibilities of parks through coordinated actions and consolidated resources, and (2) to expand and enhance NPS IR5's role in species-wide stewardship and management efforts.

Scope of the IR5 NPS Bison Stewardship Strategy

As an early step in the development of the decision framework, participants decided that the scope of the Strategy will be bison stewardship and related activities on IR5 parks over the next 25 to 50 years, but actions would be focused within the next 5 to 10 years. The long timeframe is particularly valuable for articulating long-term objectives, developing intermediate strategies that lead toward those aims, and anticipating the unfolding effects of climate change and other landscape drivers. By nesting short-term actions within a long-term vision, those actions will be better poised to strategically achieve the ultimate objectives.

The Strategy will provide a vision and guidance for collaborative stewardship of bison across parks, but it will not prescribe actions for individual parks; each park's superintendent will retain jurisdiction for deciding park-specific actions. When this document was written, only four parks within IR5 maintained bison herds; if other parks were to add bison herds in the future, NPS IR5 expects that those parks will also participate in cooperative stewardship under the Strategy.

The actions considered in developing this decision framework focus on bison in the context of the Great Plains ecological and sociological system, recognizing the limited jurisdictional boundaries of NPS parks. Direct bison management actions considered include capture and cull activities, health management, translocation, and genetic management. Management components that indirectly affect bison include invasive plant control, prescribed fire, fencing, and visitor access. Outreach actions include the development of interpretive materials, support of educational programs, and other activities that affect visitor experiences related to bison. Other considerations include how park staff will work with tribal partners, other federal and state agencies, as well as private partners to achieve the Strategy's objectives.

Objectives

The NPS IR5 vision is to manage bison as an integral component of their ecosystem, recognizing the roles that processes related to bison, fire, prairie dogs, climate, and weather play in shaping landscape pattern and, in turn, the role the landscape pattern plays in supporting bison (Knapp et al. 1999). The prairie ecosystems in which bison live are naturally dynamic in time and heterogeneous across space; this variability is a central characteristic that drives floral and faunal diversity (Vinton et al. 1993, Fuhlendorf and Engle 2001, Fuhlendorf et al. 2006). Thus, the NPS IR5 vision is that actions guided by the Strategy will maintain and enhance ecosystem functions within the bison-prairie system in IR5 parks. These ecosystems are also subject to anthropogenic forces like climate change and land conversion in the surrounding landscapes. Consequently, the NPS IR5 also envisions a Strategy that maximizes ecological resilience and adaptive capacity in the face of these anthropogenic threats while recognizing that managers need to prepare for situations in which accommodating or directing ecological change is necessary. The vitality and health of the bison herd itself is critical to achieve these goals.

In this section, we describe the fundamental objectives, performance metrics, and process objectives developed for the Strategy so far. *Fundamental objectives* are the long-term desired outcomes. *Means objectives* provide paths to achieve one or more fundamental objectives. *Performance metrics* are measures of the objectives that can be used to evaluate management alternatives and track progress. Setting performance measure thresholds (i.e., the value of a metric at which the objective is considered met) requires evaluating trade-offs among all the fundamental objectives and thus occurs later in the decision-making process. Likewise, management triggers are a component of the alternatives being evaluated and thus are not specified when developing performance metrics. *Process objectives* are objectives that relate to how the plan is developed and how it is carried out.

The objectives and performance metrics described below were developed by the BLT, in coordination with NPS staff and partners; they guide the development of specific management actions. It is expected that there will be trade-offs inherent in the fundamental objectives; that is, a focus on achieving one may work against achieving another. Explicitly stating these objectives and evaluating potential tradeoffs among fundamental objectives increases decision-making transparency as well as accountability for optimizing actions in keeping with park, regional, tribal, and community values.

The fundamental objectives use the terms “minimize” and “maximize.” These words describe the desired direction for each individual objective, all else being equal. When all fundamental objectives are considered together, trade-offs are often revealed because one objective cannot be maximized without impinging on another objective. Finding the right balance among objectives is one of the central challenges in developing the Strategy.

Fundamental Objectives

The fundamental objectives for the Strategy fall into four categories: (1) persistence of wild and healthy bison; (2) supporting tribal buffalo culture; (3) persistence of native ecological communities and processes; and (4) public outreach and education. For each of these categories, we describe specific fundamental objectives and associated performance metrics.

Persistence of Wild and Healthy Bison

These objectives center around the health, wildness, and well-being of bison herds in the parks, as well as the genetic integrity and adaptive potential of the species. One of the central concepts of this plan is to manage the bison herds in IR5 parks not as four or more separate herds, but as a meta-population that contributes to the long-term persistence and ecological restoration of bison in North America.

1. *Maximize the long-term persistence of bison in IR5 parks*
   The bison herds in the parks currently exhibit robust intrinsic rates of population growth, and such growth potential provides resilience that supports long-term persistence.

   Performance metric of the fundamental objective: (1) intrinsic bison population growth rate across IR5 parks.

   Because the intrinsic rate of growth is the population growth rate at low population density and in the absence of anthropogenic removals, this performance metric cannot be measured directly in the Strategy's management context. Two means objectives support the fundamental objective and their performance can be assessed as proxies for the fundamental objective.

   A. *Maximize demographic rates (survival and reproduction)*
      Maintenance of demographic rates that support a high intrinsic rate of growth involves limiting anthropogenic causes of mortality and providing high quality habitat to support reproduction.

      Performance metrics: (2) observed annual adult female mortality rate, not including mortality from removal; (3) observed annual total mortality, identified by cause; (4) observed annual number of calves per adult female.

   B. *Maximize herd health*
      Maximizing herd health contributes to the long-term persistence of bison, as poor health can affect survival and reproduction rates. One of the indicators of the health of a bison herd is its natural resistance to disease. The prevalence of disease is affected by the immunological health of the herd, population density relative to limiting resources, proximity to livestock, and vaccination and handling practices, among other factors. This objective therefore seeks to minimize the effects of non-native diseases on bison health and on the ability to move bison among herds.

      Performance metrics: (5) fraction of the herd that tests positive for antigens to a panel of diseases of concern; and (6) fraction of animals identified for translocation that test positive for diseases of concern.

2. *Maximize the long-term adaptive capacity of bison in North America*
   In the face of system change, bison also need to retain the adaptive capacity to respond to conditions that may be different in the future. Such adaptive capacity can arise from three mechanisms: dispersal; phenotypic plasticity in morphology and behavior; and evolution. Because all IR5 herds are fenced, dispersal can only occur through translocation; thus, the distribution of bison across varied landscapes in NPS IR5 and beyond reflects this aspect of adaptive capacity. Adaptation from existing phenotypic plasticity can be facilitated by retaining variability in morphology and behavior within and across herds. Finally, the potential for evolution is reflected in genetic diversity within the individual parks, among the parks, and collectively across all herds in North America.

   Performance metrics: (1) number and distribution of IR5 park bison supplied to conservation herds (which may include some tribal herds) in North America; (2) mean kinship of bison within each park (this is a measure of inbreeding, which we would like to minimize); (3) genetic diversity of bison across IR5 parks (specific measures need to be developed but would likely address heterozygosity, allelic diversity, and other metrics commonly reported for genetic studies); and (4) the number, size, and geographical distribution of conservation herds in North America.

3. *Maximize the wildness of the bison herds*
   One of the primary aims of the Strategy is to have bison functioning, behaving, and interacting with their environment like wild bison would have historically. There are three elements to this objective: minimizing cattle gene introgression; minimizing the constraints on and interventions with the bison herds; and maintaining wild behavior. In the absence of information as to how cattle gene introgression affects bison physiology or behavior, minimizing introgression reduces the probability of any effects manifesting in park bison herds. Wildness could also be lost through habituation or selection; both mechanisms of loss are to be avoided, but loss of wildness through selection is particularly contrary to the aims of the Strategy.

   Performance metrics: (1) degree of cattle gene introgression; (2) sex ratio; (3) various measures of natural behavior (such as sparring competitions during the breeding season, wallowing behavior, behaviors relating to predators) and domestic behavior (such as approaching or following vehicles or people); and (4) various measures of how often interventions are taken (e.g., number of times an animal is handled in its lifetime, frequency of supplemental feeding).

4. *Maximize humane treatment of bison, while allowing natural processes to occur*
   Bison occasionally become injured, both as a natural consequence of their lives and through interaction with humans (e.g., car collisions, capture operations). Parks will care for or cull animals that are injured through human interactions but will not intervene in cases where injuries are not directly associated with humans unless absolutely necessary. Minimizing any harm caused during handling is an important part of this objective.

Performance metric: 1) number of animals or proportion of herd injured during management activities; and 2) number of animals or proportion of herd culled following injury due to natural behavior.

Supporting Tribal Buffalo Culture

Native Americans in the Great Plains have a long and close relationship with bison. Bison provided food, clothing, tools, and shelter to native people for thousands of years and were the principal economy of those people. When bison were purposely driven nearly to extinction in the nineteenth century by European Americans, Native American culture and people were devastated. Today, Tribes seek to maintain and restore their cultural practices and strengthen their sovereignty by reconnecting with these sacred animals. As part of the Strategy, the NPS seeks to support Tribes in these aims.

5. *Improve relationships, trust, and communication with Tribes to enhance shared stewardship of bison within and beyond IR5*
   Many Tribes manage bison herds of their own and have expertise in bison stewardship, both in contemporary and historical capacities. Through individual Tribes and ITBC, parks can build relationships to foster the exchange of information and resources and develop a shared vision for bison stewardship.

   Performance metrics: Relationships and trust are difficult to measure. Proxy measures include (1) the number of IR5 NPS employees who are members of Native American Tribes; (2) the regular attendance of ITBC and individual Tribes at IR5 NPS bison-related meetings; (3) the regular attendance of IR5 NPS staff at tribal events and meetings; (4) early engagement of tribal entities on IR5 NPS planning processes; (5) regular operational communication between NPS IR5 and ITBC about bison activities; and (6) the regular inclusion of the NPS Regional Office of American Indian Affairs in bison-related meetings.

6. *Maximize the number of live, healthy bison that can be transferred to tribal herds*
   As noted above, many Tribes maintain bison herds and many others wish to establish such herds in an effort to strengthen their sovereignty, develop economic opportunities, restore their cultural practices, and provide a traditional, healthy, self-sustaining food source for their people. Because of the demographic success of NPS herds, animals need to be removed regularly to keep the herds from exceeding their desired population sizes in parks. By providing these animals to tribal partners, both tribal and park goals can be met. The intended recipients are recognized tribal entities, not individual tribal members.

   Performance metric: (1) the percentage of bison removed from IR5 parks that are transferred alive and healthy to recognized tribal entities per year.

Persistence of Native Ecological Communities and Processes

Historically, the three major factors shaping prairie ecosystems were climate, fire, and grazing (Axelrod 1985). Grazing and fire, alone and in concert, recycled nutrients and created variation in vegetation structure and composition through space and time (Fuhlendorf and Engle 2001). Furthermore, bison literally created landscape features through their wallowing (Knapp et al. 1999). The heterogeneity across the landscape created by these processes in turn supported biodiversity in plant, animal, and fungal communities. This set of objectives addresses the goal of achieving a sustainable but dynamic prairie ecosystem. Bison management is a crucial part of achieving this broader goal.

The objectives focus on communities and their components under the assumption that integrity of those communities is driven by integrity of the ecological processes; therefore, high-integrity communities are an indicator that the underlying ecological processes are functioning. These objectives focus on prairie communities because of their strong relationship with bison; this focus does not preclude the importance of forest and other vegetation types in these parks.

7. *Maximize structural and compositional heterogeneity of native prairie plant communities across space and time within each park*
   Within prairie communities, natural disturbance processes create heterogeneity in horizontal and vertical structure and in plant species composition. This heterogeneity provides a rich set of habitats to support biodiversity.

   Performance metrics: (1) dissimilarity index among 0.1 ha plots, as measured by the total number of native plant species in 10 1-m^2 subplots within a 0.1 ha area; (2) standard deviation of vegetation visual obstruction readings conducted across the entire park; (3) local and park-wide native graminoid richness; (4) local and park-wide native forb richness; (5) abundance of plant species of special concern (e.g., threatened and endangered species, species in a park's enabling legislation, species at risk of disease, vulnerable species and species assemblages as indicated by their state and global rarity ranks).

8. *Maximize the abundance and diversity of animal species of special concern*
   The native prairie ecosystem in IR5 parks hosts a diversity of insects, birds, amphibians, reptiles, and mammals that affect and are affected by, directly and indirectly, bison on the landscape. A prairie with high ecological integrity contains sustainable populations of a wide variety of species in each of these categories.

   Performance metrics: (1) richness and abundance of native grassland bird species; (2) abundance and diversity of native pollinators; (3) abundance of other animal species of special concern (e.g., groups with documented substantial decline in the region, keystone species, environmental engineers, threatened and endangered species, species in a park's enabling legislation, species at risk of disease, vulnerable species and species assemblages as indicated by their state and global rarity ranks).

9. *Minimize the loss of native grassland within each park*
   Tallgrass and mixed-grass prairies are characterized by their vast expanses, over which bison roamed freely. Minimizing the loss of grasslands dominated by native prairie plant species to development, woody encroachment, invasion, or other degrading processes is a central component of conserving and restoring the ecosystem in which bison historically thrived.

   Performance metrics: (1) proportion of each park occupied by native prairie vegetation types; (2) density of encroachment-prone woody species in areas managed to be grassland; and (3) spatial extent of bare ground in soil types expected to support vegetation.

10. *Minimize the abundance of exotic plants in the park landscape*
    Non-native plants have become established in park landscapes; some of those plants outcompete native vegetation, undermine ecosystem processes, reduce the habitat needed to support native biodiversity, and provide little forage to bison and other grazers. NPS has a policy to control exotic plants where it is prudent and feasible to do so. Minimizing exotic plants in the prairie ecosystems affected by bison management both supports ecosystem function and maintains native plant assemblages.

    Performance metrics: (1) relative abundance of exotic and native plant species in each park; and (2) area of each park occupied by target exotic plant species.

11. *Maximize riparian area and wetland integrity*
    Areas associated with surface water within the parks are rare and important habitats that both support bison and are affected by them. Bison need access to water sources throughout the year, but they can adversely impact the integrity of those systems through trampling and grazing.

    Performance metrics: (1) percent of riparian woody vegetation browsed, (2) stubble height, (3) degree of streambank alteration (hoof print density), and (4) plant species composition adjacent to streams, seeps, and springs; (5) water temperature, turbidity, and *E. coli* concentration, (5) aquatic macroinvertebrate composition, and (6) native fish species richness and abundance in natural surface waters.

Public Outreach and Education

As the national mammal, bison have cultural and historical significance for the public. People of all ages are interested in bison and other wildlife, as well as the management of national parks. Viewing healthy bison herds contributes substantially to the visitor experience at the parks participating in the Strategy. These objectives center around the experiential and educational outcomes for the public, as related to bison and their habitats.

12. *Maximize the number of healthy, wild bison that are visible to the public*
    Many visitors come to IR5 parks specifically to see bison roaming in natural habitat, without signs of management (like fences). The achievement of this objective is affected by several factors: the size of the bison herds; whether bison are using areas that are visible to visitors;

and possibly other factors. Human dimensions research may be useful to increase our understanding of the visitor experience.

Performance metrics: (1) the number of IR5 parks at which bison can be seen by the public; (2) the number of tribal herds in the area encompassed by IR5 that are visible to the public; (3) the area of land within IR5 parks that is accessible to the public and contains bison; (4) average number of bison sighted per hour by a visitor driving on park roads; and (5) average number of bison per day sighted by a visitor hiking park trails.

13. *Maximize the safety of visitors*
    Wild bison are potentially dangerous. Collisions with vehicles and interactions with people on foot pose a risk to visitors and to bison. The design and maintenance of roads and trails can affect these interactions.

    Performance metrics: (1) annual number of bison-related injuries to visitors; (2) annual number of bison-vehicle collisions; (3) annual number of citations for non-compliance with human-wildlife regulations.

14. *Maximize public understanding of the past, present, and future of bison and Native Americans in the Great Plains*
    The shared story of bison and Native Americans in the Great Plains exemplifies many important themes. These include the relationship between humans and the environment in which they live; the connection between genocide and ecocide; and the close connection between environmental stewardship and social justice. NPS and Tribes in the Great Plains can jointly help to tell this ongoing story to the larger public through bison management, interpretive programs, educational initiatives, literature, wayside exhibits, social media, and on-line resources.

    Performance metrics: (1) establishment and maintenance of a long-term partnership between NPS and Tribes in the Great Plains to co-develop and co-teach curricula related to bison; (2) number of initiatives and opportunities for public education about bison and Native Americans developed jointly by NPS and ITBC or individual Tribes; and (3) the number of people viewing bison-related materials and attending bison-related presentations per year.

Process and Strategic Objectives

The fundamental objectives above describe *what* the Strategy aims to achieve over time; the process and strategic objectives below describe other guiding principles about *how* to achieve its goals.

Collaboration and Efficiency

One of the primary motivations for developing the Strategy is to increase efficiency in bison management and interpretation. Resources are limited in IR5 parks, and strategic collaboration (e.g., sharing staff, equipment, funding, and other resources; capturing bison during different years in different parks) can lead to increased efficiencies. Wherever possible, parks will look for opportunities to share resources and streamline processes. Collaboration and efficiency can also be enhanced when clear performance metrics and coupled monitoring systems provide accountability.

Engaging Partners

NPS is just one of many organizations concerned with bison and their habitats in the region, and the bureau controls a limited portion of the land base available for managing bison. NPS manages its bison and its lands within a broad and diverse community and recognizes that improved efficiencies can be achieved through close coordination with other entities that are working towards shared objectives.

Engagement of partners occurs on at least three levels: (1) coordination with others who manage bison and their habitats (e.g., other DOI bureaus, U.S. Department of Agriculture, State agencies, non-governmental organizations, Tribes) to identify and work towards shared objectives at the landscape level; (2) cooperative relationships with entities who participate in bison management or stewardship activities on national parks (such as TNC at TAPR and the Oglala Sioux Tribe at BADL); and (3) cooperative relationships with researchers and other non-park staff who can provide technical services or conduct research to benefit national parks. A central guidance principle of the Strategy is that NPS IR5 will work to increase its engagement with partners to manage bison across the Great Plains.

Adaptive Management

Bison are part of a complex socio-ecological system; understanding of how management actions affect achievement of the fundamental objectives described above in this system is limited. The Strategy will embrace the basic tenets of adaptive management by including monitoring that evaluates whether objectives are achieved, and by forming and testing hypotheses of how to improve management when they are not. Later steps in the decision-making process will reveal key uncertainties; resolving those uncertainties will provide information critical for better future decisions.

Alternative Stewardship Strategies

The Strategy will specify how the parks, NPS IR5, and cooperating tribal entities will work together to manage bison populations, prairie ecosystems, and associated public outreach and education. Any strategy is composed of many smaller action elements packaged together in some sensible manner. To explore a range of possible strategies, we first compiled a set of action elements under consideration, then we created six exploratory combinations ("portfolios") of those action elements.

Action elements

The elements that could be a part of the Strategy include actions that 1) directly manage bison, 2) have an indirect effect on bison, 3) are aimed at developing partnerships, and 4) are aimed at public outreach and education. In the April 2019 workshop, we worked with the BLT and other experts to outline a broad range of possible actions under each of these categories.

Direct Bison Management Actions

Target density of bison

One of the major long-term decisions each Park makes is the target density of bison. At very low levels, bison have only minor effects on the vegetation and do not provide their key ecosystem function. Very low densities likely also imply small population sizes subject to associated genetic complications. At very high densities, bison might adversely impact vegetation, water, and other animals, and create logistical challenges such as bison escaping parks. As discussed below, the density of bison appears to be a key factor in the trade-offs among many of the fundamental objectives. Currently, bison density targets are set so that bison will consume about 0.33 of each park's average herbaceous annual net primary production. In this context, options considered in the workshop were:

- High density (steady): high vegetation utilization in most of the park. This might correspond to bison utilization of near 0.67 of average herbaceous annual net primary production.
- Medium density (steady): moderate vegetation utilization throughout the park, corresponding to a bison consumption range of 0.33 to 0.50 of average herbaceous annual net primary production.
- Low density (steady): under-utilizing the capacity of the park to support bison, corresponding to bison consumption of 0.25 of the average herbaceous annual net primary production.
- Variable density: less frequent removal of animals allows the density of bison to fluctuate over time.

Bison removal strategy

A second major action element that directly affects bison is removal of bison from park herds. Considerations include: the frequency of removal; the age and sex of the animals removed; the selection strategy for removals (random, systematic, kinship-based, behavioral-based); the capture method (helicopter, horse, passive method like using minerals or water as bait); and the variability of removals over time. The set of options considered in the workshop setting was:

- Annual removal of yearlings, using helicopters for capture

- Removal every fourth year of yearlings through 3.5-year-old animals
- Removal after dry years (on average every fourth year), using passive attractants (water)

Method of removal

The primary method to remove bison from parks has been live removal, through a process that involves collecting animals into a holding facility, then loading and transporting them live to recipients. Several other options could also be used. For the purposes of discussion, the following non-exhaustive set of options was considered:

- Live removals
- Lethal removal using skilled volunteers
- Tribal ceremonial hunts (i.e., allow associated Tribes to carry out lethal removals using practices they deem culturally appropriate and valuable)
- Primarily live removals, but also a small number of tribal ceremonial hunts

Distribution of live removals

When live bison are removed from park herds, the parks must decide where those animals go. There are several interested recipients and parks would like a method for determining how to distribute these animals when the demand exceeds the supply. A legal analysis may be needed to determine what options are suitable according to DOI and NPS policy, as well as under each Park's enabling legislation, so it was premature to identify the full set of allowable options during the workshop. The options below provide a sense of those that might be considered:

- Prioritize establishing herds in parks that don't have them now
- Other federal herds have the highest priority, followed by ITBC and Tribes, who have the first right of refusal, and finally requests from other entities
- Flexible distribution at the discretion of the superintendent or BLT

Genetic management

Components of actions to move genes among conservation herds (or not) and preserve specific genes include: (1) which herds are connected through genetic management and how transfers are selected; (2) methods for genetic transfer (live animals, artificial insemination, or embryo transplants); and (3) gene banking (preservation of germ cells or tissue). In the workshop setting, we considered a small, non-exhaustive set of options:

- Isolate herds to preserve lineages
- NPS IR5 metapopulation strategy. Here the focus would be on the genetic composition and connections among IR5 parks. The strategy would be to minimize inbreeding and optimize allelic diversity and heterozygosity within IR5 parks.
- Full North American metapopulation strategy. This approach would consider IR5 parks as part of the much larger North American bison metapopulation and would base gene movement decisions on the objectives and needs of the full metapopulation.

Method of augmentation

A park may wish to increase the size of its bison herd for reasons other than genetic management. In this context, there are essentially two options for augmenting bison herds within parks:

- Natural recruitment
- Natural recruitment plus translocation from elsewhere

Managing distribution of bison within the park

Park managers have some tools to influence the distribution of bison within the parks, which in turn can influence their effects on vegetation. In the workshop setting, the following options were considered:

- External fence only; no other deliberate management of movement
- Protect all sensitive resources (natural water sources, rare plants) from bison
- Water and salt blocks used to vary the area within the park where bison are concentrated (noting that there is some uncertainty about the effectiveness of this action)
- Use prescribed fire as the primary tool to influence bison distribution, and bison distribution is the primary influence in prescribed fire decisions
- Internal fencing, with water and salt supplementation, to move bison, with a focus on enhancing the visitor experience
- Internal fencing and heavily controlled grazing regime to achieve specific habitat goals
- Expand bison range within parks

Carcass disposal

When bison die in parks from natural causes, their carcasses provide resources for other animals, but the carcasses can also create undesirable situations, depending on their location. Two possible options for carcass disposal considered in the workshop were:

- Leave carcasses where found
- Actively move carcasses to enhance safe scavenging opportunities, visitor experience, and other objectives

Handling of injured and sick animals

Parks could take several approaches toward intervening when bison are injured or ill. We assumed that parks have and follow a set of best management practices that are documented elsewhere and did not otherwise explore options for this type of management.

Indirect Bison Management Actions

Management of other wildlife

Park enabling legislation, foundation statements, and other management plans require that decision making consider other species, and the general conservation status of other species may influence how much management emphasis parks put on bison versus these other species. Managers must

consider how these other animal species interact with bison, including as competitors, prey, or ecosystem engineers. The set of options for this emphasis considered in the workshop setting was:

- Prioritize bison over all other wildlife species
- Prioritize other herbivores (such as prairie dogs or elk) over bison
- Enhance the native herbivore community with those currently missing from the park, such as pronghorn at TAPR
- Manage bison primarily for their role as part of the ecosystem to create and maintain specific habitat types for other wildlife
- Introduce bison predators (such as wolves)

Vegetation management

Invasive species, fire suppression, altered grazing regimes, and a rapidly changing and highly variable climate are just some of the stressors that affect the composition and structure of native plant communities in IR5 parks. Chemical and mechanical treatment of noxious weeds and invasive species, planting native species, and prescribed fires targeting exotic grasses or native woody species are some of the management actions used to combat these stressors. Currently, none of the IR5 bison parks have vegetation management plans that guide and prioritize these actions. Moreover, resources currently dedicated to vegetation management are probably not enough to reduce exotic species abundance and woody encroachment into prairies, but they might be sufficient to "hold the line." The financial and staff resources needed for these actions compete with resources for other park priorities, but the management actions also generally improve forage quantity and quality for bison and other wildlife, as well as the visitor experience of the parks. Different degrees of emphasis on direct vegetation management considered in the workshop were:

- Minimize direct attention to vegetation management (reduce from current level)
- Maintain current practices and attention to vegetation management
- Maintain current resources for vegetation management but focus them on high-priority areas, with those priorities driven by visitor perception (e.g., greatest emphasis on high-visitor-use areas, noxious weed control, and showy wildflower displays)
- Maintain current resources for vegetation management but focus them on high-priority areas, with those priorities driven by ecology (ecological priorities to be determined)
- Greatly increase direct attention to vegetation so that the approach is active restoration park-wide

Visitor use of park back-country areas

Visitor use of park back-country areas (> 100 yards from roads) indirectly affects bison in many ways. Most obvious is the nature and frequency of direct encounters between bison and humans, and between bison and stock animals. More subtle effects include the likelihood of invasive plant species spreading into larger areas of a park, which could affect forage quality and quantity. Consequently, different levels of this use were considered:

- No restrictions
- Reduce or exclude equestrian use
- Reduce visitor use of the back-country, possibly by eliminating maintenance of developed trails
- Encourage back-country use

Actions Aimed at Developing Partnerships

Partnership Actions

Partnerships among parks and with other entities are critical to region-wide bison stewardship. Actions related to partnerships were generally considered synergistic with other objectives, having no clear tradeoffs with them. As such, participants identified a non-exclusive list of potential actions to support this objective.

- Create a 1-page briefing document about the draft Strategy to notify and obtain input from relevant people (e.g., ITBC, NPS, DOI)
- Develop an Environmental Assessment that describes the mechanics of the BLT, including Tribe involvement (e.g., establishing formal cooperator status for ITBC, updating BLT charter to include seat for ITBC) and consultation processes
- Review and continue with individual park Memoranda of Understanding (MOUs), and develop appropriate additional region-wide MOUs to formalize collaborations and mechanisms to move bison (e.g., an MOU between ITBC and BLT)
- Foster two-way exchange with tribal entities (defined as federally recognized Tribes and federally chartered Indian organization under Section 17 of Indian Reorganization Act) via forums for information sharing, involvement in relevant activities and meetings, and cross-training of staff
- Explore possibility of Tribes harvesting bison within parks for cultural and spiritual purposes
- Maintain ability to implement genetic-diversity transfers between parks, and between parks and tribal entities
- Explore alternative procedures for responding to requests from individual entities (NGOs, zoos, individual Tribes)

Actions Aimed at Public Outreach and Education

Public Outreach Actions

Participants identified a non-exclusive list of potential actions to support this objective. The abbreviated list of public outreach actions developed at the workshop was:

- Increase the number of park units in IR5 that have bison
- Expand bison lands that are accessible to the public (e.g., expanded bison range at BADL)

- Identify tribal herds that could be visible to the public, and increase the visibility of tribal herds or bison at other park units that don't currently have bison (as appropriate, and in consultation with Tribes)
- Increase safety messaging through additional signage, printed and verbal information distributed to visitors at entry, and positive (i.e., educational and non-punitive) engagement between visitors and law enforcement
- Standardize safety messaging across parks (e.g., >25 yd viewing distance)
- Synchronize and jointly develop educational programs and curricula with bison organizations (parks, Tribes, ITBC, zoos), leveraging existing material where possible
- Share information and educational materials through social media, evening programs, and printed materials

Alternative portfolios

Any proposed stewardship strategy can be viewed as a portfolio of the action elements listed above, and there are a vast number of ways that the action elements could be combined. For the purposes of exploration, we constructed six alternative portfolios, which can be viewed as six alternative sketches of the Strategy. We developed the exploratory portfolios by identifying six philosophical approaches to bison stewardship, each of which emphasizes some objectives over others. Breakout groups composed of members of the BLT and other experts with knowledge of NPS IR5 bison management and stewardship then identified the action elements that made sense under each of the philosophical themes. Groups often qualified the action elements described above or described entirely new action elements. The exploratory alternative portfolios are summarized in Table 1 and described in detail below.

Theme 1: Visitor Focus

This exploratory strategy's focus is managing bison and related natural resources to enhance the experience of visitors to the parks. One of the central ways to do this is to ensure that visitors can readily view bison engaging in several different behaviors. This strategy aims to maintain a moderate to high density of bison (at a level that would use about 50% of average herbaceous annual net primary production), with annual live removals that are visible to the public. Bison spatial use of a park would be managed through provision of water and salt licks but in ways that minimize visitors' perception of manipulation. Carcasses would be left where found, so visitors could see the natural processes of scavenging and decomposition, unless the carcasses or the associated processes pose a hazard to visitors, as might occur if they are in campgrounds, parking areas, or near a visitor center. Sick and injured animals would be rehabilitated or euthanized. Visitors want to see other wildlife as well, so bison stewardship in a manner compatible with other native wildlife would be pursued. Vegetation management would emphasize colorful, native vegetation in visitor high-use areas—for example, abundant wildflower displays near roads and visitor centers. Backcountry use of the park would be encouraged, with appropriate emphasis on safety of visitors. This strategy would invest heavily in public outreach and education.

Table 1. Summary of six exploratory alternative stewardship strategies constructed by participants in the April 2019 workshop. Each alternative is a full portfolio of action elements designed around a theme directed at a subset of the fundamental objectives. For each portfolio, the key or distinguishing component of each action element is listed.

Action element	Theme 1: Visitors	Theme 2: Genetics	Theme 3: ecosystems	Theme 4: Tribes	Theme 5: Flexibility	Theme 6: production
A. Herd density	medium	medium	variable	medium	low	medium
B. Removal strategy	regular and publicly visible	sex ratio- and kinship-sensitive annual removal of yearlings	variable to mimic natural processes	annual removal of 1-3.5-year-olds,	annual or biennial removal	annual removal of mostly male yearlings
C. Removal method	live removals and tribal hunts	primarily live removals, secondarily lethal	primarily natural processes (including tribal hunts); secondarily live removals	primarily live removals; secondarily tribal hunts	primarily live removals, secondarily lethal removals	live removals
D. Distribution of live bison from parks	no preference	priority is genetic conservation herds	if they must occur, to other federal herds and Tribes	top priority: federal herds; second: ITBC and Tribes; third: requests from other entities	flexible range of options with decisions at discretion of superintendent	no preference
E. Genetic management	no preference	focus on NPS IR5 metapopulation; include artificial insemination and gene banking	protect survival and enhance natural behaviors	include tribal herds as part of NPS IR5 metapopulation	full North American metapopulation strategy	full North American metapopulation strategy
F. Augmentation	other than ensuring visibility of calves, no preference	natural recruitment plus translocation from elsewhere	natural recruitment plus translocation from elsewhere	natural recruitment plus translocation from compatible tribal herds	natural recruitment plus translocation from elsewhere	natural recruitment only

Table 1 (continued). Summary of six exploratory alternative stewardship strategies constructed by participants in the April 2019 workshop. Each alternative is a full portfolio of action elements designed around a theme directed at a subset of the fundamental objectives. For each portfolio, the key or distinguishing component of each action element is listed.

Action element	Theme 1: Visitors	Theme 2: Genetics	Theme 3: ecosystems	Theme 4: Tribes	Theme 5: Flexibility	Theme 6: production
G. Methods for distributing bison within parks	water and salt blocks to vary area of concentration	fencing to protect developed areas and sensitive resources; provide water in upland sites	fencing and lures to protect sensitive resources and fire to encourage bison movement	base on traditional ecological knowledge	primarily external fence, with ability to use water to vary areas of concentration	external fence only
H. Carcass disposal	leave where found unless a clear safety concern	actively remove carcasses from public view	leave where found except if near roadways	distribute carcasses to Tribes	situation- and park-specific decision	actively remove carcasses from public view
I. Handling of injured and sick animals	euthanasia, rehabilitation, or rescue	standard best management practices (BMP)	standard BMP	standard BMP and tribal BMP	standard BMP, including euthanasia	standard BMP
J. Management of other wildlife	use bison as a tool to facilitate other wildlife	prioritize bison	bison as part of complete (including predators) ecosystem	use bison as a tool to facilitate other wildlife, including predators	use bison to facilitate other wildlife but bison with slightly higher priority than others	prioritize bison
K. Vegetation management	good wildflower displays in visitor high-use areas	active restoration	active restoration, with high priority areas set by ecological needs	active restoration	current practices and attention	active restoration, plus potential for supplemental feeding
L. Public use	facilitate and encourage back-country use	limit back-country use and exclude all equestrian use	limit or exclude back-country use	emphasize special use by tribes	no restrictions	limit back-country use

Table 1 (continued). Summary of six exploratory alternative stewardship strategies constructed by participants in the April 2019 workshop. Each alternative is a full portfolio of action elements designed around a theme directed at a subset of the fundamental objectives. For each portfolio, the key or distinguishing component of each action element is listed.

Action element	Theme 1: Visitors	Theme 2: Genetics	Theme 3: ecosystems	Theme 4: Tribes	Theme 5: Flexibility	Theme 6: production
M. Partnerships	maximize number of partners	partner to support adaptive resilience	partner with prairie preservation groups and Tribes	all suggested actions	establish MOU between parks and ITBC; explore possibility of cultural/spiritual hunts; maintain current flexibility in distributing live bison from parks	create MOUs and agreements to make transfer of animals easy
N. Public outreach	all suggested actions	aggressive outreach to explain genetics focus	emphasize bison as part of the whole; increase educational interactions	in addition to all suggested actions, work with tribal councils, schools, colleges and universities and multi-tribe organizations	do what we can and take advantage of opportunities	improve visitor safety, increase number of parks with bison, increase visibility of bison on tribal lands

Theme 2: Genetics Management

This exploratory strategy focuses on the contribution of bison herds in IR5 parks to the genetic management of the North American bison metapopulation. To this end, it is important to maintain the largest number of bison possible at the parks (representing use of about 50% of average herbaceous annual net primary production) in order to minimize genetic drift and to provide a large number of animals available for movement to other conservation herds. Annual removal of live animals would focus on yearlings in an even sex ratio, with retention of a representative genetic sample in the individual park herds. Genetic management would occur through transfer of live animals among parks, transfer of genetic material (via artificial insemination), and comprehensive gene banking. The primary purpose of live removals would be to provide genetic stock to maintain and enhance the genetic composition of IR5 NPS herds collectively, with contributions to and augmentation from the larger North American metapopulation. Animals removed that are not needed for genetic management would be available for distribution to Tribes for other purposes. Active restoration of native prairie vegetation would help support the bison herd and provide a natural ecosystem. A wide set of partnerships would be developed to support genetic management and adaptive resilience across the landscape, and public outreach would focus on the importance of genetic management.

Theme 3: Native Prairie Ecosystem

Under this exploratory strategy, the focus is on managing an intact and naturally functioning grassland ecosystem, with bison as a critical part of that ecosystem but with no higher priority than any other component. This would entail allowing variability in bison herd density in each park through time in order to restore temporal variability in grazing intensity on vegetation, as well as natural selection processes on bison that are currently lacking (density-dependent social behaviors, predator avoidance, etc.). When and how many bison are removed would be determined by climate, prairie condition, and other ecosystem metrics; the methods for removing them would be by predation (by humans and other animals) and other natural causes of mortality when possible, or by means that closely mimic those processes when those are insufficient for achieving other ecosystem objectives. This would be reinforced by the focus of any management of genetic composition that does occur being the retention of natural behaviors. Recognizing the constraints that fire suppression outside the park and confinement of animals place on many natural processes, an active, adaptive approach to distribute bison within each park would use fire to encourage bison to graze in manager-identified areas of the park each year, and sensitive resources would be protected from over-use by fencing, alternative water sources, and mineral lures. The area available to bison within IR5 would be maximized by expanding bison ranges in current bison parks and establishing bison herds in IR5 parks without them. Greater emphasis on actively restoring native vegetation would occur than currently, with priority for the resources spent on that emphasis being determined by ecological needs. Public outreach and partnerships would focus on telling and achieving the whole ecosystem story.

Theme 4: Tribal Collaboration

Under this exploratory strategy, the primary focus is on engaging and partnering with Tribes and tribal organizations in stewarding bison and supporting Tribal buffalo culture in IR5. Partnerships and relationships (both formal and informal) between a range of tribal entities and NPS are foundational to the strategy. These relationships would facilitate special use of bison by tribal entities, including ceremonial hunts by Tribes, the distribution of bison carcasses to Tribes, and increasing opportunities for tribal entities to receive available bison through first right-of-refusal and individual requests. At the same time, tribal entities would also contribute to NPS herds and their genetic management through transfers and translocations with compatible tribal herds, and parks would incorporate traditional ecological knowledge and tribal best-management practices into their management approaches. To support a robust bison metapopulation and transfers to tribal entities, a moderate density of bison would be maintained in IR5 parks, but active restoration of vegetation and the facilitation of other wildlife (including predators) would also be important.

Theme 5: Individual Park Flexibility

This exploratory strategy focuses on providing individual parks flexibility in their bison stewardship decision-making. Bison would be maintained at a low density and would be removed from the park using a variety of capture methods for live animals and some lethal removal every one or two years. Distribution of live animals could be to any entity allowed by NPS policy and would be at the discretion of each park's superintendent, and parks could accept bison from other appropriate herds. Treatment of injured or sick bison and carcasses of dead bison would also be largely at the park's discretion. Any management for genetic concerns would follow a full North American metapopulation strategy. Bison would have a slight emphasis over other wildlife species in management decisions, though they could be managed to enhance habitat for those species. Vegetation management would follow current practices, and public outreach would be opportunistic. Additional partnerships would be explored but would not be entered if they reduced each park's flexibility in deciding how to distribute its bison.

Theme 6: Bison Production

The primary objective of this exploratory strategy is to maximize the production of bison. Bison available for transfer at each park would be used to start new conservation herds, provide bison to Tribes, or contribute to genetic management of the bison metapopulation. To maximize bison production, bison habitat in each park would be improved, restored, or created to increase its carrying capacity. Bison density would be managed continuously at half of the carrying capacity to maximize reproduction. In addition, park bison herds would be managed (via animals selected for live removal) to increase the number of reproductive-aged females. Establishment of new bison herds would also be prioritized to further increase production. Capture activities would be increased to remove the larger number of animals produced each year. The increase in capture activities would require additional resources and reduce visitor access to the park.

Consequence Analysis

The previous sections of this report describe the desired outcomes of stewardship and management (the fundamental objectives) and several ways in which those outcomes could be pursued (the alternative strategies). A full scientific evaluation of those alternatives would consider how well each strategy would achieve each of the fundamental objectives. Such evaluation might occur through a variety of methods, including quantitative models derived from empirical evidence, expert judgment, or a combination thereof. When multiple objectives are involved, a consequence table is often used to summarize the relative strengths and weaknesses of each alternative with respect to each of the multiple objectives. Such a consequence table is the primary scientific input, but, because the table rarely yields a unique optimal solution, the decision makers must then examine and manage trade-offs among the objectives after considering the relative value they place on each objective. The tools of multi-criteria decision analysis (MCDA) can provide support for decision makers at this stage (Keeney and Raiffa 1976).

The workshops conducted to support the development of this report were not structured to include evaluation of the alternative strategies, so a consequence table was not completed. After the workshops, to illustrate how analysis could proceed, we developed an example of a consequence table for the Strategy (Table 2). Four of the authors of this report scored each alternative against each fundamental objective, based on their interpretation and synthesis of the information shared in the two workshops, using the following coarse scale. A score of 1 indicated that the strategy in question would perform very well on the objective relative to all possible, reasonable strategies; a score of 0 indicated the strategy would perform moderately, in the middle of the range of alternatives; and a score of -1 indicated the strategy would perform very poorly on this objective. Where necessary, intermediate scores of 0.5 and -0.5 were used. We averaged the scores across the four authors to generate the values in Table 2 as an example of how this process may be helpful in considering various stewardship strategies. Such scores would inevitably vary with different or additional inputs from managers, subject matter experts, and analyses.

The placeholder values in Table 2 demonstrate patterns that are typical in multiple-objective decision problems. First, there is no alternative that performs best on all the objectives. For example, while Theme 3 (Ecosystem Focus) performs best of the six alternatives on all the ecosystem objectives, it performs poorly on the public outreach and tribal transfer objectives. Second, achieving high performance on some objectives comes with steep costs on other objectives. Themes 1, 2, 3, and 6 all perform well on a small subset of objectives related to their respective themes but fare more poorly on other objectives. Third, there are strategies that balance a wide set of objectives and are neither best nor worst on many objectives. For example, themes 4 (Tribes) and 5 (Flexibility) do reasonably well on most objectives and avoid high costs on any objectives. Fourth, some objectives are relatively easy to achieve (i.e., all strategies perform well). For example, in our demonstration analysis, Objective 1 (bison persistence) had a high chance of success in all strategies. In summary, these patterns illustrate that the design and choice of a stewardship strategy will surely involve trade-offs among the fundamental objectives. Navigating these trade-offs is the central challenge that decision makers face, and SDM provides the tools to comprehensively evaluate the options.

Table 2. Demonstration consequence table with placeholder entries. The structure of the table reveals an assessment task—the need to evaluate each alternative strategy against each fundamental objective. The entries in the table show the kinds of patterns that can result from such an evaluation. Shading ranges from deep blue, indicating poor performance of a strategy (column) on a fundamental objective (row), to bright yellow, indicating strong performance of a strategy on an objective.*

Category	Fundamental Objective	Theme 1: Visitors	Theme 2: Genetics	Theme 3: Ecosystems	Theme 4: Tribes	Theme 5: Flexibility	Theme 6: Production
Wild and Healthy Bison	1. Bison persistence in IR5	0.875	1	1	1	0.875	0.75
	2. Adaptive capacity in North America	-0.125	1	0.375	0.375	0.75	0.125
	3. Wildness	-0.5	0.125	1	0.125	0.125	-0.875
	4. Humane treatment	0.5	0.5	0.625	0.875	0.875	0.375
Tribal Buffalo Culture	5. Shared stewardship	0.25	0.125	0.5	1	0.125	0.375
	6. Transfers to Tribes	0.625	-0.125	0	1	0.25	1
Ecological Communities and Processes	7. Landscape heterogeneity and diversity	-0.375	0.25	1	0.375	-0.125	-0.125
	8. Animal species of special concern	0.375	-0.5	1	0.5	0	-0.75
	9. Native grassland loss	-0.375	0.375	1	0.625	0	0.375
	10. Exotic plants	-0.125	0.75	1	0.25	-0.125	-0.25
	11. Riparian and wetland areas	0	0.375	0.625	0.125	0.5	-0.375
Public Outreach	12. Bison visibility to public	1	0	-0.375	0.125	0.375	0.625
	13. Visitor safety	0.125	0.375	-0.125	0.125	0.625	-0.375
	14. Public understanding of past, present, future of bison and Native Americans	0.5	0.125	0.625	1	0	0

* Cell shading color saturation ranges from dark yellow (rating = 1.0, strong performance) to light yellow (rating = 0.125) and from light blue (rating = -0.125) to dark blue (rating = -1.0, poor performance). The larger the number, the stronger the strategy's performance.

The participants at the workshops did discuss some potential trade-offs among the exploratory alternative strategies. One discussion considered whether an emphasis on genetic management—perhaps even for the benefit of the North American metapopulation of bison—creates any tension with other objectives. For instance, under Theme 2 (Genetics), would fewer animals be available for transfer to Tribes? Would there be any unintended risks, like transmission of disease? As constructed, and as tentatively evaluated, it does appear that Theme 2 carries some trade-offs with transferring animals to Tribes, bison visibility to the public, and other high-priority animal species, but it is possible that these effects could be mitigated by modifying the strategy. Furthermore, current analysis of DOI bison herds (Hartway et al., in prep.) shows that even aggressive genetic management does not require movement of many animals per year.

Another discussion considered whether the objective to maintain the wildness of bison involves trade-offs with other objectives. A high degree of handling (as in most of the alternatives in Table 2, and particularly Theme 6) can habituate bison to interactions with humans and possibly even select for more docile animals.

A third discussion, initiated at the workshop and continued in a subsequent group call with a subset of workshop participants, highlighted a trade-off not addressed in Table 2 and the fundamental objectives behind it. This trade-off concerned the effects of increasing bison density on IR5 parks. Historically, bison densities in all IR5 parks except TAPR have been kept at low levels relative to forage production to reduce visitor safety concerns, bison escapes from parks, and costs involved with gathering and processing bison for removal. Further, many parks have assumed that higher bison densities risk diminished bison health in drought years or following widespread wildfire because parks lack adequate staff and other resources to adjust densities quickly (within a year) in response to such events. Finally, a strong concern, especially at BADL and WICA, is that water, not forage, limits the bison capacity of a park; the degraded vegetation condition observed around some water sources in these parks provides evidence of this limitation. However, some evidence suggests that low bison density results in degraded vegetation condition away from water resources (i.e., the widespread prairie) (Miller et al. 2017). Some of these potential tradeoffs are captured in Table 2, but some are not.

Summary and Next Steps

As a keystone species (Knapp et al. 1999) and an important tribal resource, bison management affects the health and genetic integrity of park herds, the ongoing recovery of the species, multiple aspects of grassland ecological function, and NPS relationships with Tribes and other partners. Bison are also a key component of the visitor experience and an opportunity for outreach, interpretation, and education. Several management actions and decisions, such as herd age and sex structures and genetic composition, affect only bison, but others, such as bison herd size and prescribed fire and invasive plant control practices, affect the broader park ecosystem. While many studies have been completed and others are underway, NPS IR5 needs a way to consolidate existing and incoming information to strategically align park actions with desired park and regional outcomes.

Thus, the decision framing developed by IR5 park managers and subject matter experts described in this report includes objectives relating specifically to bison but also to Tribal buffalo culture, ecological communities and processes, and public outreach. The intent of the Strategy is to provide resource managers and park superintendents support and guidance for their short- and long-term management decisions, to increase transparency and consistency in bison stewardship across parks, and improve park accountability in achieving ecological, cultural, and bison stewardship goals across the region.

The decision structure described above—the management context, the fundamental objectives, and the alternative stewardship strategies—shows the nature of the decision faced by NPS IR5, the BLT, and the individual parks. Parks can undertake a wide range and combination of activities with regard to bison stewardship to help NPS IR5, the parks, and their partners achieve a substantial number of objectives. A consequence table (Table 2) can be used to illustrate this structure, and the structure itself raises two important points: (1) filling out the table is an important assessment task; and (2) there are likely to be trade-offs among the objectives.

Assessment Steps

Evaluating alternative stewardship strategies against fundamental objectives (desired outcomes) is the central scientific evaluation task for the decisions faced regarding NPS IR5 bison stewardship. An evaluation like this will require input from experts in bison population dynamics, conservation genetics, prairie ecosystem science, and social science, as well as input from Tribes. Such an evaluation can occur in several ways. Where data are available, quantitative assessment of the alternatives can be undertaken using predictive models built on statistical evidence. Where data are not readily available, the alternatives can be evaluated using a formal expert judgment process, which can still produce quantitative estimates of the consequences. At the very least, the alternatives can be evaluated via a compilation and interpretation of scientific literature.

The first step in a more detailed assessment process will be to review, and possibly revise, the performance metrics described above. Performance metrics provide the operational interpretation of the fundamental objectives and often reveal important subtleties in their meaning. Ideally, performance metrics directly measure the fundamental objective itself, not an associated means

objective or a proxy of the fundamental objective. Furthermore, the performance metrics need to be specific enough for objective evaluation of their response under each alternative strategy.

The second step in a more detailed assessment process will be to determine which considerations are important to embed in the analysis. A deeper evaluation of strategies might require a more careful consideration of complex ecological dynamics, such as species and ecosystem responses to climate change. The BLT could consider whether the fundamental objectives identified in this process may benefit from a "climate smart" review (Stein et al. 2014) to better ensure the long-term vision and goals have relevance and longevity in light of uncertain future conditions. Alternative portfolios of actions could also be evaluated considering a non-stationary climate to avoid choosing a seemingly advantageous portfolio of actions that may perform poorly under novel climate conditions. For instance, an alternative that emphasizes bison production that is deemed sustainable under current conditions could be perilous under a hot and dry future if forage or water becomes scarce. Ecosystem modeling could be used to evaluate such climate and management scenarios (e.g., Miller et al. 2017).

Note that the process we used to develop values in Table 2 resembled an expert judgment process; it was not meant to be definitive, only demonstrative. A proper expert judgement process would follow best practices that avoid dynamics known to result in bias and overconfidence by such panels (Hanea et al. 2017). The steps in a robust expert judgment process are (1) careful and deliberate selection of experts; (2) training of the experts in sources of bias and methods to overcome them; (3) review and development of performance metrics to reduce linguistic uncertainty; (4) initial scoring of alternatives against objectives by individual experts, using a four-point elicitation method (Speirs-Bridge et al. 2010); (5) group discussion of initial results to identify insights as well as inconsistencies in interpretation; (6) a second round of scoring by individual experts; and (7) aggregation of results. The results of such a process would include point estimates of the performance of each alternative against each objective, as well as intervals that captured the uncertainty expressed by the experts.

The alternatives could instead be evaluated quantitatively against the objectives by developing predictive models that integrate the best available information. Such models would need to take all the relevant elements of a strategy as input and forecast the outcomes in terms of the performance metrics. For some of the fundamental objectives, existing models could be modified to this purpose, but for many of the objectives, new models would need to be developed based on the available literature and data. Whether through expert judgment or models, a consequence table could summarize the predicted outcomes associated with each objective, for each alternative strategy. Such a consequence table, like the example in Table 2, could then serve as the core scientific summary that leads to the deliberative steps.

Deliberative Steps

In multiple-objective settings, choosing a preferred alternative often involves evaluating trade-offs and sacrificing performance on some objectives. The balance among those objectives is an expression of the values of the decision makers, and such value judgments are often difficult to make. MCDA and other methods in the field of decision analysis can help decision makers and

stakeholders explore their underlying values and identify a preferred alternative (Keeney and Raiffa 1976).

A deliberate approach to considering multiple objectives, as the structure described in this report allows, is important for avoiding a few pitfalls in decision making. Sometimes, by focusing on a narrow set of objectives or considering only a small set of alternatives, decision makers will ignore important trade-offs and not realize what they are giving up. For example, if the parks focused solely on bison persistence and adaptation, they might not consider the potential effects of bison management on other components of the ecosystem and thus not have the chance to consider how they want to balance those trade-offs. On the other hand, sometimes decision makers will avoid promising strategies because they think there are trade-offs that cannot be mitigated. In these cases, a structured approach allows decision makers to ask whether the trade-offs are real or only perceived.

The decision structure captured in Table 2 is an initial prototype and requires revision. Many other alternative portfolios could be created from action elements not included in the workshop exercise that produced the lists presented here. Objectives might also be missing. One objective suggested in the discussion of trade-offs at the second workshop was to minimize various logistical management challenges (e.g., escaped bison, difficult captures). These challenges, as well as some other trade-offs discussed in the workshop and illustrated in Table 2, could be ameliorated if the parks dedicated more resources to address them. This illustrates that the current list of objectives lacks one that speaks to the staff and budget limitations on the parks, NPS IR5, and their tribal partners. The groups who crafted the six exploratory alternatives may have implicitly created options that could be implemented with available resources, but that limitation was not explicitly stated. If such limits do affect choices, the decision makers would need to weigh whether the increased costs were offset by the benefits achieved. A row representing cost or other limiting resources could be added to Table 2 to achieve this.

Path Forward

In summary, this report describes the underlying decision context for the development of an IR5 NPS bison stewardship strategy, identifies fundamental objectives that NPS IR5, parks, and stakeholders hope to achieve through a long-term stewardship strategy, and provides a set of potential alternative strategies that may span the range of approaches NPS IR5 and its partners could take.

Following the workshops that provided the content of this document and participant review of the document, we provided the BLT with three possible paths forward.

- Path 1: the BLT, NPS IR5, and their partners may find that the information in this report provides enough insight about the underlying decision problem to allow them to move forward in developing a preferred alternative, suggesting that they know how to evaluate and manage the trade-offs presented here and that may arise as they go forward into the planning process.
- Path 2: the decision makers and stakeholders might want a detailed evaluation of the alternatives in this report, either through quantitative analysis, expert judgment, or a

combination of both, before proceeding to systematic consideration of the trade-offs that would be integrated into developing alternatives for the planning process.

- Path 3: the decision makers and stakeholders might decide that important elements of the decision context are not captured by the prototype in this report, requiring them to return to the appropriate stage of this analysis and revise key components of the decision structure before proceeding further.

The BLT decided that further refinement of the decision framework is needed. Specifically, they will finalize objectives and use insights from the alternatives described above to develop a more realistic set. They will also determine which approach (quantitative modeling, expert judgement, literature summary) they will use to evaluate the new alternatives considered for the final Strategy.

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Appendix A

Table A-1. List of people who participated in at least part of one of the two workshops. Affiliations follow the administrative nomenclature at the time of the workshops.

Participant	Title	Affiliation	Workshop 1	Workshop 2
Mike Pflaum	Superintendent	Badlands National Park	x	x
Eddie Childers	Wildlife Biologist and Acting Resource Management Program Manager	Badlands National Park	x	x
Kristen Hase	Natural Resource Program Manager and Acting Superintendent	Tallgrass Prairie National Preserve	x	x
Wendy Ross	Superintendent	Theodore Roosevelt National Park	x	x
Blake McCann	Resource Management Program Manager	Theodore Roosevelt National Park	x	x
Vidal Davila	Superintendent	Wind Cave National Park	x	x
Greg Schroeder	Resource Management Program Manager	Wind Cave National Park	x	x
Angela Jarding	Wildlife Biologist	Wind Cave National Park	x	x
Scott Blackburn	Environmental Coordinator / NEPA Lead	Midwest Region	x	–
Bob Bryson	Associate Regional Director, Cultural & Natural Resources	Midwest Region	x	x
Dan Licht	Wildlife Biologist	Midwest Region	x	x
Reed Robinson	Tribal Relations Indian Affairs Manager	Midwest Region	x	x
Isabel Ashton	Plant Ecologist	Northern Great Plains Inventory & Monitoring Network	x	x
Kara Paintner-Green	Coordinator	Northern Great Plains Inventory & Monitoring Network	–	x
Sherry Leis	Plant Ecologist	Heartland Inventory & Monitoring Network	–	x

Participant	Title	Affiliation	Workshop 1	Workshop 2
Greg Eckert	Restoration Ecologist	Biological Resources Division, Washington Office	x	–
Amanda Hardy	Wildlife Biologist	Biological Resources Division, Washington Office	x	–
Tracy Thompson	Veterinary Medical Officer	Biological Resources Division, Washington Office	–	x
Brendan Moynahan	Research Coordinator	Rocky Mountains Cooperative Ecosystem Studies Unit, Intermountain Region	x	x
Gregor Schuurman	Climate Change Adaptation Specialist	Climate Change Response Program, Washington Office	x	–
Arnell Abold	Executive Director	InterTribal Buffalo Council	x	x
Megan Davenport	Wildlife Biologist	InterTribal Buffalo Council	–	x
Zintkala Eiring	Technical Service Provider	InterTribal Buffalo Council	–	x
Eric Selchert	Technical Service Provider	InterTribal Buffalo Council	–	x
Dan Wenner	Legal counsel	InterTribal Buffalo Council	x	x
Paula Matile	Conservation Specialist	The Nature Conservancy in Kansas	–	x
Glen Sargeant	Research Wildlife Biologist	USGS Northern Prairie Wildlife Research Center	–	x
Tanya Shenk	Ecologist/Research Coordinator	Great Plains Cooperative Ecosystem Studies Unit, Midwest Region	x	x
Nicole Athearn	Research Coordinator	Great Rivers Cooperative Ecosystem Studies Unit, Midwest Region	x	–
Paula Capece	Ecologist/Data Manager	Southeast Coast Inventory & Monitoring Network	x	–
Brian Miller	Research Ecologist	USGS North Central Climate Adaptation Science Center	x	x

Participant	Title	Affiliation	Workshop 1	Workshop 2
Amy Symstad	Research Ecologist	USGS Northern Prairie Wildlife Research Center	x	x
Mike Runge	Research Ecologist	USGS Patuxent Wildlife Research Center	x	x

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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