Arizona Bison Management Plan

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Approved:

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ARIZONA BISON MANAGEMENT PLAN

I. PURPOSE OF THE PLAN

A. General

This document provides strategic direction for statewide management of bison in Arizona. The Arizona Game and Fish Department (Department) adaptively manages bison and their habitat to provide maximum and diverse recreational opportunities while avoiding adverse impacts to the habitat. Bison represent a sustainable resource for hunting and public wildlife viewing, while providing intrinsic value to the public and economic benefit to northern Arizona communities. Arizona's bison are classified as native wildlife and as a big game mammal according of A.R.S 17-101. Their status as free ranging state-managed herds on public land is a rare condition nationally. Bison were reintroduced to Arizona in 1906 and have been on the landscape continuously since. There have been three public Department managed bison herds over the years: the House Rock bison herd, the Raymond bison herd and a herd on Fort Huachuca, which no longer exists.

Arizona's wildlife resources demand prudent and increasingly intensive management to accommodate numerous and varied public demands and growing impacts from people such as habitat loss and fragmentation. Add bison's natural instinct to roam, their large size, and management issues intensify. This action plan includes the history of Arizona's bison, their current status, bison range, issues and concerns, and management goals, objectives, and strategies to guide management of bison into the future. This plan is intended to guide managers and biologists, and also aid in the decision-making process of the Department and the Arizona Game and Fish Commission.

The implementation of this plan will allow for the management of two distinct bison lineages to be managed in Arizona. These bison represent important narratives relating to the near extirpation and recovery of this iconic American species.

B. Dates

This statewide bison plan is not an annual implementation document, but rather a 10 year plan in effect from the listed date. It will be reviewed and updated as management strategies are implemented, priorities met, or new management techniques become available and implemented.

II. HISTORY

A. Nationally

The American bison, consisting of both Plains and Wood bison, is an icon of wildlife conservation in North America. It is one of the first species to rise to national attention and be saved from the verge of extinction. The near extirpation occurred largely due to unregulated market hunting to supply leather for worldwide markets, subdue threats posed by Native Americans during westward expansion, clear railroad lines of bison to speed transit, and unregulated take during a time when bison numbers were thought to be limitless. American bison were reduced from tens of millions at the time of European colonization to an estimate of less than 1,000 remaining bison in North America by the late 1800s (Hornaday 1889; Seton 1927). Wood bison were thought to have dropped as low as 250 animals of the estimated 1,000 remaining bison. There was some sentiment in the late 1800s to halt the destruction of bison, but laws to protect them came with no enforcement and were not enacted until near extirpation. The only remaining wild Plains bison herd not in

captivity was in Pelican Valley in Yellowstone National Park (Danz 1997; Meagher 1973), with an official estimated count of 25 bison.

Plains bison were saved from extinction by the independent actions of a few private citizens, many of who witnessed firsthand the destruction of the bison herds. Between 1873 and 1889, mainly five individuals consisting of ranchers and bison market hunters, in locations ranging from Manitoba to Texas, captured the last of the wild Plains bison (except for those in Yellowstone). Their efforts to save the few remaining bison secured the foundation stock for most contemporary public and private Plains bison herds. These early efforts to save bison at a crucial time are regarded as a conservation success story. Unfortunately, soon after capture many of the remaining bison were crossed with cattle to create a hybrid livestock to withstand environmental extremes better than cattle and to still maintain the favorable table fare of beef.

Current estimates of American bison are around 500,000 animals. Of this about 20,000 Plains and 11,000 Wood bison are in public trust herds with the remainder privately owned. Recent genetic studies show more than 90% of today's bison were founded with bison that have evidence of cattle ancestry. Further, most publicly owned Plains bison populations are descended from only a few founder animals, basically from an effective population size of less than 100 individual bison (Hedrick, 2009). Both cattle DNA introgression and genetic bottleneck are issues which may have lowered bison genetic diversity and fitness compared to pre-settlement herds. The presence of low levels of cattle gene introgression in bison does not necessarily diminish their value as bison, nor to the public who enjoy them as they are visually indistinguishable from pure bison. However, an effort to preserve the remaining genetic diversity and reduce the percentage of cattle DNA in public bison herds when and where appropriate is common to most if not all public bison managers across North America.

B. Arizona

Archeological Record

Limited evidence of pre-settlement bison occurrence in Arizona exists; however, bison parts and remains have been discovered across Arizona (Figure 1). These include bison bones, hoofs, hair, and dung uncovered at several sites (Huffer 2013). The limited pre-settlement extent of bison parts could suggest trade between native peoples and may not be indicative of persistent localized presence or frequent use of bison in Arizona. Some evidence suggests bison were present in the southwest at a minimum intermittently in small herds or wandering bachelor groups of males, perhaps in response to harsh winters further north, widespread climate changes, or fluctuations in the availability of water and forage (Huffer 2013; pgs 106-107). Remains of a bison cow and fetus believed to have been deposited around 1610 A.D. have been excavated at Murray Springs in southeastern Arizona (Agenbroad and Haynes 1975) and would represent breeding bison in the area at that time. Recently, bison remains may have been identified at the Cave Creek Midden in southern Arizona suggesting a 3,000 year-old hunting kill site (Wismer et al. 2016). A final report on the findings at this site has yet to be published. Further, Mead (2002) concluded, "Bison were in and adjacent to the Grand Canyon over the past 11,000 years" and can be considered native to northern Arizona. Martin et al. (2017), similarly concluded, "Our findings indicate that *Bison bison* should be considered a native species on the Colorado Plateau because they have a nearly continuous record of inhabitance in the region". In conclusion, bison remains which have been found and examined seem to indicate bison did occur at least occasionally in Arizona, which is consistent with a species at the edge of its historical range.

Written Record

Some early southwest explorers recorded what may indicate the presence of bison in Arizona. One confusing record is of a Spanish expedition from Zuni, New Mexico to the south rim of the Grand Canyon in the 1500s. Zuni is in the far west-central portion of New Mexico and within 12 miles of the Arizona border. After returning to Zuni, one of the explorers, Cardenas, reported seeing bison during the expedition, but the location was not specified or officially recorded (Mead 2002). If this account is accurate, it likely occurred in Arizona as most of the expedition would have occurred in present day Arizona. Another report is from a Catholic Father apparently being served a meal consisting of bison meat while visiting the Havasupai Tribe near the Little Colorado River in 1776 (Coues 1900). Additionally, indigenous people along the San Pedro River through southeastern Arizona were in possession of bison hides from a 1539 report (Mead 2002; Reed 1955). Bison hides were however, widely traded throughout the southwest and these bison hides may have been acquired through trade and brought to southeast Arizona rather than taken off bison in the area.

Rock Art

Native American rock art of bison are known from a couple sites in Arizona. One is found along the Arizona-Utah border near Kanab, Utah (Figure 2) and another bison image is found at the base of the Grand Wash Cliffs north of the Colorado River (Weaver 1984:14; Figure 3).

The limited archeological and historic bison artifacts, rock art, stories and knowledge within associated tribes of the greater Grand Canyon region suggest bison likely only occurred infrequently and at very low abundance. Huffer (2013; pg 10) concluded that, "If bison were present in the Southwest, as the evidence suggests, they likely entered the region only occasionally as small, dispersed herds."

Native American Tribes of Arizona with Bison Tradition

The Kaibab Paiute (Southern Paiute) tribes along the Arizona north-central border with Utah, the Navajo, Hualapai, Havasupai, Yavapai-Apache, and Hopi tribes have oral or recorded stories or other connections to bison (Appendix 1). These stories of bison give further evidence to the historical distribution and nativity of bison in Arizona.

Bison Nativity to Arizona

Taking the totality of the written record, archeological record, rock art, and Native American tradition, they suggest bison occurred in the past in Arizona. There is no evidence bison were ever locally abundant as in other portions of bison North American range. The collective evidence is consistent with what would be expected from a species at the southwest edge of its original continental range. Recent research and bison range maps depict northern and southern Arizona within the known southwestern original range of bison (Figure 5) (Truett 1996; Sanderson, et al 2007). The Department of the Interior (DOI) Bison Conservation Initiative adopted the Sanderson et al. map and Gates et al. (2010) as the best available sound science describing the bison continental historic range for purposes of ongoing DOI-wide and bureau-specific bison conservation planning and stewardship activities, that includes areas at the edge of the species' historic range such as the Grand Canyon region. A review of the status of the American bison by the International Union for Conservation of Nature (IUCN) considers the Kaibab Plateau area within the west-southwestern edge of bison historic range (Gates et al. 2010). Based on the totality of evidence and consistent with its long-term management of bison as wild big game in Arizona, the Department's position is that bison are native wildlife within their original historic range in Arizona.

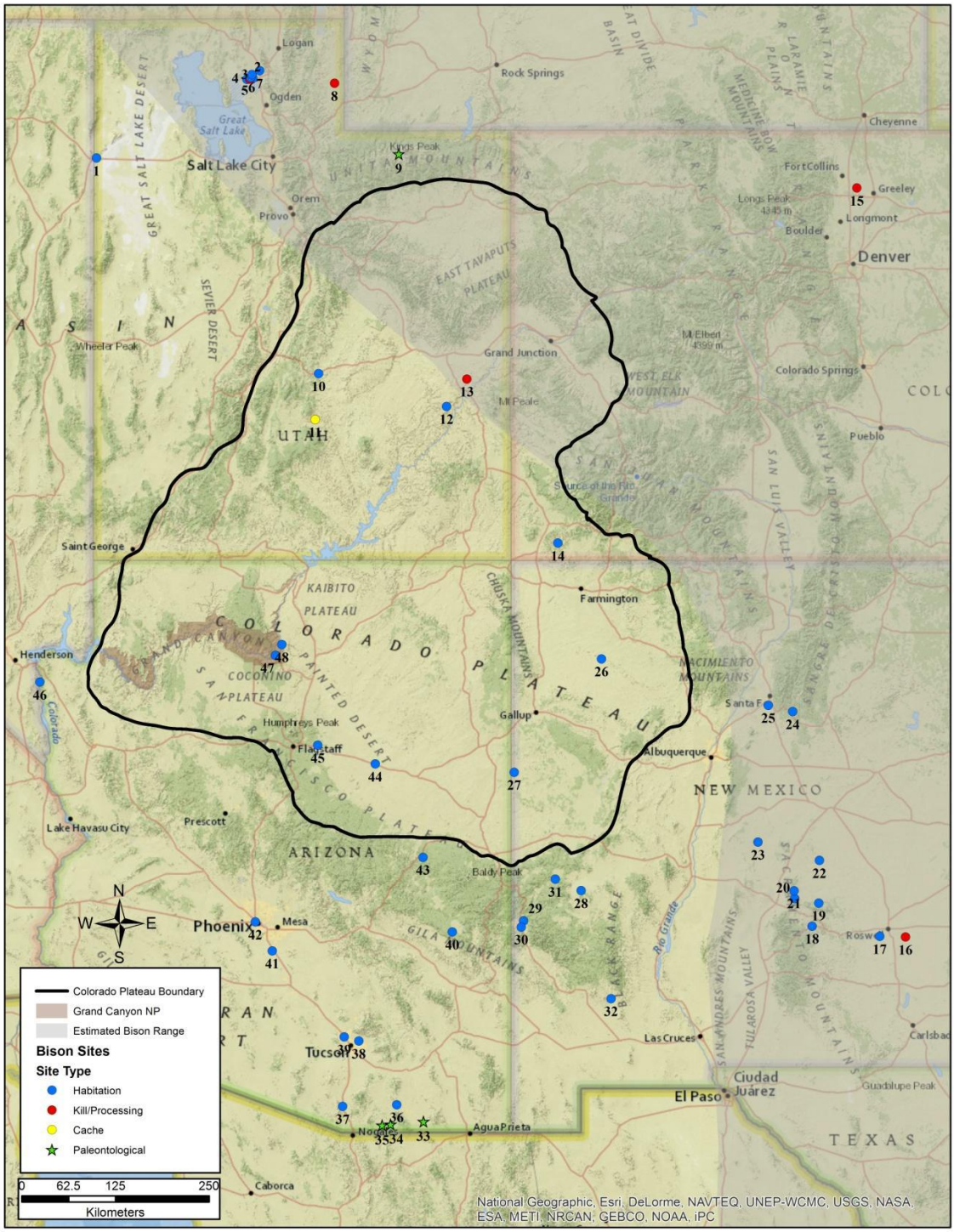

Figure 1. Holocene paleontological and archaeological sites containing bison remains in the southwest (Huffer 2013).

Figure 2. Pictograph of Bison from Kanab Creek, Utah

Figure 3. Grand Wash Cliffs Pictograph

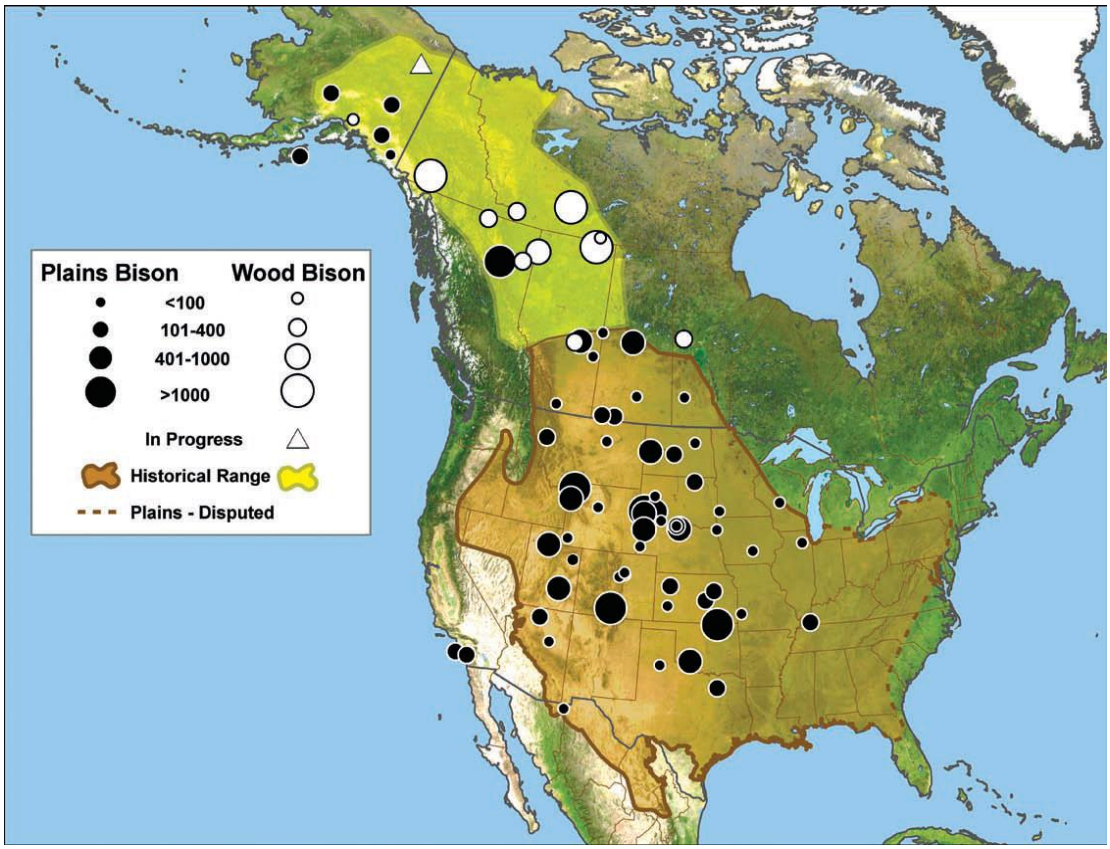

Figure 4. Sanderson's map of bison continental original range

Bison Return to Arizona

In January 1906, Charles "Buffalo" Jones acquired a federal permit to fence large areas of the Kaibab Plateau for bison and other big game animals. It appears Jones and the U.S. Government entered into a partnership, where both parties would share in the profits of hybrids produced by crossing bison and cattle. The government provided the land and two bison bulls from Yellowstone National Park and Jones provided the know-how, care, and cattle (Easton, R. and M. Brown 1961, pages 136-140). Later that same year, President Theodore Roosevelt issued a proclamation creating the Grand Canyon Game Preserve (Preserve) on November 28, 1906. The proclamation stated in part that the area is "set aside for the protection of game animals and shall be recognized as a breeding place." The early writings specifically mention "buffalo" as part of the game animals to be managed on the Kaibab Plateau. The Preserve predates the establishment of both the Kaibab National Forest and Grand Canyon National Park (GRCA) and originally included all the lands in both the current North Kaibab Ranger District and GRCA, although GRCA was later excluded from the Preserve.

Starting in June 1906, with his secured federal grazing permit, Buffalo Jones trailed one group of 30 bison and a second group of 57 bison about 175 miles from the railroad station at Lund, Utah to the Kaibab Plateau (Easton, R. and M. Brown 1961, page 137). The 87 bison were not unknown to him, as they were part of his original Garden City, Kansas herd that he rounded up between 1886 and 1889. Jones had personally caught most of these bison as calves from the last remaining wild bison herds from the Texas panhandle and northeast New Mexico and which he had lost 11 years earlier due to bankruptcy (Dary 1974, pages 226-227). Thus,

with both bison and Galloway cattle in hand on the Kaibab Plateau, Jones started his second "cattalo" cross attempt near Bright Angel Point (now part of GRCA), much as he had done with his original Garden City bison herd in the late 1880s. With minor breeding success and little financial return due to high birth mortality and male sterility, the Kaibab cattalo venture failed in just 3 years, just as his earlier attempt in Kansas failed. In 1909, Jones rounded up most of the bison and trailed them back to the railroad in Lund, Utah. Only 15-20 bison on the Kaibab Plateau remained where "Uncle" Jimmy Owens (Brown 2012, page 143) took possession of them; Owens was an original investor in the venture.

These remaining bison were largely left to range where they wanted by Owens. They eventually drifted down to the south end of House Rock Valley and continued to grow in number. The state of Arizona negotiated with Owens to purchase these bison with the assistance of Arizona's congressional delegation, the state legislature, and the American Bison Society. Installment payments totaling $10,000 were paid over 3 years, with final payment given to Owens in December 1927 (Brown 2012, page 143). Arizona was now the owner of Jones's original herd with the purchase of 98 bison. Descendants of these bison formed the core of the bison in the House Rock herd and Raymond herd, until the Raymond herd was completely replaced with the Wind Cave National Park (WICA) bison lineage in October 2017.

The Arizona Game and Fish Commission (Commission) gained management authority over the bison with its creation in 1929. The Commission considered the bison herd a great asset and was championed as the only place in the world, at the time, where the public could hunt bison on public land. It must be remembered in those days bison were still recovering from near extirpation in the late 1800s. Seeing bison anywhere, let alone Arizona was considered a thrill. It was not unusual either for "pintos" (bison with light brown or white spots) to be in the herd. Whether these pintos were the result of cross breeding with cattle or natural color variations being expressed is open for debate (Brown 2012, page 146). Interesting though, color variations like white leggings and white faces were recorded in pure bison, prior to the near extirpation and any crossings with cattle (Dary 1974).

Establishment of Official Bison Range in Arizona

The Department has managed bison on three separate bison ranges in Arizona over the years (Brown 2012). The first, as already discussed, was in House Rock Valley. The bison herd roamed House Rock Valley prior to the state of Arizona purchasing them until the official establishment of House Rock Wildlife Area (HRWA), which was for use by wildlife and excluded livestock grazing on August 8, 1950 (Figure 6 and Appendix 4). Over 20 years in the making, Arizona finally secured range exclusively for bison. The U.S. Forest Service (USFS), Bureau of Land Management (BLM), Commission, and four livestock grazing permitees entered into the agreement, which in part stated the USFS agreed to "…set aside the South Canyon and Fence Canyon allotments as an area for the grazing of buffalo and deer as long as the Arizona Game and Fish Commission continues to use the aforementioned area for the grazing of buffalo." Similarly, the Commission agreed "… to maintain an adequate fence on the north boundary of the buffalo allotment on the Kaibab National Forest and to keep the buffalo confined to their designated range on the Kaibab National Forest" and to pass sufficient water from the South Canyon pipeline to water 200 cattle yearlong on BLM land north of HRWA. This agreement set aside 67,865 acres of USFS land exclusively for Arizona's first bison herd and the North Kaibab deer herd. The House Rock bison herd stayed on HRWA until the mid-1990s when they began to venture up on top of the North Kaibab Plateau.

HRWA is located along the southeastern edge of the North Kaibab Plateau about 20 miles south of U.S. Highway 89A and 25 miles southwest of Cliff Dwellers Lodge in Coconino County. The Department owned wildlife area headquarters encompasses 30 acres with the remaining 53,850 acres being of Kaibab National Forest land. Elevation varies from 5,300 feet to 8,000 feet. The HRWA is located within the USDA-NRCS's Major Land Resource Area (MLRA) 35, Colorado Plateau. The lower elevations of the northern and eastern portions of the wildlife area are within the subdivision Land Resource Unit (LRU) 35.3, Sagebrush-Grasslands, characterized by Wyoming big sagebrush. The dominant ecological site in this portion of the wildlife area is Shallow Loamy, 10-14" occurring as flat to gently sloping terrain dissected by steep sided drainages. The southern and western portion of the wildlife area transitions to higher elevations crossing into LRU 35-6, Pinyon-Juniper Sagebrush, with Colorado pinyon and Utah juniper as characteristic plants. The terrain is of gently to steeply sloping ridges generally running in an east-west orientation. At the highest elevations to the west and east, the wildlife area is within LRU 35-8, Ponderosa Pine Forests, with ponderosa pine the characteristic plant. Major canyons include South, Saddle, North, and Buck Farm canyons.

The western portion of HRWA is winter range for the North Kaibab mule deer herd. The wildlife area contains some of the best winter range available on the east side of the Kaibab Plateau. Pronghorn are found in the grasslands and desert bighorn sheep are found occasionally along the rim of Marble Canyon and Grand Canyon.

A second bison range was established at Raymond Wildlife Area (RWA), about 20 miles east of Flagstaff and 10 miles south of I-40 at Buffalo Range Exit (Figure 6). Originally established as winter range for the famed Anderson Mesa pronghorn herd in 1942, bison were moved from HRWA to RWA in 1945 to alleviate overgrazing concerns at HRWA during a period of drought. Bison have continually been managed at RWA since and have numbered as high as 358 bison. RWA consists of 14,637 acres, of which 9,438 acres are Commission-owned land and 5,199 acres are Arizona State Land Department (ASLD) leased land.

The majority of Raymond Wildlife Area is located within the USDA-NRCS's Major Land Resource Area (MLRA) 35, Colorado Plateau, Land Resource Unit (LRU) 35.1, Mixed Grass Plains. A small portion of the wildlife area, Anderson Ridge, is within LRU 35.7, Woodland Grassland. The dominant ecological site on the wildlife area is Shallow Loamy 10-14" p.z. occurring as flat to gently sloping terrain dissected by steep sided drainages. Elevations range from about 5,500 feet to over 6,700 feet on Anderson Point. Pronghorn, elk, mule deer and about 50 other wildlife species can be found on RWA with most wildlife use occurring in the winter.

A third, little know bison herd, was established on Fort Huachuca in southern Arizona in 1949, when the Army deactivated the base following World War II. Hualapai Valley near Kingman had also been considered, but was dropped in favor of Fort Huachuca as a third state bison range. At the time, Fort Huachuca was renamed the Vorhies Research Project Area, and there were as many as 461 bison on site at one point. By 1951, the Army reactivated Fort Huachuca and wanted the bison removed. The remaining animals were either removed by hunters or sold by 1956 (Brown 2012).

Figure 5. Current bison range in Arizona.

Past Bison Hunt Strategies

The first public bison hunt in Arizona was held in late December 1927 (shortly after the state acquired the House Rock herd) with the harvest of 15 bulls and 2 cows (Brown 2012, page 143). Initial hunts were conducted in large pastures after the bison were rounded up. It appears these pastures (old cattle pastures) were fairly large in size, and early hunts were conducted on the open range in this manner until 1950. Hunters were selected through a random drawing with each hunter choosing the bison they wished and hunting in the order drawn. Each hunter kept the head, hide, and 100 pounds of meat or one quarter. Management cost associated with the House Rock bison herd was financed from the sale of the remaining bison meat. In 1940, regulations changed to allow hunters the option of purchasing the remaining quarters for 10 cents a pound for front quarter and 12 cents a pound for the hind quarters. This marked the first fees paid by the hunter, other than the cost of a hunting license.

With the official creation of HRWA in 1950, the bison herd had grown too large to continue to harvest bison in this manner. New corrals were built at HRWA, RWA, and Fort Huachuca to facilitate an increased bison

harvest. Bison on each area were rounded up into the new corrals, sorted, and harvested in the corrals rather than on the open range. Eight to 10 bison were released at a time before drawn hunters. Hunters, again, got to keep the head, hide, and one quarter of meat with the option to purchase the rest. Bison hunts alternated annually between HRWA and RWA, and was an "all hands on deck" operation for the Department. Bison hunts were conducted this way until 1972, when mounting public pressure after the release of the 1971 movie "Bless the Beasts and Children" changed the way the Department conducted bison hunts.

After 1972, bison hunts were again conducted back out on the open wildlife areas with drawn hunters being guided by the Department. Hunters were directed which animal to take within the herd and usually shot in the order drawn. This strategy was used to control bison numbers at RWA between 1972 and 2017. It was designed to have minimal disturbance to a bison herd while still allowing harvest, but this type of hunt still had an effect and not always positive in regard to either herd staying on designated range after harvest. Given the small size of RWA, it requires carefully managed hunting practices to keep bison from leaving the wildlife area.

In 1982, after consideration of mounting Department expenses with conducting House Rock herd hunts, it was decided to change the hunt structure again. No longer did the Department guide hunters. Instead, hunts became complete open public hunts, in the same way deer and elk hunts are conducted. Department personnel presented a pre-hunt orientation on the evening before opening day and often assisted hunters in finding bison.

With this change in hunt structure, the Department lost control of the interaction between hunters and bison. Although it took 10+ years to occur, by the early to mid-1990s, the House Rock herd began spending more time in the Saddle Mountain Wilderness west of HRWA, due to the increased disturbance created through open public hunting. An additive attraction off HRWA during this same time was wildfire in the Saddle Mountain Wilderness, which likely attract and held bison longer than before in the wilderness.

As the bison spent more time in the remote, rugged wilderness and less time in the open grassland of HRWA, hunt success dropped, bison numbers increased, and population objectives of less than 100 bison were exceeded. In response, the Department increased bison permits to increase harvest and lower bison numbers to within population objectives. With fewer bison available to hunters on HRWA and rugged and remote wilderness conditions to contend with, bison hunters brought more help to locate and pack bison out of the wilderness. With more people in the field, human disturbance increased further, pushing the herd further from HRWA. With this increased disturbance, it is believed the herd eventually found safety inside GRCA, where they took refuge from hunting. During this time, the bison continued to return to HRWA each summer to breed; as bison are tied to traditional breeding grounds and HRWA is where the herd ranged and bred for more than 80 years.

In order to reduce the ever growing herd, the Department instituted population management hunts when the herd returned to HRWA during the summers of 2005-2009. The unfortunate consequences of these hunts and added hunting pressure when the bison returned to HRWA was to sever the annual summer return of the herd to breed on HRWA. The House Rock herd has not returned to HRWA since the summer of 2009, except for a few individuals for a very short time. Those animals were probably bulls looking for cows and when they found none, they returned to the top of the Kaibab Plateau. The breeding ground then shifted from HRWA to the Kaibab Plateau. As a consequence, the majority of the original House Rock bison sub-population now spends the majority of its time on GRCA and continues to grow in number.

Past Bison Translocations into Arizona

Since 1929, periodic bison translocations into the House Rock and Raymond herds to increase genetic diversity have occurred. The following is a summary of those translocations:

Date	Release Site	Number and Sex	Source
1929	House Rock	4 bulls	Wind Cave National Park, South Dakota
1942	House Rock	12 bulls	Wichita Wildlife Refuge, Oklahoma
1946	House Rock	6 bulls	Wichita Wildlife Refuge, Oklahoma
1949	Ft Huachuca	15 yearling bulls	National Bison Refuge, Montana
1950	Raymond	15 bulls	Yellowstone National Park
1956	Raymond	10 bulls	Wichita Wildlife Refuge, Oklahoma
1956	House Rock	10 bulls	Wichita Wildlife Refuge, Oklahoma
1962	Raymond	5 bulls	Wichita Wildlife Refuge, Oklahoma
1980	House Rock	3 unknown	National Bison Range, Montana
2001	Raymond	3 cows(2 yrlg/1 calf), 3 yrlg bulls	Henry Mountains, Utah
2001	House Rock	2 yrlg cows, 3 yrlg bulls	Henry Mountains, Utah
2017	Raymond	11 ylg cows, 13 ygl bulls, 10 2½ old cows, 12 2½ old bulls	Wind Cave National Park, South Dakota
2017	House Rock	10 ylg cows, 5 yrlg bulls	American Prairie Reserve, Montana

III. SPECIES ASSESSMENT

A. Natural History

Arizona's bison are American Plains bison (*Bison bison bison*) mostly from the southern plains. Plains bison are the only native bison to the lower 48 states, with the American Wood bison (*Bison bison athabascae*) native to Alaska and Canada. Bison were not noted in Arizona during the settlement period of the 1800s, although bison remains have been confirmed in various locations in northern, central, and southeastern Arizona (see section II. History). Currently, the Department manages 2 bison herds in north central Arizona, the House Rock herd and the Raymond herd (Figure 5).

Bison have the broadest original range of any indigenous ungulate species in North America, reflecting adaptations permitting them to survive in most ecosystems that produce a diet of grasses and sedges. Successful management depends largely on understanding bison behavior, which is dictated by their response to disturbance, biological characteristics, and ecological role. Bison are better adapted to temperature extremes than most cattle breeds and expend less energy under extreme cold than do cattle because of their superior insulation of their hide and hair (Peters and Slen 1964).

There are many historical observations of huge herds of Plains bison on the Great Plains. Even in these large herds, there are definable cohesive sub-herds of cows, calves, and immature bulls, which have bonded together forming "social groups". Leadership within these social groups is matriarchal and the lead cows are believed to be of the same lineage. Outside of breeding, mature bulls form separate, smaller bachelor groups throughout much of the year. The largest herd concentrations occur during the breeding season when mature

bulls join social groups, which is typically mid-June to September in Arizona. Dominant bulls form "tending bonds" with individual cows prior to and during estrus (Meagher 1973). The bull will typically attempt to keep other bulls away and keep the cow near the edge of a social group until she accepts breeding. Groups of adult or sub-adult males rarely exceed 10 individuals. Female bison range in weight from 750-1200 pounds while bulls can weigh over 2000 pounds. Female's typically enter estrus as 2-year-olds and give birth to their first calf at age 3. Mature females in some bison populations reproduce each year. Females continue to breed until over 16 years of age and typically give birth to only 1 calf at a time, but occasionally twin. Young bulls are often capable of breeding as yearlings, but generally do not breed until age 5 or 6 when they become large enough to compete with older, larger bulls.

Female bison close to parturition are restless and excitable and usually separate from other females prior to giving birth. Birth weights of free-ranging Plains bison range from 30-70 pounds. A calf is typically weaned by 7 to 8 months of age, although some nursing may extend longer (Green et al. 1993). Cows and other members of a social group tend to cooperatively protect calves from predators. There is some size differences noted in geographically separate herds which may be attributed to differences in climate, nutritional plane, and genetic lineages.

A unique behavior of bison, more than any other ungulate, is dry wallowing. They are also known for rubbing and horning. Wallowing is rolling in dry loose soil and tearing at the earth with horns and hooves as a bison rolls. Rubbing and horning involve rubbing heads and bodies on erupt objects, such as trees or fence posts. Both sexes and all age classes engage in wallowing, rubbing, and horning behavior throughout the year. Sexually mature males wallow more frequently during the rut, urinating in wallows before pawing and rolling. Bison also wallow to cool themselves during the hot summer months, get relief from biting insects, and aid in coat shedding.

Bison frequently travel single file along established trails when moving between locations. Historically, bison migrated long distances to water, between summer and winter locations, and between foraging locations. Some of the early westward pioneer trails followed established bison trails (Roe 1970). Adult males are often the first to pioneer into new unoccupied areas, and this range expansion is generally density-driven.

B. Ecological Role

Historically, millions of Plains bison ranged over North America's grasslands and functioned as a keystone species, meaning they played a unique and crucial role in the way an ecosystem functions (Knapp et al.1999). Without a keystone species, an ecosystem would be dramatically different. At a landscape level, millions of bison served as ecosystem engineers, both responding to and creating habitat diversity. For instance, millions of bison would create millions of wallows, which had a major effect on surface hydrology and runoff. Ephemeral pools of standing water persisted in wallows for many days following spring snow melt or rainstorms which in turn supported a variety of wetland plant species. Similarly, bison wallows provided important breeding habitat for some toad and salamander species (Bragg 1940; Corn and Peterson 1996). Also, millions of bison would directly affect vegetation through grazing and physical disturbance, by stimulating nutrient recycling and seed dispersal. Such actions help to maintain meadows and grasslands on which bison and many other animal and plant species depend. In tallgrass prairie, bison grazing of grasses increased soil temperature, light availability, and soil moisture availability for forb species (Fahnestock and Knapp 1993). The net result was beneficial for increased forb production, resulting in more forbs available for other herbivores such as pronghorn. Some studies suggest bison can reduce vegetation height to levels

aiding the colonization of an area by prairie dogs (Virchow and Hygnstrom 2002). Knapp et al. (1999); found bison grazing, wallowing and natural fire enhanced grassland diversity necessary to provide suitable nesting sites for a variety of obligate grassland nesting bird species. Bison also aid seed dispersal of many plants by the seeds becoming attached to bison hair or from passage through the digestive tract and deposited elsewhere. Horning damage to trees along grassland borders is also effective in slowing invasion of trees into these communities.

Historical bison numbers in Arizona were quite lower in density than those seen elsewhere in historic bison range. It is believed bison numbers in Arizona were 1-2 orders of magnitude lower than in core north central and south central grassland herds (Plumb et al. 2013). Bison were also at times likely absent from Arizona, which archeological evidence seems to suggest. This seems reasonable as all wildlife populations fluctuate over time. The nutritional plain and moisture pattern of short and tall grass prairie habitat found in core historical range is vastly different than range that would have been available to bison in the southwest. Range in the southwest simply could not, in the past or now, support bison numbers like other areas of core historical range. Allowing bison to graze freely and influence the landscape is important, as their disturbance actions stimulates nutrient recycling and seed dispersal. The current number of bison on RWA, at less than 50 head, is not at a level to significantly influence the habitat in this way. However, the current House Rock herd is significantly impacting the habitat on GRCA (NPS 2017).

C. Genetics

Mitochondrial DNA and a suite of nuclear DNA microsatellite tests confirm cattle DNA remained in the original Raymond and House Rock bison herds and are believed to be remnant from the deliberate cross breeding attempts by Charles Jones (Wakeling 2006; Hedrick 2010). Even with detectable levels of cattle DNA introgression in these herds, that alone does not invalidate the overall value of either herd as bison. Hedrick (2010) estimated 97.5% (39 of 40 samples) of bison in both herds possess cattle mitochondrial (mt) DNA, while <2% possessed cattle autosomal DNA (Appendix 6). Additionally, no rare or unique bison genes were detected in either bison herd that are not found in other bison herds elsewhere. While the old Raymond bison possessed and the original House Rock bison continue to possess relatively high levels of cattle introgression compared to other tested bison herds, it is important to remember only a few federal conservation herds (Grand Teton National Park, Sully's Hill National Game Refuge, Wind Cave National Park and Yellowstone National Park) do not have detectable levels of cattle DNA (Hedrick 2010; Greg Schroeder, Chief of Resource Management, Wind Cave National Park; personal communication). Most bison that survived the near extirpation in the late 1800s were crossed with cattle at some point. The overall autosomal cattle DNA is low in Arizona's bison (1.9%) compared to total bison DNA. Both bison herds still looked and acted like bison and were indistinguishable from bison with no cattle introgression. The Department considered them bison and not "beefalo" or "cattalo." The American Beefalo Association defines beefalo as 3/8 bison and 5/8 bovine, with any cattle breed making up the bovine portion. Neither the original House Rock nor Raymond bison approach near this threshold.

Many valued bison conservation populations possess cattle DNA introgression, and management options are available to reduce cattle DNA presence over time. A team of biologists working on the Grand Canyon Bison Environmental Assessment (EA) concluded, "although the current genetic status of the population (House Rock herd) needs to be understood, the genetics of the population should not interfere with the continued management of this population as ecologically restored wild, free-ranging bison" (Plumb, G. E., et al 2016).

D. Disease

Two diseases of concern in bison are Bovine Brucellosis and Bovine Tuberculosis (BTB) (Anne Justice-Allen, Department veterinarian, personal communication). Bovine brucellosis is a bacterial infection and usually results in abortion of calves. Primary hosts include bison and cattle, but wild ungulates such as elk are also susceptible and can be hosts. BTB is a chronic infectious disease caused by a bacterial infection. BTB is progressively debilitating and can cause reduced fertility and weakness, with advanced cases being fatal. Currently, brucellosis is only endemic to bison and elk in and near Yellowstone National Park, and BTB is only endemic to bison in and near Wood Buffalo National Park in Canada. Both of these diseases are zoonotic.

The Department collects blood samples from hunters who harvest bison from the original House Rock herd and collects blood and fecal samples from live bison during sorting at RWA to test for intestinal parasites, Bovine Brucellosis, Anaplasma, Bovine Viral Diarrhea Virus (BVDV), and Johne's disease. The Department may also test for Epizootic Hemorrhagic Disease (EHD), Bluetongue occasionally.

To date, there has been no detection of Bovine Brucellosis, EHD, Bluetongue or BVDV in Arizona's bison herds. Additionally, there have not been any detections noted in cattle for Bovine Brucellosis or BTB on and around the North Kaibab Plateau from the Arizona Department of Agriculture State Veterinarian's Office (Anne Justice-Allen, personal communication). There has been some positive detections for Anaplasma in the new Raymond herd and the original House Rock herd and one positive detection for Johne's disease in the new Raymond herd.

IV. MANAGEMENT

A current Environmental Assessment Checklist (EAC) (EAC # M17-0712024431 - Comprehensive Bison Management at House Rock WA and Raymond WA) guides bison management activities of the Raymond and House Rock bison herds; and is valid through December 31, 2022.

Bison Management Goals:

1. Maintain bison populations at levels which provide maximum and diverse recreational opportunities while avoiding adverse impacts to the habitat;
2. Manage the House Rock bison herd to be concentrated on House Rock Wildlife Area in support of long term bison conservation; and
3. Manage the Raymond bison herd in support of long term bison conservation of genetically diverse WICA lineage of bison.

A. Herd Objectives, Status, Surveys and Range Monitoring:

Determine annual recruitment rates, sex ratios and the general condition of bison range.

<u>House Rock Herd</u>

1. Currently, there are two subpopulations within the House Rock bison herd consisting of:
    a. the original House Rock bison now occupying GRCA and KNF lands on the Kaibab Plateau; and

b. a new young group of bison from the American Prairie Reserve (APR) in Montana on the northeast part of HRWA released in December 2017.

2. The Department's House Rock herd population objective is 80-200 bison. This population ranged was developed through a GRCA technical assistance report, which was requested by GRCA to inform the Park's bison management planning, where bison nativity, genetics, landscape size and bison abundance and density were discussed (Plumb, G. E., et al 2016). To develop this report a team of biologists from GRCA, Kaibab National Forest, the BLM and the Department, established in cooperation and consensus agreement the herd objective of 80-200. This population objective is based on what is believed to be low historical occurrence of bison at the southwest edge of continental occurrence. The Department agrees with the conclusions within this report and currently GRCA does not.

3. This same report (Plumb, G. E., et al 2016) references a possible 215,000 acre bison range for the House Rock bison herd extending from HRWA over to the west side of the Kaibab Plateau including areas on GRCA. Consensus agreement has not been reached between GRCA, KNF and the Department on this larger bison range. Further, the KNF Forest Plan states:
   a. The bison should be managed so that the herd is concentrated within HRWA.
   b. The size of the bison herd should be in balance with ecological conditions on HRWA.
   c. Active management should be used to minimize impacts from bison to sensitive resources, particularly outside the HRWA.

   Adaptive management strategies will be implemented to encourage the new APR bison to be concentrated on HRWA per the Kaibab National Forest Plan. Similarly, adaptive management strategies will be implemented to discourage the original bison on the Kaibab Plateau from interacting and breeding with the new APR bison. If opportunities arise and federal agencies desires change in the future, the larger 215,000 acre bison range may be revisited.

4. The original House Rock herd is estimated to be in the low 400s as of May 2020 and fairly stable the last several years. A sample model run put the population at 429 animals (range 261-624). This estimate is calculated using a Bayesian Integrated Population Model. Due to thick conifer cover on GRCA and on the adjacent KNF, House Rock bison are difficult to survey from either the ground or air. Past population estimates are obtained through population modelling, supplemented with harvest data gathered from bison checkout forms. Annual recruitment data are determined from summer pictures/surveys of bison taken as they venture into the meadows along Arizona Highway 67 on top of the North Kaibab Plateau.

5. Range monitoring on HWRA has not been consistently measured over the years. In 2014, the Kaibab National Forest in cooperation with the Department, conducted a range evaluation at HRWA. The report titled, "House Rock Wildlife Area Bison Carrying Capacity Report 2014" (Michael (Hannemann 2014), established monitoring sites and photo plots. The report estimates grazing capacity for HRWA for bison at 2,788 to 5,018 animal unit months (AUMs) or 232 to 418 bison year-round. It further recommends an initial bison population of 90-100 bison on HRWA, where again adaptive management will be deployed to achieve desirable bison density and distribution This initial

starting population may be adjusted (up or down) through range monitoring in cooperation and consensus agreement between the KNF and the Department.

Raymond Herd

The Department entered into a partnership with the National Park Service-Wind Cave National Park (WICA) by signing a MOU in 2015, to manage bison of Wind Cave origin at RWA. With this MOU the Department agreed to remove the "old" Raymond herd prior to the arrival of 60 Wind Cave bison. Further the Department agreed to manage only the Wind Cave bison linage at RWA and to exchange bison periodically with WICA to maintain genetic diversity. The decision was made to move forward with the MOU not because the Raymond herd was not of value, but to move the Department's bison management to a national level to conserve and preserve bison as they were before forced breeding occurred with cattle. As stated earlier (page 3), there is an effort nationally to preserve the remaining genetic diversity and reduce the percentage of cattle DNA in public held bison herds, when and where appropriate. The old Raymond herd was removed through public hunting by mid-October 2017 and 46 new Wind Cave bison were roaming RWA by the end of 2017.

1. The new Raymond herd will be allowed to grow to 80-100 adult bison. This objective was established through forage estimates, Commission desire to increase the Raymond herd, and known bison behavior. This number can be adjusted using adaptive management based on herd behavior and forage monitoring described below.

2. RWA habitat use is monitored 3 times per year at 5 locations scattered across the wildlife area through the Forage Resource Study Group (FRSG) in coordination with ASLD range staff. To date, use of important forage plants is light and usually <10%. A Grazing Questionnaire is required annually from ASLD, who estimate 10 adult bison per section can be grazed at RWA based on past forage estimates. This allows for grazing of 228 adult bison if RWA were to be managed at full capacity. A conservative estimate of 6 adult bison per section would equate to 137 adult bison, well below estimated forage capacity and the new population objective of the Raymond bison herd.

B. Bison Checkout Procedure and Determining Hunt Success:

1. A hunter issued a bison hunt permit-tag or non-permit-tag shall check out no more than 3 days after the end of the hunt, regardless of whether the hunter was successful, unsuccessful, or did not participate (R12-4-306E). There is no physical checkout required of harvested bison. Hunters are encouraged to check out online, but can also checkout by phone or in person at the Flagstaff Regional Office, through the Raymond Wildlife Area manager, or the Kaibab check station (if the check station is open for a Kaibab deer hunt).

2. Region 2 front counter, Terrestrial Wildlife Program staff, and House Rock/Raymond wildlife area managers will be familiar with check-out procedures. Region 2 will prepare a statewide bison hunt summary and provide that summary to the Big Game Supervisor and Game Data Manager in the Terrestrial Wildlife Branch.

3. Region 2 personnel will monitor hunter check outs to ensure hunter compliance. Cumulative hunt data will be used to formulate hunt recommendations.

C. Blood Collection for DNA and Disease Testing:

1. House Rock bison hunters are encouraged to collect blood samples from all original bison sub-population harvested to enable the Department to test for diseases described in Section III D, although it is not mandatory.
2. Blood from the Wind Cave bison translocated to RWA was collected on blood cards to document the founder herd DNA prior to transporting and release on RWA in October 2017. DNA testing of the new APR bison at HRWA was conducted prior to transport to HRWA by APR personnel in November 2017. Results were provided to the Department to also document their DNA signature. These DNA results will be used to determine strategies to best maintain and enhance diversity of Arizona's bison herds.

3. The Department's Wildlife Health Program will maintain a file of all DNA and blood samples collected, tested, and any results. This data will be used to monitor Arizona's bison for diseases, DNA monitoring and inform management decision making.

D. Hunt Recommendations:

The Department will use survey and hunt data, herd population objectives, and knowledge of bison herd behavior to determine an annual bison harvest, and formulate hunt recommendations to accomplish that harvest.

1. Survey data will be summarized by wildlife area managers and Terrestrial Wildlife specialists using current hunt recommendation templates and tools. Survey technique, design, and data manipulation will be documented, if appropriate.

2. A population estimate will be calculated for the original House Rock herd annually. The Raymond herd and new House Rock subpopulation will be determined by direct count.

3. Hunt recommendations will be developed in conformance with the Guidelines for Hunting Season Recommendations and bison management plans.

4. Bison hunt recommendations and survey data will be submitted to Terrestrial Wildlife Branch for review in accordance with the Hunt Recommendations Guideline schedule.

E. Harvest Strategies:

<u>House Rock herd</u>

Current harvest of the original bison subpopulation is accomplished through open public hunts near the GRCA and KNF boundary on top of the Kaibab Plateau. The Department assists these hunters by providing a Bison Hunter Packet covering sex and age identification, legalities, and what each hunter can expect on the hunts. Additionally, the Department sometimes hosts a Bison Hunter Clinic to assist House Rock bison hunters. The difficult balance for the Department is to maximize harvest of the original bison when they are off GRCA and available to hunters without reducing or impacting the availability of bison for hunting off GRCA. Too much human disturbance on KNF land, results in bison retreating to GRCA, where it is not lawful to hunt. GRCA currently serves as a refuge for this subpopulation. The new APR bison are harvested, as appropriate, informed by overall population objectives (80-200 individuals) and annual range monitoring results. Current plans are to achieve harvest separate from any cow-calf groups on HRWA through sorting

at HRWA headquarters, when possible. Each House Rock bison hunter on the new House Rock bison must sign a written acknowledgment that they have received, read, understand, and agree to comply with the requirements of R12-4-306. Each hunter is scheduled for their hunt, usually in the order drawn, is accompanied by an authorized Department employee, and must take only the bison designated by the Department. Authorized employees may assist in taking the bison if the hunter fails to dispatch a wounded bison given a reasonable opportunity, typically 2 shots.

Raymond Herd

Starting in 2018, harvest from the Raymond bison herd was separate from the main Raymond herd accomplished by sorting the herd prior to harvest. Harvest will still be closely managed by authorized Department employees to ensure favorable outcomes and are managed by Department employees per Commission Rule R12-4-306. Each Raymond bison hunter must sign a written acknowledgment that they have received, read, understand, and agree to comply with the requirements of R12-4-306. Each hunter is scheduled for their hunt, usually in the order drawn, is accompanied by an authorized Department employee, and must take only the bison designated by the Department. Authorized employees may assist in taking the bison if the hunter fails to dispatch a wounded bison given a reasonable opportunity, typically 2 shots.

F. Translocations:

A key goal for bison conservation nationally is to maintain genetic diversity and reduce cattle gene introgression, when and where possible, feasible and appropriate. Translocations are used to start new bison populations and also to maintain and improve genetics in existing herds. Section II History discusses past bison translocations into both the House Rock and the Raymond herds. Future translocations will continue to be necessary to maintain or improve genetic integrity and to maintain compliance with the MOU with WICA. Periodic transfer of bison will occur between bison populations of the WICA lineage and the Raymond bison herd. The purpose and intent of translocating bison to HRWA is first and foremost to re-establish bison site fidelity to HRWA (concentrate bison within HRWA per the KNF Forest Plan) and secondarily to improve the genetic integrity of the House Rock bison herd (see the Genetics section in ISSUES, CONCERNS AND OPPORTUNITIES). Any bison moved into Arizona must also be compliant with state law as administered by the state veterinarian's office.

1. An Environmental Assessment Checklist (EAC) and approved Bison Translocation Plan will be completed and in place for all proposed bison translocations per DOM I1.2. Both will include a description of the source of bison, whether that source is in state or out of state to include the bison lineage if known; capture and release methodologies and locations; and include any agreements in place with other agencies both in state and out of state, and planned monitoring of released bison.

2. Department personnel may capture bison using round up or baiting (bison cake or water) into capture corrals for larger capture operations or by immobilization drugs for capturing a small number of bison.

3. Captured bison can be transported to a release site in livestock trailers or by semi-truck livestock transport trailers. Animals will be released into corrals and holding pastures at any release site to acclimate to new surrounding and to destress from handling prior to release into larger areas. A satellite GPS collar should be attached to at least one young cow for monitoring purposes. Ear tagging or pit ear tagging may be part of the translocation depending on source and objectives.

G. Supplemental Feed and Minerals: Feed and mineral supplements are effective in acclimating bison to human presence, establishing site fidelity to a specified bison range, and moving bison from one area to another (e.g., a capture location).

1. Bison are attracted to salt and will readily use salt when available. Salt can be used as an attractant to a capture site, used to lead bison to new areas, and legally used when hunting.

2. Supplemental feed in the form of commercially produced "bison cake" is readily eaten by both the House Rock and Raymond herds. Bison cake has been used successfully with the House Rock herd to attract and capture bison on GRCA. Bison cake is used to move animals and aid in developing site fidelity of new bison to each wildlife area.

3. Bison cake specifically formulated for range conditions in the southwest was developed at the Ted Turner bison ranches in New Mexico. This special blend is proprietary to the Turner ranches. The Department has permission to use this proprietary blend which can be purchased from A.C. Nutrition in Roswell, New Mexico. Other bison cake is produced by feed companies in the mid-west at reduced costs, but that feed is not formulated specific for southwest range. A small amount of this other cake was tested at RWA in 2015. The Raymond bison readily ate this cake alongside the cake produced by A.C. Nutrition. Further testing of this other feed on a larger scale will determine which supplemental feed to purchase in the future.

H. Bison Fencing: Fencing is extremely important to manage and retain bison to specified range.

Background

Bison leaving both wildlife areas was frequent in the past and a chronic source of conflict with adjacent landowners, permitees, and land management agencies. Bison have traveled over 25 miles northwest of HRWA onto the North Kaibab Plateau and over 15 miles south of RWA. Bison fence standards vary slightly between RWA and HRWA due to the high number of elk crossings at RWA, which required a top cable wire and sometimes a bottom cable to prevent fence breakage. HRWA is different with no elk to contend with, but does experience high mule deer crossing on the northwest side. New bison fence standards are allowing safe crossing of deer, pronghorn, and elk at both wildlife areas. These standards have changed over time since first being implemented at RWA in 2013; as deer, elk, pronghorn and bison have reacted to them.

HRWA

HRWA has never been completely fenced due to rugged terrain, the Saddle Mountain Wildness (on which cattle do not graze) on the western boundary, and concern over interfering with eastside winter movement of the North Kaibab mule deer herd. The north boundary fence of HRWA must be maintained by the Department, per the 1950 KNF MOU (Appendix 4). Old remnant gap fencing on the west side of HRWA between steep features of the Cockscombs and in North, Fence, Wildcat and South canyons remain. These old gap fences are in various stages of serviceability. These gap fences may have helped contain bison to some extent on HRWA in the past, but according to old wildlife area managers the bison also went around them. Our plan is to develop HRWA site fidelity through the new APR bison, habitat manipulation, water distribution, new fencing, and affinity to the north end of HRWA for calving and breeding. The gap fences should not be necessary to concentrate bison

on HRWA. However, should these gap fences be determined necessary to achieve desired objectives, then adaptive management approaches will be implemented to achieve them. The 1950 MOU creating HRWA does not require or mention gap fence.

The north and northwest perimeter fence at HRWA was upgraded to the new bison fence standard (described below) in summer 2015. Additionally, a new northeast pasture (about 4,000 acres) was completed in summer 2016. In total, 12.7 miles of fence were rebuilt between summer 2015 and summer 2016.

RWA

RWA is surrounded by private land cattle ranches (Flying M and Bar T Bar) who lease checkerboard state trust land. Complaints about the Raymond bison herd are related to interference with livestock operations, consumption of forage, and damage to fences, corrals, and other improvements. The Department has responded to these complaints by gathering errant bison, mending broken fences and gates, and in some cases lethally removing offending animals. Boundary fencing on RWA has changed over time including electric fencing, 6-8 strands of wire extending to nearly 9 feet in height, use of hog wire panels, while also trying to allow safe passage of pronghorn, elk and deer. These fence adaptations have met with limited success.

The new bison fence design (described below) was developed and tested on RWA in 2013 with much greater success than past wildlife area fences. Since development, the new fence standard has been implemented on over 18 miles of perimeter fence, a cross fence and on an interior pasture fence at RWA.

NEW Bison Fence Specifications (2020)

- H-Braces: construct of welded 2 7/8” pipe or use juniper posts at ¼ mile intervals; if too rocky at the ¼ mile mark, drill rock a depth of 20” and use 2 7/8” pipe with auger set. Use live juniper trees if available w minimum of 10” diameter with protective wood stay collar around tree;
- T-posts: 6 or 6.5 footers every 20 feet;
- Wire: 5 strand fence at 46” total height:

  bottom wire- smooth wire (HRWA); cable in high elk crossing areas on RWA at 20”
  2nd wire-barbed at 26”
  3rd wire- barbed at 32”
  4th wire- barbed at 38”
  5th wire- smooth wire (House Rock); cable (Raymond) at 46”
- Cable support (when used): 6-7 foot wooden posts of at least 5” diameter every 250-300 feet with above ground height of 5 feet;
- Double strand tie wire of 18 gauge wire to attach ¼” cable to T-posts and wooden posts;
- Install 5 foot tall 2”x 2” wooden stays every 42” with the top of the stay 14” above the top wire/cable. This makes the fence look like it is actually over 6 feet tall and is key in tying the fence altogether making it look imposing to bison;
- Clear fence line of tree limbs a minimum of 4 feet on each side of fence.

I. Water Maintenance and Development

Maintenance of existing water developments is a high priority on both wildlife areas to anchor bison and other wildlife on these areas. Wildlife area managers are responsible for monitoring waters and making necessary repairs and maintenance.

House Rock Wildlife Area

South Canyon Spring supplies water to HRWA, including domestic water for headquarters. The spring box is about 3 miles up South Canyon off the southwest portion of HRWA. There are 10 water troughs fed through about 17 miles of pipeline, including the main pipeline and a spur line. The South Canyon pipeline was built in the 1930s and received upgrades in 1996 and 2015. Adjusting water flows to each trough on HRWA requires constant attention. A Certificate of Water Right on South Canyon Spring, dated 1950, is held by the Commission for 2,555,000 gallons of water per annum. The Kaibab National Forest also holds a Certificate of Water Right on South Canyon Spring for an additional 3,656,000 gallons of water per annum for domestic and stock watering. Currently, there are 3 additional wildlife catchments on HRWA that are maintained, with several more planned. The desire is to have water available to bison on HRWA to aid distribution, site fidelity to and concentration of bison to HRWA. Water distribution is also supplied to aid the eastside Kaibab mule deer population, mainly in winter, but also year round.

Per the 1950 MOU (Appendix 8) with the KNF, the Department agrees to maintain the pipeline and to pass sufficient water for 200 head of cattle to the pipeline on the BLM lands when available at the source. Balancing available water captured at the springbox at South Canyon Spring with domestic and wildlife (bison, pronghorn, deer and frog refugia's at Tank 3, 4 and 8) requires careful planning. Department engineers reviewed, evaluated and documented current pipeline structure in a 2014 report. Also, a hand shake agreement was developed between KNF, Grand Canyon Trust and the Department detailing how water from South Canyon Spring will be managed to meet the 1950 MOU.

Raymond Wildlife Area

There are 11 developed dirt tanks on RWA and 3 wells (East, Headquarters, and West). Off of these wells, there are 8 additional water troughs fed by about 7 miles of maintained pipeline. Six of these water troughs have water circulation systems installed to prevent freezing and are powered remotely with solar panels. Plans are to outfit all 8 troughs with circulation systems. Maintenance of the dirt tanks is covered by EAC# M10-10062330 Amendment 1 Raymond Wildlife Area Earthen Tank Management. The Commission has water rights to three wells at RWA. The Commission has an 1928 certificate of water right for 198 acre-feet per annum from "T" Tank Draw, a tributary of Canyon Diablo. The Commission also has a water right from Anderson Canyon, granted in 1947, for a canal system to supply water to some of the stock tanks. An agreement dating from 1948 provides for equal division of the waters from Tillman Ditch, which originates in Section 1, T18N, R10E and extends easterly for approximately six miles, between the Commission and the neighbors to the south.

J. Education and Outreach

Allowing for compatible outdoor recreational opportunities for future and current generations is stated within the Department mission statement. Bison are unique and desirable as watchable wildlife due to their size, their association with the "wild west," and their unique conservation history. Both wildlife areas have documented past visitation approaching 1,000 visitors per year and have attracted visitors from

throughout the United States and from as far as Europe and Japan. Allowing for bison viewing opportunities and public education of bison management issues is important to building public understanding and support for management of this iconic and largest of North American land mammals.

A visitor's center was built at RWA in 2014, with plans to expand bison outreach opportunities to tell the story of bison history, management, and conservation in Arizona and North America. In October 2015, a Bison Workshop was held at RWA with 32 people attending the 4-hour event. Attendees were served a "cowboy" lunch featuring bison burgers and brats. A new 125 acre pasture has been constructed to hold bison close to headquarters for sorting and allow for up close bison viewing. In the visitors' center, visitors can view bison videos, a bull bison mount, a bull bison hide, and bison skulls.

School groups from the Flagstaff area have visited RWA. In the last 10 years, school visitations have declined, due mostly to the Raymond bison herd having unfavorable herd behavior and being unavailable to see during trips. Changes in management at RWA have created favorable herd behavior and opportunities to emphasize bison as watchable wildlife.

A bison hide and aspen display frame has been built telling the story of Arizona's bison management. This bull bison hide has the bison story painted on the hide side and is used at outreach events to educate the public of our bison management, our two bison herds, and promote bison viewing at both RWA and HRWA.

Possible bison outreach events:

1. Raymond bison workshop in conjunction with National Bison Day the first Saturday in November
2. Bison photography workshop at Raymond May-July focusing on new born calves
3. Department Outdoor Expo
4. Bison hide display at other Department wildlife fairs
5. Bison hide display travelling to Department regional offices. New display case needs to be built

V. ISSUES, CONCERNS AND OPPORTUNITIES

There are many issues associated with managing bison. Bison are the largest terrestrial animal in North America and can be difficult to keep on designated range. Near extirpation in the late 1800s caused a population bottleneck and historical forced breeding with cattle left genetic integrity concerns with all free-ranging, public bison herds. With these challenges also comes opportunities for not only managing bison in Arizona, but for Arizona's management to contribute nationally to the conservation of bison through partnerships with other bison managers.

The following issues, concerns and opportunities are priorities for managing both the Raymond and House Rock bison herds currently and into the future. Important funding sources for management of Arizona's bison herds are through the Federal Aid in Wildlife Restoration Act and Bison Special Tag program.

A. National Bison Management Considerations

A Bison Conservation Working Group, comprised of bison experts including private bison ranchers, consultants, private and tribal association representatives, conservationists concerned about bison, and

bison researchers have produced a bison management guideline titled, "Bison Conservation Management: Guidelines for Herd Managers" (Appendix 2). This group's recommendations for managing bison are summed up into 3 basic steps:

1. Maintain the wild characteristics of bison, while avoiding domestication,
2. Conserve the genetic diversity and genetic integrity of bison, and
3. Restore and maintain biodiversity and ecosystem functioning.

It is important to remember these are recommended guidelines developed by a working group to assist bison manager's decision making and are not adopted or endorsed by the Arizona Game and Fish Commission or Department. These guidelines are designed to give bison managers a common set of factors to consider. If management of bison is considered at the continental scale and similar factors are taken into consideration, bison at the species level stand to benefit. Bison managers must consider the characteristics of each habitat, range, specific herds, and management goals when making management decisions. Interestingly though, Arizona's management in recent years reflects these guidelines, even though they were developed independent of our input or knowledge. While cattle gene introgression does not define the value of bison in Arizona, this plan outlines steps the Department may take in order to influence bison genetics while not disrupting wildlife related recreational opportunities or the Department's ability to manage bison.

Maintaining wild characteristics of bison can be achieved by allowing bison herds to interact with other bison herds. This is not possible between Arizona's herds as they are geographically separate. What we can do though is maintain a mix of age classes (calves, yearlings, and adults) and sexes, so natural herd behavior of passing learned behavior from adults to younger animals and allowing for natural selection processes to occur within a herd is retained. Allowing bison to interact freely with their habitat is also important to retain wild character and achieving functioning ecosystems. Additionally, maintaining a minimum general size of a range and minimal human handling are important to retain wild bison characteristics and avoiding domestication.

Current management of the Raymond herd to maintain the wild character of bison is more difficult than with the House Rock herd. RWA is surrounded by a mix of private, state, and tribal land on which several cattle ranches operate. There are no federal multiple use lands adjoining RWA, resulting in a management goal of containing the herd solely within RWA and not allowing the herd trespass on surrounding land. Additionally, RWA is smaller in size than HRWA at less than 15,000 acres. Management needs are balanced with the desire to maintain the wild character of bison and being good neighbors with surrounding cattle operations. In balancing these needs, decisions are sometimes made to remove more difficult animal(s) in order to keep the herd situated on RWA. For example, lead cows that do not allow managers to approach the herd or wandering bulls have been are removed in the past. Culling the herd is achieved through public hunting. Starting in 2018, all harvest on RWA will be separate from the main cow/calf herd(s), thus removing the main disturbance factor influencing undesirable herd behavior.

For smaller bison herds like Raymond, a goal for conservation is to have multiple similar aged bulls that are allowed to breed with multiple females. This allows for male competition, which is an important feature of natural selection. The sex ratio at RWA was widened to about 1 adult bull per 6 adult cows beginning in 2012. A narrower sex ratio than this created a situation where excess bulls formed bachelor groups, which roamed off RWA and only returned during breeding season. This resulted in many

complaints from surrounding cattle ranches and countless Department employee hours returning bison to RWA. Once the sex ratio was widened to a 1:6 ratio and the RWA perimeter fence upgraded to the new fence standard, the wide wondering of the Raymond herd ended. A narrower sex ratio of 1:2 or 1:3 (as suggested in the guidelines for conservation herds, Appendix 2) will be attempted with the WICA bison. The ratio can then be adjusted according to herd behavior and management needs. This ratio will still allow for competition between mature bulls for natural selection processes to occur. Breeding competition helps to reduce chances of genetic drift and inbreeding. In the agreement with WICA to replace the old Raymond bison herd, periodic transfers of both sexes will occur. The House Rock herd can be managed for a narrower bull to cow ratio and an older age structure to mimic natural bison herd demographics, allowing for natural selection.

Minimal human handling of bison also maintains the wild characteristics of bison. The Department has not rounded up either bison herd since 1971. Round up and sorting of bison will become an important future management tool. Out of state shipping to other WICA (per agreement) linage herds will require handling for tagging and vaccinations; having the ability to handle, sort and identify individual bison will be necessary. Such roundups may also aid in reestablishing bison site fidelity and future genetic management at HRWA. Once round ups and sorting bison for shipping or harvest are implemented, they will not exceed the recommended guideline of not more than once a year at either wildlife area.

Both the House Rock and Raymond herds are allowed to roam freely and interact with the environment as they desire. The smaller size of RWA can be a challenge, as there is a limit to that freedom, with the need to keep the herd to the wildlife area. HRWA is much larger, at 67,865 acres. Both bison herds are managed to maintain range biodiversity and ecosystem function, as each herd determines when and where to graze and rest.

B. Genetics and Linages

Genetic composition of both the House Rock and Raymond herds were discussed in Section III Species Assessment-Genetics. A Bison Conservation Genetics Workshop was held in 2008 and produced several recommendations for managing bison genetics (Appendix 3). Workshop recommendations were:

1. A moderate bison population size of about 1,000 animals is necessary to meet a long-term goal of achieving a 90% probability of retaining 90% of allelic diversity for 200 years. Bison herds with fewer than about 400 animals are unlikely to meet a long-term goal of achieving a 90% probability of retaining 90% of genetic heterozygosity for 200 years. Bison herds can be managed jointly, even if separated by distance to form metapopulations approaching 1,000 head.

2. Maximize the number of breeding males in a population. Bison studies have shown that there can be strong sexual selection in small bison herds. That is, the majority of offspring come from a small proportion of males, which reduces the effective population size and increases the loss of genetic diversity over time.

3. Bison herds with no molecular evidence of cattle ancestry constitute a genetic resource that must be protected from inadvertent cattle introgression and high priority should be given to expanding those populations to establish new bison conservation herds.

4. Bison herds with low (< 2%) cattle introgression are still very valuable and many contain important and unique bison genetics. Removal of individuals with cattle mtDNA may be warranted, but removal based on cattle DNA at nuclear loci could have unintended consequences of reducing overall variation. These bison should be augmented with bison of similar genetic makeup to increase the effective herd size.

5. When the level of cattle introgression is high, augmentation or systematic herd replacement should be considered, using animals made available from Department of Interior (DOI) herds or other sources that represent the same lineages. Genetic monitoring is a key part of management to determine the effectiveness of such an undertaking.

House Rock herd

The original House Rock bison represent a unique heritage of their own as they are descendants of some the last wild bison of the southern Plains bison herd that roamed the panhandle of Texas and northeast New Mexico. Jones also mixed in other bison he was able to purchase in the 1880s, including a group from Manitoba. The exact background of the animals Jones brought to Arizona is unknown. These bison were crossed with cattle from 1906-1909 and have been subsequently back bred with bison bulls over the last 100 years to a point where their nuclear DNA is comprised of < 2% cattle, but their mitochondrial DNA remains high from cattle. There was also an additional 40 bison translocated into the original House Rock bison herd since 1929 (refer to Past Bison Translocations into Arizona section).

The new APR bison at HRWA are descendants of bison from the last of the northern Plains bison herd from Montana and the Dakotas. These bison are descendants of a mix of mainly Elk Island bison (originally from Montana) in Canada and WICA lineages. APR bison remain free of cattle introgression and contain high bison genetic diversity.

Department direction and emphases is to manage the House Rock bison herd to be concentrated on House Rock Wildlife Area in support of long term bison conservation. This decision is heavily informed by the KNF Forest Plan. PIT and ear tags will be used to identify APR bison and any adult bison not identified by either tagging will be removed from the House Rock herd.

Raymond Herd

The Commission entered into a Memorandum of Agreement with the U.S. Department of the Interior, National Park Service, WICA in 2015 to replace the Raymond bison herd (Appendix 5). The WICA bison lineage is unique and distinct from other bison herds, and one in which cattle gene introgression has not been detected. The long-term conservation objectives of this agreement are to:

1. Establish a Plains Bison Conservation Herd that ensures a 90% probability of retaining 90% of genetic heterozygosity for 200 years (in reference to Genetic recommendation #1 above).
2. Establish an ecologically functioning population of bison possessing the Wind Cave lineage on Commission leased or fee-title owned lands comprising RWA. Establish a WICA lineage bison population that serves as a source for bison restoration.
3. Establish a population at RWA that enhances the long-term survival of the species genetically, behaviorally, and ecologically and that promotes range health and biodiversity.
4. Maintain a bison population at RWA capable of sustaining a variety of consumptive (hunting) and non-consumptive uses and contributing to the cultural, aesthetic, and economics of the public regionally and nationally.
5. Disseminate scientific information on reintroduction techniques and the ecological requirements for successful Plains Bison restoration.
6. Contribute to restoring and maintaining natural ecological processes and native biological diversity.
7. Periodically transfer live bison between WICA and RWA to facilitate genetic exchange between the RWA and WICA herd lineages and to accomplish mutual management and conservation goals. The founding and maintenance of a new bison herd at RWA will help to ensure the future preservation of genetically diverse bison by both expanding the total metapopulation size of the WICA lineage of bison and will build redundancy into bison populations thereby insulating against future risk.

The new Raymond bison herd will meet objectives of both consumptive and non-consumptive use through continued public hunting, bison viewing, and intrinsic value to the public while meeting the important elements of managing to retain wild characteristics and natural breeding selection processes. The new Raymond bison herd was founded with 46 WICA bison at no charge. The Department only paid transportation costs to ship from WICA to RWA in late October 2017. The old Raymond bison herd was removed prior to the WICA bison arrival.

C. Translocations

House Rock herd

The original House Rock herd represents an entirely different set of management challenges due to complexities of the herd residing almost entirely on GRCA, where Department authority and ability to manage the herd is very limited. The Department decided through collaboration with other bison managers and our own experiences of translocating original House Rock bison captured on GRCA to HRWA in 2014, that best way to develop bison site fidelity and concentrate bison on HRWA (as stated in the KNF Forest Plan) would be through the release of new naïve bison from an outside herd. Various potential sources for new bison were consulted and ultimately yearling bison from APR were available to the Department in late 2017. A MOU was signed between APR and the Department, where 15 yearling bison consisting of 10 females and 5 male, were transferred from APR to HRWA on December 1, 2017. These 15 bison were held in the corrals at HRWA until March 20, 2018, when they were released into the 4,000 acre holding pasture.

Raymond Herd

The old Raymond herd was replaced in October 2017. Replacing the old Raymond herd allowed the Department to enter into a new era of bison management. With a national bison conservation movement to conserve Plains bison without cattle introgression and the availability of WICA bison of known conservation value free to the Department, the Commission entered into a MOU with NPS-Wind Cave National Park (Appendix 5) to replace the old Raymond herd. The translocation of 46 WICA bison to create a new Raymond bison herd consisting entirely of WICA bison was completed in October 2017.The new Raymond bison herd will be one of several satellite herds of WICA bison herds managed in cooperation to reach a metapopulation of at least 1000 WICA bison.

D. Disease Surveillance

Annually conduct disease testing in Arizona's bison herds.

Raymond herd

1. Collect blood while sorting bison and test for Bovine Brucellosis, Anaplasma, Epizootic Hemorrhagic Disease (EHD), Bluetongue, Bovine Viral Diarrhea Virus (BVDV);
2. Collect fecal samples while sorting bison to test for Johne's disease.

House Rock

1. Continue to collect blood samples from harvested bison and test for Bovine Brucellosis, Anaplasma, Epizootic Hemorrhagic Disease (EHD), Bluetongue, Bovine Viral Diarrhea Virus (BVDV);

Lethally remove any bison from either herd testing positive for Bovine Brucellosis or Johne's disease and dispose of per Department Wildlife Health Program procedures.

E. Harvest Options

Managing the Raymond and House Rock bison herds allows the Department to provide unique hunting experiences. Bison are very susceptible to hunting disturbance though as the Department learned this lesson the hard way, as discussed in Section II. History-Past Bison Hunt Structure. Two hunting experiences will be available on the House Rock herd. Hunting the original bison is more challenging along the GRCA-KNF boundary on top of the Kaibab Plateau. These hunts are open public land hunts, in remote areas with lower hunt success. Adaptive approaches to hunting the original bison are continuously implemented since the bison found sanctuary on GRCA and will continue to be important as GRCA implements bison reduction actions.

A new hunt structure began in the fall of 2018 at RWA where harvest is accomplished separate of the main cow/calf groups. This hunt structure will also be implemented on the new APR bison at HRWA. With RWA being smaller in size and the need to tightly control human-bison interaction with highly regulated hunts led by authorized Department personnel, hunt success is typically 100%. As such, the RWA hunt is not a physically challenging hunt and is usually takes one day. Some sportsman prefer the easier hunt experience available at RWA, while others prefer the challenging hunting aspect of the original House Rock herd. Managing hunt options at both wildlife areas will continue to be important and will be the management tool used to achieve desired herd population objectives.

GRCA and the Department will continue to coordinate on the implementation of the Park's bison reduction actions and may necessitate additional management actions outside GRCA on KNF land as the original bison react to GRCA reduction efforts.

F. Bison Management Actions and Range Improvements

Range management projects that improve forage quality are an important component of bison management. Fire can be an effective tool to achieve improved forage, but has been absent from both areas for a long time. Advantages of fire include removing old woody vegetation to stimulate new grass and forb production, an earlier growing season (created by bare ground), an increase in forage production, and nutrient cycling. Fire may also serve to anchor bison to particular areas. With new bison at both wildlife areas, potential burning, other habitat improvement projects and infrastructure upgrades will assist in developing site fidelity. Planning is underway to determine feasibility, costs, funding sources, and development of habitat and infrastructure improvement projects.

House Rock Herd

Coordination is underway between Flagstaff regional staff and the KNF, North Kaibab Ranger District on feasibility, archeological needs, and desirability of developing habitat and infrastructure improvement projects on HRWA. All but 30 acres (Department base property) of HRWA is administered by KNF, so close coordination with KNF is essential.

Necessary Actions:

1. Continue meeting with KNF to develop long range bison infrastructure and habitat management plans for HRWA. Complete necessary EAC's for each project listed below.

2. Continue to meet as appropriate with GRCA to develop and initiate bison removal actions identified in the 2017 Bison Removal EA.

3. Improve bison management through upgrades to infrastructure at HRWA:
   a) Identify, plan and construct (when appropriate) two new bison waters in the NW and NE part of HRWA to aid in bison distribution and site fidelity. Construction of the NW water is a higher priority with a goal of being in place by December 2021.
   b) Construct a new 2-3 acre pasture on the eastside of the current corrals to aid in trapping and holding bison at the corrals also by December 2021.
   c) Replace the current corral at headquarters with a new functional and safe bison corral system with completion goal- October 2021.
   d) Identify, plan and construct a new West pasture. A new West Pasture will allow for an expanded range and continued concentration of the new APR bison currently in the NE pasture. This fence line will follow the old HRWA east-west fence identified in the 1984 AMP. The new fence will allow for a separation of the original House Rock bison should any return to HRWA during reduction actions on GRCA. New cattle guards will be installed, where necessary, with new fence construction. A completion goal for the new fence is December 2021.

4. Close the NE portion of HRWA to bison hunters drawn for original bison on the Kaibab Plateau to protect the new APR bison while they are developing site fidelity to HRWA. The rest of HRWA will be open for these bison hunters to harvest any original bison that may return to HRWA while reduction actions are ongoing on GRCA. Adaptive management will be implemented depending

on GRCA reduction success and bison movement. Selective harvest will occur on the new APR bison, when appropriate, to meet management objectives.

5. Translocate a second bison social group to improve genetic diversity of the new House Rock bison herd in late 2021 or early 2022. This second group of bison should remain in the 4,000 acre holding pasture a minimum of three years to complete three breeding and calving cycles, similar to that completed with the first group, prior to the gates being opened into the new West Pasture and them having any interaction with the first APR bison social group.

6. Test genetics of the new House Rock herd, as appropriate over time; and seek opportunities to partner with other bison managers where the new House Rock bison herd would be a satellite herd of a larger bison metapopulation, as currently in place with the new Raymond herd.

7. Due to its age, the South Canyon pipeline is at the end of its functional life. Besides a few standalone water catchments, all wildlife and domestic water at HRWA is provided by the South Canyon pipeline. There have been three documented breaks in this pipeline between 2018-2020. These are extremely difficult to repair. In 2020, the Department will initiate a study on how to tackle this pipeline replacement that will most likely be implemented in phases over the next 2-10 years.

Raymond Wildlife Area

Coordination is underway between Flagstaff regional staff, archeology staff, and Arizona State Forestry (who have developed a burn plan and are willing to conduct burning operations for the Department) to explore options and costs associated development and implementation of a burn plan for RWA. Additionally, infrastructure upgrades are being developed and planned.

Necessary Actions:

Regional staff will complete the following for burn operation planning:

1. Determine archeological survey needs, funding options and completion of archeological surveys;

2. Develop a burn rotation plan for RWA in coordination with Arizona State Forestry;

3. Complete necessary EAC's; and

4. Coordinate with surrounding Flying M, Meteor Crater and Hopi Three Canyon Ranches during the development of the burn plan and prior to any burn operations.

Improve bison management through upgrades to RWA infrastructure:

1. Complete new bison corral expansion by November 2020;

2. Plan and construct a new bison fence along the south base of Anderson Point to by-pass the difficult to maintain wildlife area boundary fence along the top of Anderson Point. Complete by December 2021.
3. Explore options of new water sites in Kroger pasture in the northwest part of RWA.

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Appendix 1. Native American Tribes of Arizona with connection to bison

Hopi

During the Hopi migration period in the SW, clans traveled up to the southern area of Utah, then across to Colorado. Starving and desperate, the clans, the Greasewood and other clans, were met by several bands of Utes. The Utes offered help providing the Hopi people bison robes for clothing and shelter. They also gave them supplies of food including bison meat and jerky.

The Greasewood clan leaders were thankful for the help and vowed to always remember the Utes for their friendship. After staying with the Utes for several more years, they traveled with the Utes who showed them the villages in the area now known as Mesa Verde National Park.

Later, the Clan decided to complete their migration and departed for a village called Hoo'ovi, the Place of the Arrow, now referred to as Aztec National Monument near present-day Farmington.

They later arrived at Orayvi (Old Oraibi) and settled there.

Years later, Orayvi received word that a band of Utes had arrived north of the village. A group of Hopi warriors met them and realized the Utes had come in peace. The Utes were in search of their Hopi relatives, the Greasewood Clan members.

So the Utes were escorted into the village and welcomed. The Greasewood clan was happy to re-unite with the Utes who they also considered their brothers and sisters. Surprisingly, the Utes had brought in a herd of bison as gifts for the Hopis!

After several years, the Utes went back home. The bison roamed NW of Orayvi and later migrated west to the Little Colorado River and beyond.

Today, the Hopi perform the buffalo dances to honor the Utes and the bison and the Greasewood clan occasionally perform the Ute Katsina and the Ute social dances to remember this history.

Leigh J. Kuwanwisiwma, Tepwungwa (Greasewood Clan)

Kaibab Piute story recorded by the John Wesley Powell expedition

to depart, Shin-au-av received a great quantity of cedar berries, and was told they were the seeds of the pine-nut tree. Then the travellers started for their homes, but when a little way off great fear came upon them, for Chai-ok, who was very wise, had concealed some pine-nuts in his top-knot, for he had discovered they were the true seeds. Then the travellers ran and Shin-au-av, burthened with his load of cedar berries, scattered them as they went. But Chai-ok kept the berries in his top-knot until he arrived on his own mountain where they were planted.

This is the reason why cedars grow on the lower hills and pine-nut trees, only on the mountains.

[MS 1795, unnumbered, p. 6 contains the following outline:

"Ong, the Canada Jay, Shin-au-av, Chai-ok, crested jay (?)

Shin-au-av, Ong and Chai-ok went to a distant land for pine-nuts to obtain seeds for they had heard of them. And when they drew near the people of that land said, Here comes Shin-au-av for pine-nuts; let us deceive him.

And they gave cedar berries to Shin-au-av, but pine-nuts to Ong and Chai-ok, and a great many to Chai-ok. And when they departed from the land and went a little way off they ran for they feared the people would follow and kill them. And Chai-ok could not keep up for he had a great load and the people followed and fell upon him and killed him. And Shin-au-av and Ong heard him scream and threw down the cedar berries and so they were scattered over the earth.

Ong threw his pine nuts away, etc., etc."[28]]

SHIN-AU-AV AND YAM-PUTS

[MSS 1795, no. 4; 794-a, no. 38]

Shin-au-av	The Wolf
Yam-puts	The Porcupine
Kuts	The Buffalo

One day Shin-au-av's wife told him to sharpen his knife and go out and cut willows for she wished to make a basket.

While he was cutting twigs down by the river side he heard a noise, and on examination discovered that Yam-puts was down by the brink of the river calling to Kuts to take him across, for he did not know how to swim himself.

On the other side of the river there was a great herd of buffalo, and after much entreaty, one of them swam across to Yam-puts' side and told the latter to get on his back; but Yam-puts demurred saying that he did not know how to ride. Then Kuts opened his mouth, and told him to get in there. This Yam-puts did.

Now the river was very broad, and the way seemed long to Yam-puts, impatient of his imprisonment, and from time to time he asked, "How far is it to the shore? How far is it now? Are we almost there?" and Kuts would answer, entreating him to be patient.

When they got to the land Yam-puts scratched Kuts' palate with his quills and set the huge beast to coughing. As last spitting Yam-puts out, the monster fell down dead. Then all the herd who were watching on the shore ran away, while Yam-puts said to himself, "With what shall I cut up Kuts?" and he searched about for some time for a stone knife.

Then Shin-au-av crossed the river, and came up to where Yam-puts stood, and asked, "What was that you were saying? Were you about to cut up the buffalo that I killed with my arrow?" Yam-puts answered not a word, but stood and looked. "I have a knife," said Shin-au-av, "let us cut him up."

As they approached Kuts, he said, "Whoever can jump over that buffalo shall wear his skin." And Yam-puts replied, "I can't jump, my legs are too short. I can only climb." But being urged he made the attempt while Shin-au-av laughed in great glee to see him waddle. Essaying to leap, Yam-puts fell back, but Shin-au-av jumped over and shouted in great exultation. Then they skinned Kuts and hung the meat in a tree, and when they had finished Shin-au-av killed Yam-puts so that he should get no share of the prize, and put his body on top of the meat, and returned home.

On his arrival his children rejoiced at his success and licked the blood from his hands as a great dainty.

Early the next morning Shin-au-av with his family went out to bring in the meat. As they came near the tree where it had been hung, they were astonished to find that it had grown so high that its top was in the heavens and that Yam-puts had been carried with the uppermost branches. They all gazed up in the tree for a long time until at last the son of Shin-au-av saw something in the top of the tree and said, "Father, the meat is up on the tree yet." Straining their eyes once more they could all see the meat and Yam-puts with it. They all shouted to Yam-puts to drop them a piece of the meat but he answered that he was hungry and needed it himself.

Shin-au-av told his family to stay and watch, for Yam-puts would be compelled in time to come down and then they could kill him again. When they were all tired they laid down under a tree and slept.

Then Yam-puts sharpened one of the large bones of Kuts with his teeth but left the meat on the other end, and dropped it upon Shin-au-av who was lying below and pinned him to the ground.

Then he descended from the tree while Shin-au-av's family ran away.

Navajo

The Dine' Story About Buffalo

This is the story that was told to me regarding buffalo that once ranged within the four sacred mountains. A band of Dine' (The People) used to follow the herd around for food, shelter, medicine, etc. They were considered to be sacred because they were the main livelihood for the People. As they ranged within the four sacred mountains, the People followed them. Reference was made to San Francisco Peak (western boundary). The origin of this story was here.

There was a vision that came to the leader of this band of Dine'. He had this vision in early dawn. In this vision, the herd was bedded down and the people camped near the herd. Somewhere in the early dawn, the leader dreamed there was a young calf that left the herd and came towards the camp from the east. The she calf came near the camp and as it came closer, it turned into a beautiful young Indian maiden robed in a buffalo hide. She approached the leader's dwelling and stood at the doorway. The maiden spoke to the leader of the Dine' and told him there are hard times coming from the east. There's going to be death and the herd might be wiped out. The maiden said there's going to be a time where they will be slaughtered by the thousands. They knew the People that followed the herd depended on the herd and that they held the herd sacred. They depended on the herd for food, shelter and clothing. They coexisted with the buffalo for many years. However, the prophecy says they fear for themselves and they knew they may be subject to death. The buffalo talked among themselves and wanted to avoid this by traveling to the north, the dark world. They knew they would be slaughtered anyway but maybe the dark world will have mercy on them. If they leave, the People will have to find other resources or they can follow the herd north. The maiden then left it up to the People. She turned around clockwise and went back to the east. As she walked away, she turned back into a buffalo.

The next morning, the leader thought about his vision and called his elders together and told them about the visit. Some believed him and some didn't. However, the leader was highly respected by the people and therefore, most believed in his vision. They discussed it among themselves and asked, "What are we going to do if they really leave us? Are we going to follow them? To the north is the land of the dark and we don't know what is there". The people talked about it. Some believed that you are not supposed to go to the dark world and it's the spirit world. Some were afraid and wanted to stay but were uncertain on how they were going to get by without the herd. Some said they were going to follow the herd. The People are also going to be oppressed and experience hardship too. The People were divided.

Shortly thereafter, the buffalo gathered and the lead buffalo headed north and the rest followed. The people watched and then followed the buffalo. At the border, some of the people followed the herd and others stayed behind. The elders talked and decided to divide the smoke and tobacco of the People and told the People to go ahead and go and maybe one day, we will unite again. One day they would reunite through the tobacco, language, culture and they would recognize one another. The People that stayed behind represent the current Dine' in the Southwest region. The People that followed the buffalo to the north are now located in Canada and are also known as Dine' and speak similar Athabascan language and have similar customs as the Dine' in the Southwest region.

Among the Dine' these stories were unwritten and were passed on from one generation to another. Some of the things were spoken by elders and my great uncles told me the good times as we know it will not last forever. Four things will happen:

1. The clanship (ke') will disappear.
2. The language will also disappear. There will only be one language.
3. There will be a lot of leaders and the direction is going to be confusing. There will be a lot of bickering and chaos and will be ineffective. The way of the true Dine is going to vanish. Culture and tradition will vanish. Efforts now are to bring back Navajo tradition and culture.
4. There will be a reunification that will occur. The Dine' will venture north and this happened in the late 1980's under the leadership of Peterson Zah. They ventured north and the reunification occurred between the two groups. The relatives in the north acknowledged similar stories and gave the People three buffalos to bring back to the four sacred mountains. The buffalo did not adjust to Dine' country in the southwest and eventually died.

Currently the prophecy that was made is happening now on the Navajo Nation.

Places on the Navajo Nation are called buffalo. For example, Buffalo Spring (Iyanbito) in New Mexico. Two religious healing ceremonies involve buffalo: the Shooting Way (Na'at'oliijí) and the Flint Way (Béeshee) chants and include Buffalo parts in these ceremonies.

Havasupai

Oral history and ethnographic sources indicate the Havasupai had contact of some sort and traditions associated with bison. The catholic father mentioned in the written record section was a Father Francisco Garces', who wrote of 'buffos' when visiting the Havasupai.

Hualapai

According to customs, the "Walapai" hunted most large game animals, except elk and bison. Only a few bison made it to "Walapai" country and because of their large size, were left alone.
(Memoirs of the American Anthropological Association, edited by A.L. Kroeber, hunting chapter by R. 9 McKennan)

Yavapai-Apache

There is an old Dilzhe'e Apache story regarding the tribe's cultural hero and the killing of the last buffalo in their region. The tribal archaeologist believes this to be an event that has come down as oral history from a time when there were buffalo in Arizona. (story reprinted from "Initial Bison Herd Reduction Environmental Assessment" by Grand Canyon National Park)

Appendix 2. American Bison Association Bison Conservation Management-Guidelines for Herd Managers. These guidelines have not been adopted by the Arizona Game and Fish Commission or Department and serve only as a reference material.

Bison Conservation Management: Guidelines for Herd Managers

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Cover photo by Diane Hargreaves

Bison Conservation Management: Guidelines for Herd Managers

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About The Bison Conservation Working Group

The Bison Conservation Working Group is comprised of experts including private bison ranchers, consultants, private and tribal association representatives, conservationists concerned about bison, and bison researchers. The Working Group was initially convened to create scientific research-supported guidelines for private bison herd managers interested in supporting more rigorous principles for bison conservation management. As the group's work progressed it became apparent that the guidelines should focus on outcomes rather than the type of landowner. With this in mind the Working Group changed its direction slightly and shaped a document that could be used as a tool by managers of any type of herd—regardless of whether it was a public, private, or NGO managed herd.

The Working Group attempted to use the latest and most widely-recognized scientific and management information on bison biology and conservation as a framework for designing guidelines that herd managers can adopt to conserve bison as a wild species. However, the Working Group recognizes that much research remains to be done to help answer important management questions. Thus, it is expected that these guidelines will be regularly updated by the Working Group as more information becomes available. These guidelines are the result of a collaborative effort and not the possession or production of a single person or institution.

The guidelines will be subject to change based on public comment and new scientific information. They can complement other initiatives and are intended to incorporate findings from other bodies of work. This tool is meant to be used on a voluntary basis.

Photo by Dennis Lingohr

Introduction

Beginning with the ancestors of today's bison, various species of bison have inhabited North America for at least 300,000 years (Potter et al. 2010). The continent now harbors one species, the American bison (Bison bison), which consists of two subspecies: the wood bison (B. bison athabascae) and the plains bison (B. bison bison). At their peak population, bison herds of tens of thousands of animals roamed across the North American landscape. Wood bison ranged as far North as northern Alaska and the Northwest Territories while plains bison's range nearly spanned North America from coast to coast (including Canada, northern Mexico, and the United States). Within the last 200 years, the continental bison population decreased from 30-50 million to roughly 1,000 in 1889 before rebounding to around 400,000 today (Gates and Ellison 2010).

During this time, bison were a source of food for multiple species (including humans), were a major grazer of grasslands, formed wallows that created mini-wetlands, and in various other ways strongly shaped many North American ecosystems (Freese et al. 2007).

Bison were also integral to Native American culture, and in the words of John Lame Deer:

"The Buffalo was part of us, his flesh and blood being absorbed by us until it became our own flesh and blood. Our clothing, our tipis, everything we needed for life came from the buffalo's body. It was hard to say where the animals ended and the human began."

This relationship has been in place since "time immemorial" with many of the Tribe's creation stories including bison. Upon the demise of the bison and the subsequent efforts at reintroduction the relationship has survived. The restoration effort has required a variety of management methods to preserve the dignity of the bison and further the Tribe's needs. The goal of the First Nations in restoration is to facilitate a return to that historical relationship with bison that accommodates the demands of today's varying societal situations.

The vast majority of bison are currently managed by private enterprises. Of the roughly 400,000 animals in North America, an estimated 93% are managed by private enterprises (nearly all plains bison); the remaining 7% are in government and non-government organization herds (Gates and Ellison 2010). The current prominence of private ownership of bison reflects the early history of bison conservation whereby the seemingly inevitable extinction of bison in the late 19th century was averted in large part by private landowners (e.g. James McKay, Charles Goodnight, Walking Coyote, Frederick Dupree) who rounded up the few remaining plains bison to establish herds that eventually became the founding stock for nearly all public and private plains bison herds today (Potter et al. 2010).

There are some potentially important differences between private and public herd management that may impact the species over the long term. It is important that the effects of these potential differences be understood and that management be adjusted to assure that bison remain the species we all care about. Two of the most notable differences between public and private herd management are the disparate commercial end goals and the variation in uses of fences. Private herds mostly have a primary end goal of selling meat and by-products to support livelihoods, while public herds are managed in pursuit of the government agency mandates. Fencing, the other significantly different aspect of management, can be used to maximize feeding and control animal movement. Almost all herds encounter fencing; however, the extent and frequency of fencing are by and large higher on land with private herds for the purpose of grass and animal management. The consequences of such management may lead to different pasture use or behavioral outcomes. The implications of this use of fencing are not yet known and therefore require further study into how it will affect bison behavior and the ecosystems which they inhabit. In spite of these differences in management, public and private herds contribute significantly to ensuring bison survival.

Photo by Diane Hargreaves

Photo by Diane Hargreaves

Species extinction can occur via two avenues:

1) the last individuals of a species die, or

2) the genetic makeup of a species changes substantially over time, whether through natural evolutionary processes, anthropogenic selection, or hybridization resulting in the extinction of the species' distinct genetic material (Freese et al. 2007).

Anthropogenic selection includes domestication wherein, over several generations, traits are purposefully selected for human needs thereby resulting in detectable changes in morphology, physiology, and behavior between the domestic and their wild progenitors (Boyd 2010). Bison narrowly escaped the first form of extinction in the late 1800s, but now conservationists are concerned that bison face the second form of extinction or, at the least, the loss of the bison as a "wild" species. These concerns originate from the number of bison in non-commercial herds as well as the exposure of bison to evolutionary pressures that shaped the species. Currently there are about 20,000 plains bison (and 11,000 wood bison) in public and NGO managed herds. A large majority of these and commercial herds number fewer than 400 animals, which decreases the potential gene pool for breeding in these herds. Some of the ecological interactions (e.g., big predators and ranging patterns) that shaped the evolutionary history of the bison are largely disrupted. This small number of animals in public herds also raises concerns about a loss or significant change in the genetic diversity of bison (Gates and Ellison 2010). Three genetic issues are of particular concern:

1) the small size of most bison populations, which exposes the species to inbreeding and loss of genetic diversity;

2) artificial selection of bison for specific traits such as rate of gain, color, or docility;

3) introgression of cattle genes in the bison genome—a legacy of early attempts, around the turn of the 20th century, to cross breed bison and domestic cattle (Boyd et al. 2010).

With appropriate management, the wild character of bison can flourish despite dramatic changes in land use across the former range of the plains bison over the past 200 years. Careful attention to maintaining the wild character of bison, natural selection in herds, and the bison's historic influence on ecosystems may lead to considerable success in both conserving the wild bison genome and the biodiversity of bison habitats. Management decisions in pursuit of the aforementioned goals happen within the confines of both a range bounded by fences and the practical social and economic realities that range managers must consider when making their herd management decisions.

As many conservation organizations, government agencies, tribes, academics, bison associations, and private enterprises work toward long-term restoration goals, it is important to take provisional steps to restore and conserve the genetic and

Photo by Diane Hargreaves

behavioral traits of bison that so strongly influence the ecosystems they inhabit. Unfortunately, bison herd management options are limited by jurisdictional boundaries as well as conflicting land uses, such as agriculture, energy, and housing developments. These factors restrict the size and availability of large areas for full ecosystem conservation approaches, and therefore require that a set of population and genetic tools be made available to help herd managers undertake practical steps toward bison conservation.

Goal

The main goal of these guidelines is to help herd managers conserve the wild characteristics of bison through the conservation of the species' genetic and behavioral traits while at the same time supporting ecosystem function and biodiversity conservation goals on the range the herd inhabits.

Principles

This document offers a recommended set of guidelines intended to help bison managers manage their herds to achieve conservation outcomes for the species and the ecosystem. The guidelines are based on elements of the "Vermejo Statement"[1] (Sanderson et al. 2008), *American Bison: Status Survey and Conservation Guidelines 2010*, as well as other scientific information and the practical experience of herd managers, conservationists, and experts participating in the Working Group. The Bison Working Group does not presume this to be a definitive document. Rather, these guidelines must be periodically updated as new scientific information emerges and experience is gained in managing commercial and public bison herds. Finally, these guidelines aim to meld existing science with the economic and social realities of bison herd management in North America.

To contribute to conservation outcomes for the species and the ecosystem in a holistic manner, these guidelines encompass three specific principles of herd management:

I. Maintain the wild characteristics of bison while avoiding domestication.

II. Conserve the genetic diversity and genetic integrity of bison.

III. Restore and maintain biodiversity and ecosystem functioning.

Outcomes

While addressing these three principles, the guidelines are designed to allow for a certain degree of flexibility and adaptation based on the characteristic of each habitat, range, or herd. At the same time, it is also true that these guidelines will recommend minimum levels for herd size and range size. These performance thresholds will restrict which bison herds can qualify as conservation

1 http://www.americanbisonsocietyonline.org/ LinkClick.aspx?fileticket=lF9Z%2BqPNtm0%3D&tab id=3140

herds[2] by implementing management proposed in the guidelines. For example, these guidelines propose a minimum range size of 5,000 acres and a minimum effective population size of 500 breeders (see definition of effective population size in the glossary).

Use of these Guidelines

The central goal for creating the guidelines is to promote the implementation of better management practices by bison managers in North America to achieve conservation goals. The guidelines can also act as a stimulus and mechanism to create greater awareness of and initiate dialogue on issues concerning the need to conserve and maintain the genetic integrity and wild characteristics of bison while maintaining the economic viability of managed bison herds. These guidelines can also be used to determine the number of bison in public and private herds in North America that meet the criteria outlined in these conservation guidelines.

The guidelines have been developed to specifically apply to plains bison and are not intended to apply to wood bison.

Conservation Herd Ratings Based on the Guidelines

Not all bison herds can readily meet the standards set out in the guidelines, yet aspects of the guidelines can be followed by most herd managers. By recognizing differing levels of conservation achievement, we can involve every bison manager who wishes to make a contribution without diluting the standards of conservation so that they are no longer scientifically valid.

The following designations describe the graduated rating of adoption of the principles of conservation herd management from most to least aligned with the guidelines:

Bison conservation herd with ecological restoration—This herd is managed to achieve the outcomes associated with all three principles of herd management laid out in the guidelines (i.e. "wild characteristics," "genetic diversity and genetic integrity," and "biodiversity and ecosystem functioning"). This herd is located within the species historic range in an ecosystem where herd management is contributing to maintaining or recovering native rangeland, other native animals (mammals, reptiles, amphibians, birds, insects etc.), and local endangered or rare species. This herd also meets the following criteria for a Bison conservation herd.

Bison conservation herd—This herd is managed to achieve the outcomes associated with two of the three principles of herd management laid out in the guidelines (i.e. "wild characteristics" and "genetic diversity & genetic integrity"). This is a herd that fully adopts all management standards necessary to meet the objective of promoting the behavioral and genetic qualities of bison to retain their wild characteristics and continued exposure to selection by natural evolutionary pressures.

Photo by Dennis Lingohr

2 The IUCN's American Bison Specialist defines a conservation herds as "wood and plains bison populations managed by national or state/provincial public governments and non-governmental organizations whose primary mission is nature conservation" (Gates and Ellison 2010). These guidelines broaden the scope to focus on results of herds managed for conservation outcomes, regardless of ownership classification.

Ecological conservation will improve ecosystem function throughout the bison's historic range and enhance the reputation of bison owners and managers.

Photo © WWF by Dennis Jorgensen

Contributor to Conservation Herd— This herd does not meet all of the standards for a bison conservation herd but management practices encourage healthy pastures, genetic diversity of the bison, and a non-interventionist approach to handling (or not handling) bison and overall management practices are ecologically sustainable.

The reason for having the graduated levels of compliance in the guidelines is that we have incomplete information concerning how evolutionary feedback operates on bison living in populations and habitats of different sizes. Until we identify thresholds that affect the evolutionary trajectory and understand the effect of those thresholds, we think it important to consider a conservation herd as meeting all stated goals and standards for bison conservation. At the very least, ecological conservation will improve ecosystem function throughout the bison's historic range and enhance the reputation of bison owners and managers.

The Three Principles of Bison Conservation Management

Principle I: Wild Bison Character

Central to bison conservation, as with other species, is the maintenance of the species wild character. It is believed by some that present herd management can remove a number of essential social and behavioral traits that can lead to erosion of the wild nature of bison. To maintain wild character of bison, bison managers should follow these five guidelines:

- **A.** Allow bison to interact with other bison
- **B.** Maintain a mix of age classes and sexes
- **C.** Allow bison to interact with their habitat
- **D.** Maintain minimum general size of a range
- **E.** Minimize human handling

The following subsections detail each of these five guidelines:

A. Allow Bison to Interact with Other Bison

Larger and more diverse herds will allow richer interactions. Managers should allow these interactions with as few restrictions as possible. Special attention should be paid to maintaining a family group structure that resembles that of natural populations wherein matrilineal groups are the norm (Gross et al. 2010).

B. Maintain a Mix of Age Classes and Sexes

Herd management should encourage wild behavioral outcomes by allowing for mixed age classes within a herd. Such contacts will allow for a variety of behaviors within the herd and allow younger animals to potentially learn certain behaviors from older animals. Critical to the maintenance of a healthy herd comprised of diverse age classes and sexes is to avoid systematic removal (harvest or culling) of animals; examples of random selection are outlined later in the document. Harvesting animals above a certain age (e.g. all animals more than 10 years old) might lead to elimination of some behavioral traits. Older animals, including some that are post-breeding age, help ensure a diverse age structure, and their social and ecological memory may influence herd social behavior and foraging patterns. Older animals may exhibit behaviors, such as wallowing and horn rubbing, not always demonstrated by younger animals that may influence ecosystem structure and processes. Furthermore, a natural diversity of age classes may create various forms of competition (e.g. for food resources, breeding, social hierarchy) and social interactions that favor natural selection instead of human-driven selection.

Photo by Diane Hargreaves

The herd's genetic health is significantly affected by the sex ratio of breeding males to breeding females, the interactions between different age classes, and herd size (see "Small Herd Managers" section,

The minimum size of a ranch suggested to make a modest contribution to the bison's role in ecosystem functioning is currently 5,000 acres of rangeland.

Photo by Duane Lammers

p. 17). The ultimate goal is to emulate the age structure of the largest existing mixed age class herds. Assessing "natural" social structures is difficult because existing herds have been subject to a variety of management techniques (Brodie 2008). The proportion of calves, yearlings, and cows will vary between populations and across time (Brodie 2008). In spite of the difficult nature of such an assessment, several studied populations demonstrate a range of 10 to 42 yearlings per 100 cows. In protected area populations (Brodie 2008), the number of calves have been shown to range between 31 and 35 per 100 cows. These variations provide some guidance concerning approximate targets, and more data should be sought to better understand the demographic structure that herd managers should aim for.

C. Allow Bison to Interact with their Habitat

Just like bison should be left to interact with other bison, herds should be allowed to interact with their habitat. This implies that bison would be allowed to engage in natural foraging throughout the year. Herd managers strive to continuously reduce supplemental feeding, and implement it only when absolutely necessary. Grasses, forbs, and sedges are the recommended supplemental feed. If possible, bison should also have the full complement of species that correspond to the natural ecosystem in which the herd in question exists, including predators, parasites, and competitors.

D. Maintain Minimum General Size of a Range

The minimum size of a ranch suggested to make a modest contribution to the bison's role in ecosystem functioning is currently 5,000 acres of rangeland (Sanderson et al 2008). This minimum range size is an attempt to replicate the natural roaming patterns of a bison herd and their effect on the rangeland. It is likely that the area required by a herd will depend on the ecoregion (see map in Appendix 1) and its forage productivity, as well as seasonal and longer-term variations in rainfall and other factors affecting productivity. Consequently, more productive ecoregions with higher

carrying capacity may have similar herd sizes in a smaller ranch than less productive ecoregions. For example, given that a portion of the bison are managed in the mixed grass prairies of the Northern Great Plains, there will need to be a considerably larger amount of land to carry an effective herd of 500 animals. Therefore, a herd manager should ensure that the stocking rate does not exceed the range's carrying capacity.

Bison ranges smaller than 5,000 acres may contribute to conservation efforts, but this will require engagement in maintaining genetic and behavioral traits in smaller herds. For example, herd managers may engage in collaborative management among two or more bison ranges located near each other, so they can effectively assemble 5,000 or more acres of total land area. Similarly, exchanges of animals among cooperating managers may increase the effective population size of the herd (see "Small Herd Managers" section, p. 17)

In order to more fully contribute to large scale ecosystem restoration, the "Vermejo Statement" estimates that 50,000 acres or more will be required as a range to have a "large" contribution to ecosystem restoration through bison management (Redford and Fern 2007).

There have been several research studies undertaken to determine the home range of large species, like bison[3]. This information supports the above size of 5,000 acres as a minimum guideline for conservation activities.

E. Minimize Human Handling

Ideally, bison should be worked (through the corrals) once a year or less. This will allow reduced stress for the bison, and minimize negative behavioral impacts, injuries, and mortality that may result from round-up and confinement. Exceptions to this guideline may result from the need to manage parasites, disease outbreaks, and other unexpected or urgent management needs.

Principle II: Bison Genetic Diversity and Genetic Integrity

Building genetic integrity and maintaining genetic diversity within a bison herd is important for resistance to disease, maintenance of reproductive health, long-term adaptability, and a host of other biological traits. Managing a single bison herd's genetic health as well as the genetic health of all North American bison has been complicated by cattle DNA introgression. The effects of cattle DNA introgression in bison are not well understood and considerable research is being conducted on this issue. Nevertheless, there is general agreement that introgression should be assiduously avoided in bison herds that show no sign of introgression, and introgression should be minimized or maintained at low levels (preferably under 5% of genetics) where it exists. An aggressive strategy to "weed out" cattle genes from a herd should also consider the possibility that some unique bison alleles could be lost in the process. Thus from a species perspective, it is important to work towards reducing cattle introgression without reducing the bison

Photo by Dennis Lingohr

3 e.g. van Duren 1983, Fortin et al. 2009, Fortin et al. 2002, Krasinska et al. 2000, Linstedt et al. 1986, Mysterud et al. 2001 and Plumb et al. 2009.

genetic diversity. For the purposes of this document, wood bison genetic introgression will be treated as cattle genetic introgression until further scientific information comes to light.

A specific challenge to managing a bison herd is the need to balance the financial viability of an operation with the need to avoid undue influence on the natural selection processes that have shaped the wild bison genome. The objective here is to maximize the influence of natural selection while minimizing the effects of human selection based on selective harvesting or culling methods. For example, the long-term effects of domestication are apparent in domestic cattle where intentional selection has resulted in an animal that is dependent on human management and has produced anatomical abnormalities such as a smaller pelvic girdle, which causes calving difficulties and, in general, a species that is no longer wild and is maladapted to the natural environment (Boyd et al. 2010, Gross et al. 2010).

The following four criteria are intended to maintain herd genetic diversity and natural selection processes, as well as to manage cattle introgression:

A. Utilize a random (harvesting or culling) selection model

B. Maintain breeding competition and minimum recommended effective population size

C. Develop alternative genetic management for small herds

D. Manage cattle genetic introgression (genetic testing)

The following subsections detail each of these four guidelines:

A. Utilize a Random (harvesting or culling) Selection Model

As mentioned above, human selection can lead to rapid erosion of genetic diversity in a herd. Therefore, bison should not be selected for harvest based on specific traits. For example, the current scientific literature has demonstrated that trophy hunting for big game animals can have surprisingly fast and undesirable genetic consequences. For example, trophy hunting of bulls targeted for big bodies, wide heads, or big horns may result in a population where these traits are less frequent.

Example 1.

One example of random selection consists of an annual 20% replacement for females, in which the first year, every 5th animal through the chute would be held for replacement. Then the second year might be the first 20% of females through the chute, and then the third year might be the middle 20% through the chute. At the fourth year, the whole procedure can be repeated.

Herd managers are encouraged to vary their random selection models, as well.

Similarly, breeding for a single-trait (e.g. color, carcass type, specific body conformation etc.) should be persistently avoided. Whether the harvest is conducted by round-up, hunting, or other means, care should generally be taken to avoid systematically removing animals with specific traits that would not, under natural conditions, be subject to mortality through disease, predation, and other natural causes.

Some exceptions to consider include the removal of particular animals with behavioral traits that affect handling, such as animals that leave the herd to charge handlers. Artificial genetic selection will most likely not occur if the herd is relatively large (several hundred animals) and an animal is occasionally removed for behavioral reasons. However, a repeated pattern of selective removal of aggressive animals may lead to docility traits in a herd that run counter to the wild nature of bison. Another potential removal from the herd may include animals that are

not participating in breeding. If present, predators would likely take severely weak or ill animals, particularly if they leave the protection of the herd. Managers should also avoid the systematic removal of females that have missed one year of reproduction. It is believed a random selection model, while not meant to replace natural selection processes, can allow enough variation in harvest methods from year to year to mimic natural processes. However, herd managers should investigate potential causes of failed breeding that might be corrected. Using tools such as blood tests to check for mineral deficiencies and diseases can lead to answers to these questions.

Photo by Diane Hargreaves

B. Maintain Breeding Competition and Effective Population Size

A conservation herd should include multiple bulls that are allowed to breed with multiple females at a given time. This allows for competition among males, an important feature of natural selection under natural conditions.

The goal of herd managers, given the following information, should be to emulate natural bison populations as much as possible. There are two extremes that are feasible for these guidelines. On the lower end of the spectrum, a sex ratio of 1 male to 10 females will require a larger total population to have an effective population with little risk of genetic drift. A sex ratio of 33–40 males to 60–67 females is a preferable option that managers can strive for. It is believed that a sex ratio outside of these bounds will lead to some negative impacts on the conservation of the herd's genetic resources, especially with a herd that has a sex ratio below 1 male to 10 females.

Studies have shown that a sex distribution of 33–36 males to 67–64 females (adults and young combined) is generally found under natural conditions (Brodie 2008). Gross (2010) places the sex ratio at 40 males to 60 females. It is also possible that the proportion of breeding males may be smaller than breeding females because males mature later and have a higher mortality rate. Intermediate sized herds, which range between 250–750 animals, will need more active management to ensure long-term genetic health, while larger herds of more than 750 and into the 2,000–3,000 range will require less active management (Gross et al. 2010). These larger herds will likely need 20 or more mature bulls per 100 cows. The breeding competition will help reduce chances of genetic drift and inbreeding, in combination with the monitoring and maintenance of an effective population size.

"Effective population size" is a technical term that specifically refers to the total number of breeding individuals under theoretically ideal conditions that contribute to the genetic diversity in an isolated population. These ideal conditions are seldom if ever attained in real populations. However, because not all breeding animals are capable of breeding, the effective population size is generally smaller than the actual number of mature animals in the population (called the "census population size"). In species populations with a highly skewed sex ratio (polygamous species) the effective population size is much smaller than the overall number of mature animals in the herd. General recommendations, assume that the "effective population

size" of a conservation herd should be a minimum of approximately 500 breeding animals (this is based on scientific recommendations related to extinction probabilities for isolated populations—see Appendix 2 for further details on Census vs. Effective Population).

For example, if a bison herd[4] has an adult sex ratio of 1 male to 10 females, a population of about 1,500 adult animals are needed to achieve an effective population size of 540 (see example in Appendix 2, Table 1). A more skewed sex ratio requires a larger herd to achieve a desired effective population size. In a herd with a ratio of 40:60 males to females, the effective population size would be 100. In a herd with 1,500 animals and a male to female ratio of 1:5, the effective population size is 1,000 animals. For a herd with a total size of 2,000 animals and a male to female ratio of 1:15, the effective population size is 500 animals.

4 Note that our use of the term "herd" should not be confused with groups of animals that often form within herds and do not consistently associate, but among which breeding generally occurs.

C. Develop Management Practices for Small Herds

The Working Group acknowledges that some bison managers may not be able to achieve the proposed minimum range of 5,000 acres and minimum effective population size of 500. Those managers still interested in participating in the bison restoration initiative can implement an animal exchange program that mimics these conditions. For example, owners of small bison herds can create the equivalent of a large herd and reach the effective population size goal of 500 by periodically exchanging breeding animals with those from other producers' herds. This will require careful planning of the appropriate combinations concerning sex, number of animals, and frequency of exchanges. In one example, if three managers who each have 300 animals regularly exchange animals they have effectively created a total population

Owners of small bison herds can create the equivalent of a large herd and reach the effective population size goal of 500 by periodically exchanging breeding animals with those from other producers' herds.

Photo by Diane Hargreaves

size of 900. Careful attention to breeding effectiveness, such as increasing male to female ratios as close to 1:1 as possible, may even increase the effective population size to close to 500, and thus these three managers will be able to maintain the genetic diversity of the cooperative herd (i.e. a "metapopulation"). A potential scenario for such exchanges is that new individual breeders should be introduced to the herd every two to six years to maintain diversity if the herd size is below the effective population size of 500. Bringing bulls into the herd is generally a faster and more effective way to introduce genetic diversity than bringing in females. The bulls should come at a young enough age to integrate them into the social cohort of the herd while not impacting herd health. Managers should be attentive to avoid introducing diseases with exchanged animals.

Photo by Diane Hargreaves

D. Manage Cattle Genetic Introgression

Because of attempts to hybridize bison and cattle around the end of the 19th century and beginning of the 20th century, cattle gene introgression remains a threat to the genetic integrity of wild bison and requires close attention by herd managers. This genetic introgression has occurred both in the mitochondrial DNA and nuclear DNA. However, the effects of cattle gene introgression on bison biology are poorly understood and no upper limit has been established for the percent of cattle DNA in bison. More research on this issue is required before more detailed recommendations can be made.

Managers should attempt to reduce the degree of cattle gene introgression where feasible and where such efforts do not jeopardize bison genetic diversity. Managers should be cautious in their attempts to reduce levels of cattle nuclear DNA because animals that are removed from the herd due to cattle nuclear introgression may also possess rare bison alleles that may be lost from the herd. However, removal of animals with cattle mitochondrial DNA haplotypes does not generally pose this risk.

Whenever possible, herd managers should conduct genetic testing to understand the genetic make-up of their herd. Testing 20% of the animals will generally provide the necessary information for the herd (N. Halbert and J. Derr, personal communications). If cattle genetic introgression is found before reaching the threshold of 20% it may be possible to stop testing, as a herd manager will therefore know that cattle genes are present in the herd. There are currently three laboratories that undertake DNA testing for bison (See Appendix 5).

If the manager determines that there is no cattle introgression in the herd, then animals with cattle DNA should not be introduced. If managers determine the presence of cattle mitochondrial DNA or nuclear DNA in a herd, then they should devise a plan to reduce cattle genetic introgression. More on this topic was elucidated at a recent conference on bison herd genetic management in Tulsa, Oklahoma[5].

5 http://www.americanbisonsocietyonline.org/ABSMeetings/2011ABSConference,Tulsa.aspx

Bison are considered ecosystem engineers in several North American ecosystems. As such, they contribute to the maintenance of biodiversity and ecosystem functioning.

Photo by Duane Lammers

Principle III: Restore and Maintain Biodiversity and Ecosystem Functioning

Bison are considered ecosystem engineers in several North American ecosystems. As such, they contribute to the maintenance of biodiversity and ecosystem functioning. Given that bison are now often confined to relatively small ranges within fenced boundaries rather than roaming across North American landscapes in their historic manner, the following guidelines are meant to help herd managers manage the ecosystem that their bison herds inhabit. This section is particularly applicable at those ranches with large areas intended for habitat restoration and biodiversity conservation objectives. Bison conservation will be based on healthy populations and healthy ecosystems. In order to meet the biodiversity criteria and qualify for ecosystem restoration, the following six criteria should be met by herd managers in order to conserve biodiversity and enhance ecosystem functioning.

A. Maintain proven habitat structural diversity

B. Utilize natural patterns and processes in bison range

C. Create and implement on-range biodiversity conservation plan

D. Interact with biodiversity within the range

E. Minimize herbicide and pesticide use

F. Minimize surface water developments that impact natural hydrologic and riparian function

The following subsections detail each of these six guidelines:

A. Maintain Proven Habitat Structural Diversity

Throughout a bison range, there are a variety of habitat types. It is important to maintain as many of these as possible. To achieve ecological restoration of the landscape:

- Maintain healthy riparian areas.
- Allow for and maintain healthy plant and species diversity.
- Allow for and do not intervene in wallow formation.

Heterogeneity both within and between habitats is important for representation of the suite of grassland birds, some of which require grassland vegetation structure that results from intense grazing to those which require structurally complex grasslands that develop from an absence of or light grazing. Other habitats—wetlands, riparian areas, and forests—that differ from site to site in plant species composition may provide habitats for different life stages of species of interest and should be maintained.

Photo by Diane Hargreaves

B. Utilize Natural Patterns and Processes in Bison Range

Herd managers should encourage natural patterns and processes in the bison range. This would allow for as much unmanaged grazing as possible for the bison. Natural patterns and processes could the use and balance of such natural environmental forces such as fire, flooding, native seed dispersal, creation of wallows, natural wetlands, predators, parasites and ecological succession.

C. Create and Implement On-range Biodiversity Conservation Plan

Once the manager creates and enacts a bison management plan that identifies key species of interest that occur in their area, they are encouraged to work with a government agency, accredited/ reputable private enterprise, conservation group, or academic institution to develop a management plan and articulate measurable goals for each key species. Such plans should include conservation and management regimes for species such as grassland birds, endangered plants, and other keystone species. Examples could include grazing management plans that adjust stocking rates (e.g. NRCS sage grouse initiative), grazing management plans that adjust timing of grazing (e.g. Colorado mountain plover plan), reintroduction/ restoration projects, habitat enhancement for native species (wetland mitigation banking), exclosures for sensitive species (e.g. endangered plants), and hunting/ harvest management plans.

Photo by Diane Hargreaves

D. Interact with Biodiversity Within the Range

Allow for other non-bison species, predators, and competitors for grass to inhabit the range if they are present. Predator control is not acceptable unless there is a basis—such as a manmade structure like a fence, wall, or road—that the predator(s) use as hunting aids to take a disproportionate number of bison. If cross fences are used as a management tool, the impacts of fencing on other wildlife should be considered in their design and their effectiveness monitored. Wildlife-friendly fencing is recommended (see Appendix 3). Fences should not impede or harm wildlife migrations or species.

E. Minimize Herbicide and Pesticide Use

Use of agrochemicals such as herbicides and pesticides should be minimized and highly targeted when used. While their use can be justified to control invasive species or disease/parasite outbreaks, their use should be in accordance with the instructions from the manufacturer and appropriate safety and storage protocols should be followed. Managers should be particularly careful to avoid or minimize wide-ranging ecosystem effects of agrochemical application, such as the effects of endocrine-disruptive herbicides on amphibians.

F. Minimize Surface Water Developments that Impact Natural Hydrologic and Riparian Function

Water can come from a diversity of sources, both artificial and natural. Natural hydrology is encouraged and can be facilitated by off-stream groundwater development. Restoring and maintaining natural stream flows, wetlands, and associated riparian areas is encouraged.

Small Herd Managers

Recognizing that many bison herds do not range on properties in excess of 5,000 acres and tend to have fewer animals than the genetics section outlined above, there are still significant contributions that these herds can make to bison conservation. It is also recognized that mixing herds to meet size requirements can be a difficult task.

Therefore, while not being a fully qualifying conservation herd, managers of small bison herds can undertake many of the above activities to contribute to bison conservation. These animals and the land they inhabit still can play an important role in conservation. Of great import, herd managers should rotate bulls to avoid inbreeding and have multiple bulls to foster breeding competition. Additionally, small herd managers can work to achieve every item in the section "Restoration and Management of Biodiversity and Ecosystem Functioning." Finally, all bison managers can maintain herds of mixed age classes and sexes with minimized human handling in a way that allows bison to interact with each other and their ecosystems.

Photo by Diane Hargreaves

While not being a fully qualifying conservation herd, managers of small bison herds can undertake many activities to contribute to bison conservation.

Conclusion

The bison is an iconic species that is both a reminder of the bounty of the past and a symbol of hope for the future—a future where a well-adapted native species can continue to supply human needs for food and other goods while having a positive impact on the environment in which it evolved. In order to maximize the opportunities for this future to occur, bison managers must collectively strive to provide bison a chance to continue to evolve and adapt through natural selection, while managing habitat on which we and the bison rely. These guidelines are a first attempt to describe a management system that will build a foundation for conserving the species across the broad spectrum of management strategies currently employed by thousands of bison managers across the North American range. If embraced by the community of bison managers, we believe the bison can meet those production objectives while maintaining the character of bison that make this one of the most iconic creatures of North America.

Bison managers must collectively strive to provide bison a chance to continue to evolve and adapt, while managing habitat on which we and the bison rely.

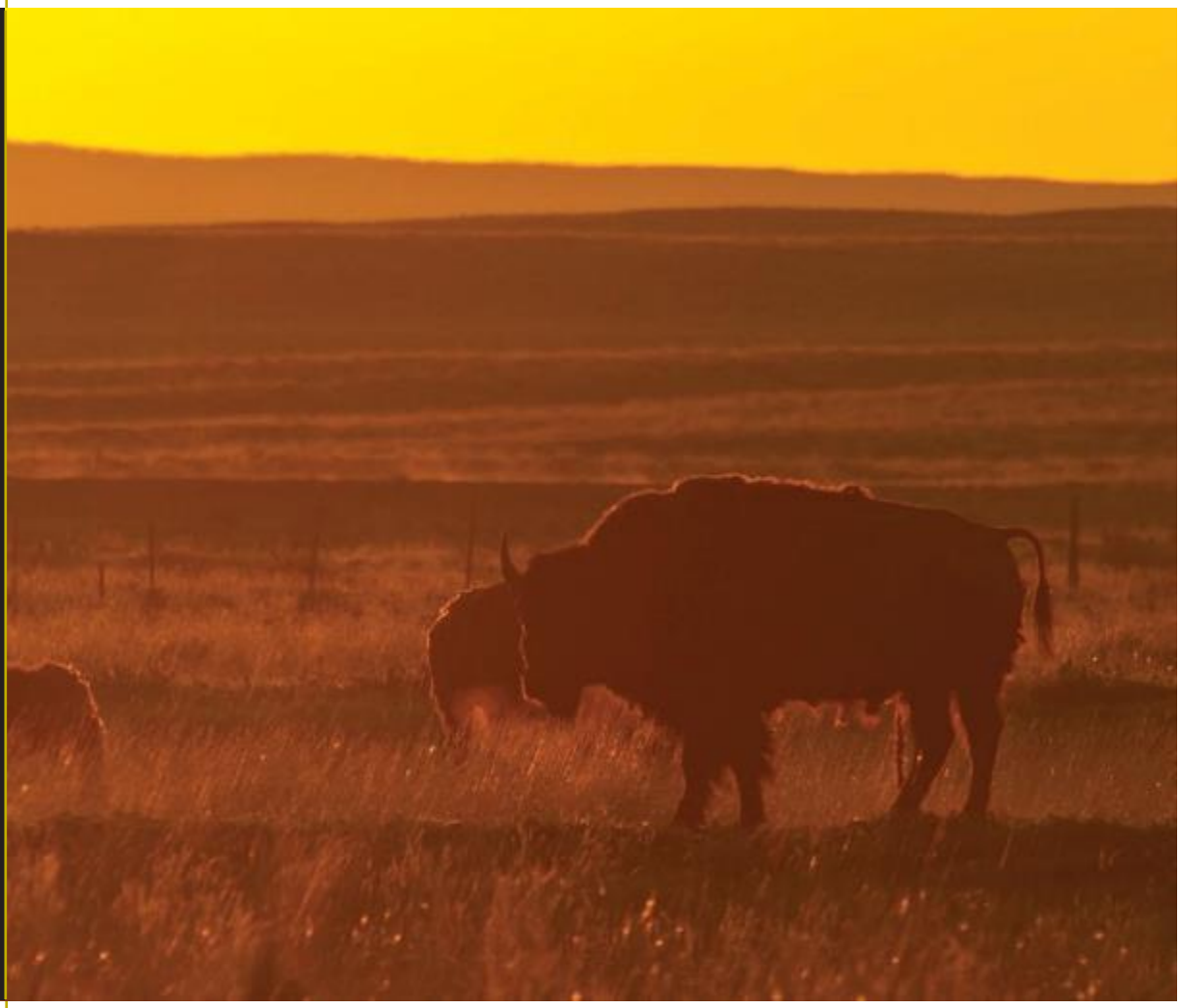


Photo by Dennis Lingohr

Appendix 1. Glossary

Agrochemicals: Fertilizers or pesticides (fungicides, herbicides, insecticides, etc.).

Allele: An alternative form of a gene. One of the different forms of a gene that can exist at a single locus (spot on a chromosome). Also one of the different forms of any segment of a chromosome. medterms.com

Biodiversity: The genetic, taxonomic, and ecosystem variety in living organisms of a given area, environment, ecosystem, or the whole planet (McAllister 1991).

Carrying Capacity: The maximum population of an organism a given habitat can support indefinitely (Rees and Wackernagel 2005).

DNA introgression: The transplantation of genes between species resulting from fertile hybrids mating successfully with one of the parent species. http://en.mimi.hu/biology/introgression.html

Ecosystem: An area that contains organisms (e.g. plants, animals, bacteria) interacting with one another and their non-living environment. Ecosystems can be of any size (e.g. forest, meadow, and log). https://www.uwsp.edu/natres/nres743/Definitions/Ecosystem.htm

Ecosystem functioning: 1) The collective intraspecific and interspecific interactions of the biota, such as primary and secondary production and mutualistic relationships. 2)The interactions between organisms and the physical environment, such as nutrient cycling, soil development, water budgeting, and flammability.

Endangered species: The classification provided to an animal or plant in danger of extinction within the foreseeable future throughout all or a significant portion of its range. fws.gov

Genetic diversity: 1) Genetic variation between and within species, which is measured by determining the proportion of polymorphic loci across the genome, or by the number of heterozygous individuals in a population. 2) The different genetic combinations in a gene pool. 3) The existing genetic variation within a population. http://www.biology-online.org/dictionary/Genetic_Diversity

Genetic drift: The process of change in the genetic composition of a population due to chance or random events rather than by natural selection, resulting in changes in allele frequencies over time. http://www.biology-online.org/dictionary/Genetic_drift

Genetic heterozygosity: (Science: genetics) The presence of different alleles at one or more loci on homologous chromosomes. http://www.biology-online.org/dictionary/Heterozygosity

Genetic locus : The location of a gene (or of a significant sequence) on a chromosome or on a linkage map. http://www.biology-online.org/dictionary/Genetic_locus

Heterogeneity: The quality of being made of many different elements, forms, kinds, or individuals

Hydrological functioning: The manner in which water effects and interacts with the earth's soil, rocks, and other features. In this case, it is important that the manner in which water interacts with these factors is not significantly altered by human structures or manipulation.

Inbreeding: The mating of two closely related persons. Also called consanguinity. The act of matingclosely related individuals. The mating of organisms between relatives, which usually decreases heterozygosity in the gene pool and done by selective breeders to produce hybrids. http://www.biology-online.org/dictionary/Inbreeding

Invasive species: 1) Non-native (or alien) to the ecosystem under consideration and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health. (Executive Order 13112). (USDA)

Keystone species: A species whose presence is crucial in maintaining the organization and diversity of their ecological communities and these species are exceptional relative to the rest of the community, in their importance (Mills et al. 1993).

Life cycle : The whole life history of an organism, usually depicted through a series of developmental stages (e.g. from zygote into a mature form where another zygote can be produced) in which an organism goes through.

MtDNA (mitochondrial DNA): Mitochondria are structures within cells that convert the energy from food into a form that cells can use. Although most DNA is packaged in chromosomes within the nucleus, mitochondria also have a small amount of their own DNA. This genetic material is known as mitochondrial DNA or mtDNA. http://ghr.nlm.nih.gov/chromosome=MT

Riparian area: An area of land directly influenced by water. An ecosystem that is transitional between land and water ecosystems. Riparian areas usually have visible vegetative or physical characteristics reflecting theinfluence of water. River sides, lake borders, and marshes are typical riparian areas.

Appendix 2. Effective Population Size

as described by Natalie Halpert, PhD

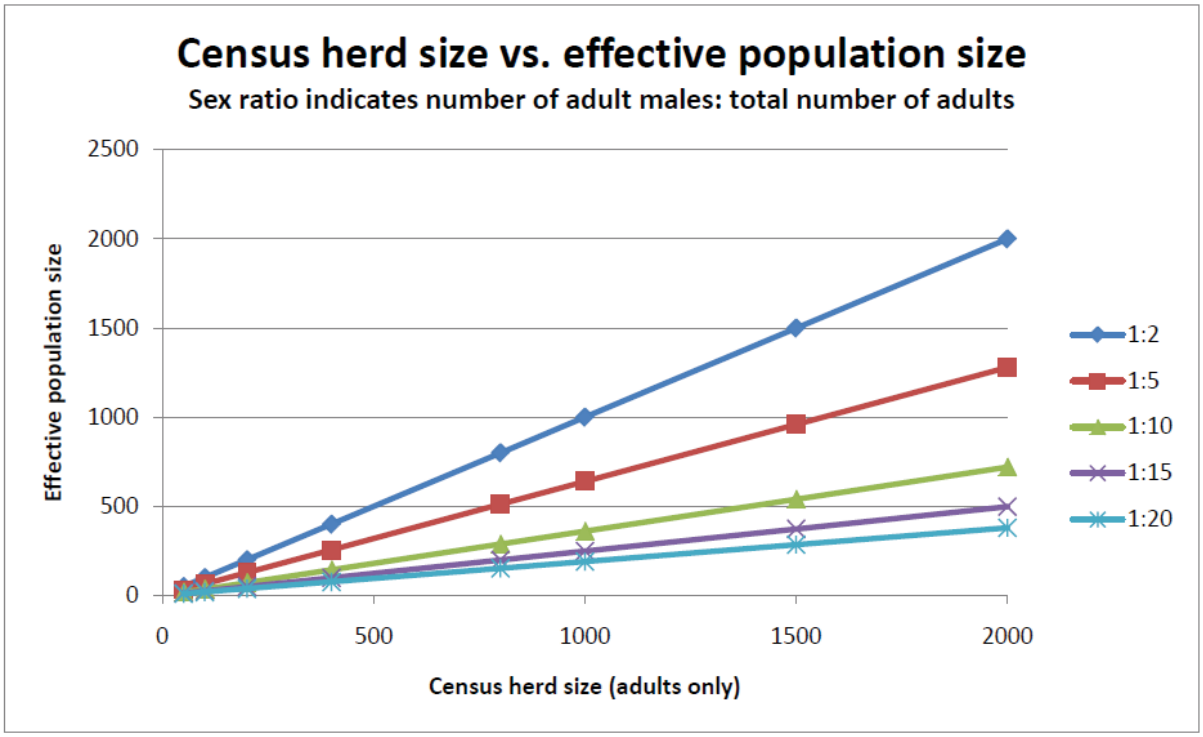
Census herd size vs. effective population size: the effect of sex ratio in bison

By Natalie Halbert, PhD
Department of Veterinary Pathobiology
Texas A&M University
January 26, 2010

Table 1: Effective population size calculated for a range of census herd sizes and sex ratios.

	Sex ratio (number of adult males: total adults)				
Census herd size (adults only)	**1:2**	**1:5**	**1:10**	**1:15**	**1:20**
50	50	32	18	12	10
100	100	64	36	25	19
200	200	128	72	50	38
400	400	256	144	100	76
800	800	512	288	199	152
1000	1000	640	360	249	190
1500	1500	960	540	373	285
2000	2000	1280	720	498	380

Figure 1: Graphical representation of effective population size, using data from Table 1.



Appendix 3. Wildlife Friendly Fencing

Information on wildlife friendly bison fencing can be found here:

http://www.canadianbison.ca/producer/Resources/documents/BisonGuidelinesJune30_2006_Web.pdf

Appendix 4. Ecoregions and Current Bison Distribution

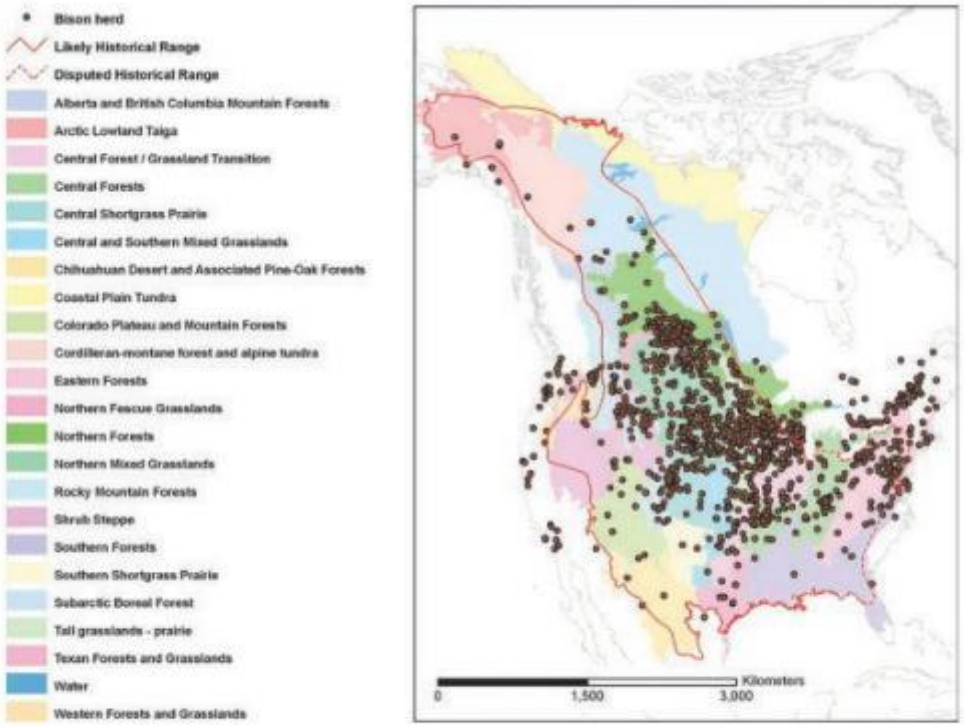


Figure 1. Distribution of a sample of existing American bison herds across the historical range (and beyond) in North America. The size of the dots overestimates the actual area occupied. Best estimates are that bison currently occupy <1% of their circa 1500 historical range (modified from Hall & Kelson 1959), shown in red. Major habitat types are indicated by colored areas in the background.

CLARIFICATION: The above map is intended to illustrate the different ecoregions that bison inhabit. The map is published in Sanderson et al. (2008) using different criteria for conservation herds than the Guidelines in this document. These herds may or may not follow the Guidelines in this document.

Appendix 5. Recommended DNA testing methods

There are ever developing methods to test bison DNA. The following three labs may best provide the service:

1. CCBR/WestCore
   Black Hills State University
   1200 University Avenue
   Spearfish, SD 57799
   605-643-6854
   westcore@bhsu.edu
2. http://www.cvm.tamu.edu/dnacore/bovid.shtml
3. Robert Schnabel - conducting Single Nucleotide Polymorphism (SNP) testing at the University of Missouri http://cafnr.missouri.edu/coe/earlyresearch/11schnabel-b.php

Appendix 6. Recommended Biodiversity and Ecosystem Assessment Methods.

In the United States, state offices of the USDA's Natural Resources Conservation Service (NRCS; http://www.nrcs.usda. gov/technical/) is one of the best places for obtaining technical assistance and guidelines for assessing the ecological conditions of private lands. In both the United States and Canada, state/federal fish and game agencies and university extension programs can often provide technical assistance or educational programming for interested landowners. Federal and state agencies can often provide the names of qualified private contractors who can conduct habitat assessments.

Appendix 7. Information on Home Range Size

A home range is the area where an animal enacts its day-to-day activities (Powell 2000). Since not all bison can migrate as they once did, it is important to understand the amount of land needed for a home range of a bison herd.

Bison home range size will be determined by habitat productivity, sex ratio, seasonal changes in habitat requirements, forage distribution, metabolic rate changes with seasonality, body mass, and the social systems of the species (Larter and Gates 1990 and Lindstedt et al. 1986). In order to determine the home range of bison, there have been several studies using telemetry to track movements, and there is a model available to estimate the home range for an individual.

Terrestrial herbivores have been modeled to have a home range size according to the following equation:

Area of home range in hectares = 2.70 x Body mass^1.02

Other issues factored into home range size will include types of habitat and productivity of that habitat. Bison tend to use different habitat types depending on the forage availability, the time of year, and predation risks while changing the size of the groups in which they associate (Fortin et al. 2009). Home range can also contract during the winter, as the bison utilize fat stores during that period (Mysterud et al. 2001).

The summer home range for bison inhabiting the Henry Mountains of southern Utah was observed at 5,200 hectares, or 12,849 acres for 6 cows that were tracked over a period of time (van Vuren 1983). The Henry Mountains' vegetation production is less than other areas which bison inhabit in North America, with a significant amount of forest (van Vuren and Bray 1986). At the time of the home range study, however, the population was well below the Henry Mountains' carrying capacity and also competed with cattle for forage (van Vuren and Bray 1986). It is therefore likely that the amount of land needed for a bison home range will not be as large as that observed for the Henry Mountains. Other home range studies of American bison state that home ranges for cows range from 6,900 to 14,300 hectares in the Badlands and 4,000 to 6,800 hectares for the herd formerly inhabiting Catalina Island (Krasinski et al. 2000).

In Yellowstone, 317,500 hectares currently comprise the primary habitat and distribution region for the Park's herd of 3,000—based on a 2008 aerial survey (Plumb et al. 2009). The bison share the area with large herds of elk and other ungulates, while migrating throughout and without the park depending on the season (Plumb et al. 2009). The theoretical carrying capacity of the park is 6,200 animals for an average of 51.2 hectares per animal. Various ecological and social management issues curtail this population from reaching its maximum.

Given the above information and model, it is important to understand that most bison would roam far beyond their current constrained habitats, regardless of their management classification (public or private). Recognizing the reality of land tenure in North America, it is therefore important to maximize the amount of land available to bison herds and calculate the carrying capacity of each individual range so that overstocking does not occur, while allowing the bison to range as freely as possible.

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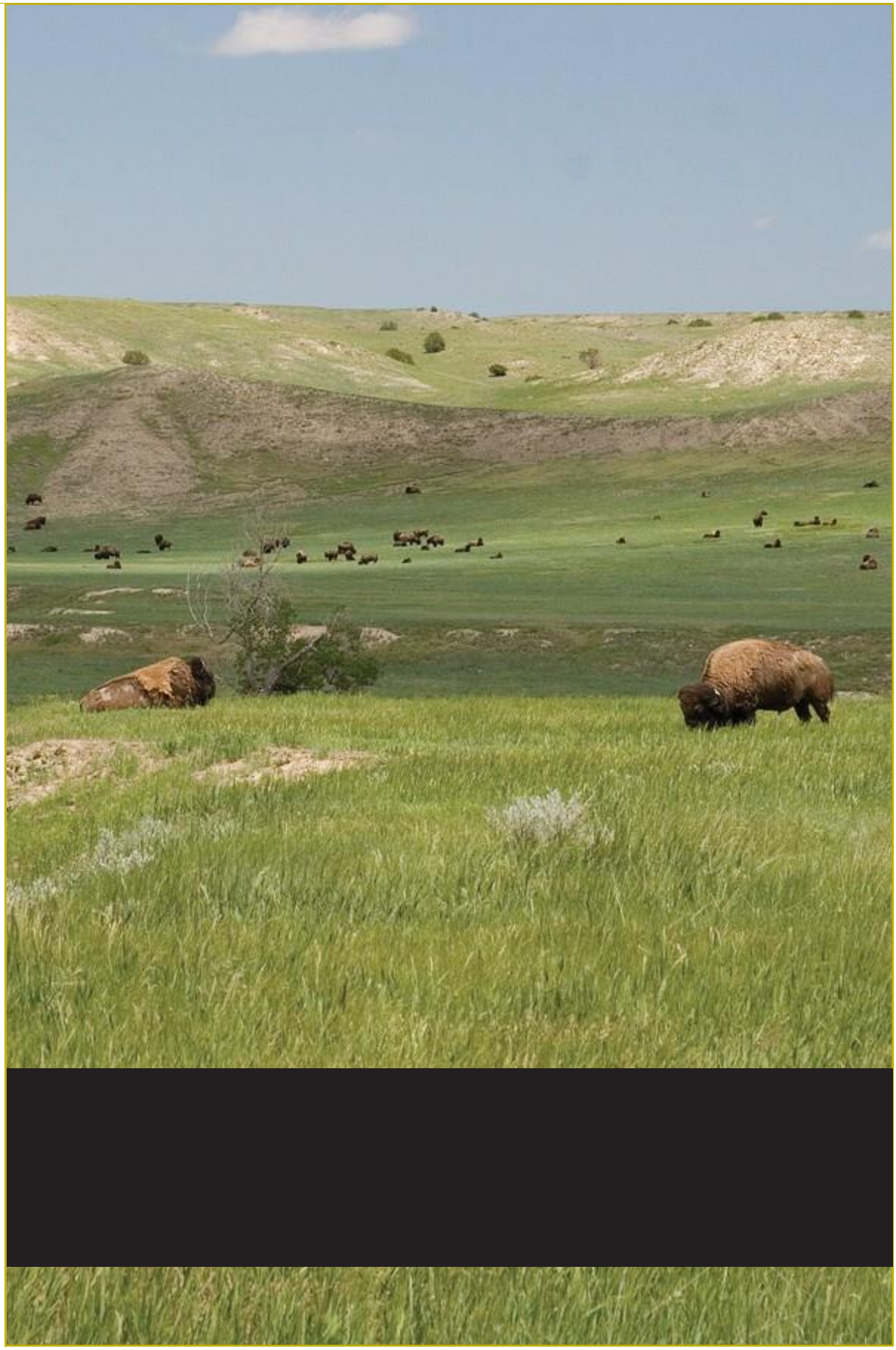

Appendix 3. Bison Conservation Genetics Workshop: Report and Recommendations. These recommendations and guidelines have not been adapted by the Arizona Game and Fish Commission or Department and serve only as reference material.

National Park Service
U.S. Department of the Interior

Natural Resource Program Center

Bison Conservation Initiative

Bison Conservation Genetics Workshop: Report and Recommendations

Natural Resource Report NPS/NRPC/BRMD/NRR—2010/257

ARIZONA BISON MANAGEMENT PLAN

ON THE COVER
Bison grazing at the National Bison Range in Montana
Photograph by Ryan Hagerty, USFWS

ARIZONA BISON MANAGEMENT PLAN

Bison Conservation Initiative

Bison Conservation Genetics Workshop: Report and Recommendations

Natural Resource Report NPS/NRPC/BRMD/NRR—2010/257

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October 2010

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

The National Park Service, Natural Resource Program Center, publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Report Series is used to disseminate high-priority, current natural resource management information with managerial application. The series targets a general, diverse audience, and may contain NPS policy considerations or address sensitive issues of management applicability.

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 collection, analysis, or reporting of the data, and whose background and expertise put them on par technically and scientifically with the authors of the information.

This report is available from the Biological Resource Management Division and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/NRPM).

Please cite this publication as:

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NPS 999/105815, October 2010

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Executive Summary

One of the first outcomes of the Department of the Interior (DOI) Bison Conservation Initiative was the Bison Conservation Genetics Workshop held in Nebraska in September 2008. The workshop brought together scientists from government agencies and non-governmental organizations with professional population geneticists to develop guidance for the genetic management of the federal bison herds. The scientists agreed on the basic tenets of genetic management for the DOI herds and discussed different approaches to meeting those goals.

First, the 12 DOI herds are an irreplaceable resource for the long-term conservation of North American plains bison. Most of the herds show low levels of cattle introgression dating from the time when they were saved from extirpation; those herds should not be mixed without careful consideration as to their origin. Herds that show no evidence of cattle ancestry by the current molecular methods are the highest priority for protection from genetic mixing with any other bison herds.

Second, despite the fact that most of the herds now managed by the U.S. government were founded with very few bison and have been maintained for many generations at relatively low population sizes, they do not show obvious effects of inbreeding. They have retained significant amounts of genetic variation by the standard measures, heterozygosity and allelic diversity. This may be explained in part by the fact that most of these herds are not remnants of a single population.

Third, to preserve genetic variation in federal bison herds over decades and centuries, herds should be managed at a population or metapopulation level of 1,000 animals or more, with a sex ratio that enables competition between breeding bulls. The parks and refuges that currently have bison herds, with the exception of Yellowstone National Park, do not have enough land to support a population of this size. In the short term, it will be important to develop satellite herds to attain population targets, and develop a metapopulation structure between herds.

Fourth and finally, the current methods used to evaluate the DOI bison herds, using mitochondrial DNA and a suite of nuclear DNA microsatellites, are highly informative at the herd level. They have confirmed relatedness of herds that we know from historical records have a common origin. They have detected cattle ancestry in most of the herds where it was suspected and have shown some loss of rare alleles. However, they do not sample across the bison genome, and the use of neutral genetic markers as the basis for selection of individual bison—either to breed or move to other herds—would be better supported by more high-resolution molecular methods currently under development.

Introduction

Bison are an iconic animal of the American frontier, represented on both the Department of the Interior (DOI) seal and the National Park Service (NPS) arrowhead. The first principle of DOI Bison Conservation Initiative was to base management of its herds on the best available science. One of the priorities of the initiative was to convene a conservation genetics workshop focused on bison to develop genetic management guidelines, including the appropriate role in future conservation actions for bison with cattle ancestry. The NPS organized the workshop at the Lied Lodge on September 2–5, 2008, and brought together a diverse group of scientists to identify and recommend management actions and research needs important to the conservation genetics of DOI bison herds.

The DOI Bison Genetics Workshop came out of significant recent developments in North American bison conservation. Renewed public interest in bison, both as a natural food source and for their historic ecological role in western landscapes, underscored the importance of the DOI bison herds in conservation of the species. At the same time, recent published studies advanced understanding of the genetic status of these bison herds.

The workshop brought together population geneticists and other biologists from the Department of the Interior, Canadian Wildlife Service, Parks Canada, Texas Parks and Wildlife, academic institutions, and non-governmental organizations, including conservation organizations and zoos (see Appendix A for a participant list). The perspective of zoos was important, as most government herds, while roaming over large areas, are still captive populations facing fences and annual round-ups. The group heard presentations on the history of conservation of North American bison and the government role in these conservation efforts, reviewed the general principles for maintaining allelic diversity within a species, and received reports on the status of DOI bison herds addressing issues of allelic diversity and introgression of livestock genes in the North American bison genome (see Appendix B for the workshop agenda).

While there was agreement on the principles that should guide the management of DOI bison herds, consensus on the management practices that would best achieve those genetic principles was not achieved in the three-day meeting. To provide clear guidance, this report has been through multiple drafts. Workshop participants Peter Dratch, Eric Lonsdorf, and Peter Gogan and NPS writer-editor Virginia Reams all contributed to writing the final report, and most of those who attended the workshop have made substantial comments to the drafts. The recommendations primarily represent the views of the population geneticists that gave their time to address the challenge of conserving North American bison on the timescale of centuries.

The participants were asked to address three questions important to the public in developing the guidelines:

1) What criteria best describe a herd of wild bison?

2) How well do bison herds under DOI management authority meet the criteria for wild bison?

3) What steps can be taken to ensure that management of the DOI herds contributes to the future of wild bison in North America?

The participants established the criteria for a wild bison herd as one with a large enough population size to prevent loss of genetic variation and with low levels of cattle or subspecies introgression, and subject to some of the forces of natural selection, including competition for breeding opportunities. The desired minimum size of a population to maintain genetic variation in bison over two centuries is estimated at 1,000 individuals (Gross and Wang 2005, Gross et al. 2006, Boyd et al. 2010). This could be achieved through establishment of a single population or management of several smaller populations as a metapopulation. While recognizing that hybridization with cattle was not natural, and mixing between bison subspecies rare, participants discussed a threshold of cattle ancestry (all of the DOI herds have less than 2% cattle genes for currently used DNA markers) in evaluation of DOI bison herds. This definition of wild bison is more restrictive than that of a bison "conservation herd," which may be defined as any herd managed by a government or non-government organization with the primary mission of nature conservation (Gates and Ellison 2010).

While the group looked at the history of both plains bison and wood bison in North America, the recommendations focus on plains bison herds in the United States managed by DOI. Addressing the question of how well do DOI bison herds meet the criteria for wild bison, the participants noted that DOI herds meet the basic threshold for genetic integrity. However, most herds are managed at numbers well below a population size of 1,000, and there are no management plans in place to manage any group of spatially isolated herds as a metapopulation. In addition, the herds are not of equal value for long-term conservation of bison.

There was a consensus among workshop participants that herds with no evidence of cattle hybridization are particularly important resources that must be safeguarded from potential introgression of livestock genes. Lineages within all DOI herds that are representative of historical conservation efforts and confirmed by genetic analysis of herds should be preserved until issues of livestock introgression are resolved with DNA analysis at higher resolution. While no DOI herds are currently subject to the full range of historic natural selective forces that influence genetic variation, management actions should maximize population size, minimize selection for docility and other traits related to domestication, strive for an even sex ratio considering differential survival, and minimally interfere with social behavior.

Finally, the DOI bison herds have a crucially important role in long-term bison conservation. Almost all herds must be increased in size to avoid negative genetic effects on a decades-to-century time scale (Gross et al. 2006). Since DOI herds are generally at or near capacity within federal boundaries, establishing satellite herds that can contribute to metapopulations is an important first step. Further, managing bison herds across current jurisdictional boundaries is an important step to long-term bison conservation. The DOI herds also are valuable source bison with which to start new conservation herds proposed by other federal, state/provincial, or tribal governments/First Nations, and others. Any new efforts should move toward establishing satellite herds that can eventually serve as interbreeding populations or metapopulations with total herd sizes of 1,000 bison to sustain genetically healthy animals over time.

Background

Brief History of American Bison Conservation

The American bison (*Bison bison*) is an icon of the conservation movement in North America. It was one of the first animals that stirred citizens and governments to intervene on behalf of a species on the verge of extinction (Coder 1975, Lothian 1981). Due largely to commercial, sport, and subsistence hunting, as well as possibly exotic bovine diseases and forage competition with domestic stock (Flores 1991), plains bison (*B. b. bison*) were reduced from tens of millions at the time of European colonization (Shaw 1995) to a few hundred by the mid-1880s (Hornaday 1889, Isenberg 2000). The other subspecies of American bison, the wood bison (*B. b. athabascae*), an inhabitant of the woodlands of northern Canada and Alaska, was reduced to an estimated 250 animals by the end of the 19th century (Hornaday 1889, Soper 1941).

While there was sentiment in the 1800s to halt the destruction of bison in North America (Dary 1989), protective legislation in Canada and the United States was not enacted until bison were near extinction. In Canada, the 1877 Buffalo Protection Act was the first attempt to legislate protection (Hewitt 1921). This measure was ineffective, however, due to lack of enforcement. In 1894, the Dominion Government passed a law protecting the surviving wood bison (Soper 1941); by this time, wild plains bison were extirpated in Canada. Plains bison were extirpated from Mexico by the 1820s (List et al. 2007).

Plains bison disappeared from the wild in the United States except in Yellowstone National Park (NP). The states of Idaho, Wyoming, and Montana implemented statutes to reduce the killing of game, including bison, between 1864 and 1872, but—like the 1877 Canadian measure—these laws were largely ineffective due to limited enforcement. The Act to Protect the Birds and Animals in Yellowstone National Park and to Punish Crimes in Said Park was signed by President Grover Cleveland in 1894, halting the extirpation of the last free-ranging plains bison population in North America (Meagher 1973). By 1902, however, fewer than 50 wild bison were estimated to remain in the remote Pelican Valley of Yellowstone NP (Meagher 1973).

Plains bison were saved from extinction by the independent actions of private citizens (Dary 1989, Coder 1975). Between 1873 and 1889, several individuals in locations ranging from Manitoba to Texas captured the last of the wild plains bison, except for the few remaining in Yellowstone NP. William Hornaday, director of the New York Zoological Park, and other wildlife advocates concerned about the loss of this symbol of the American West formed the American Bison Society (ABS) in 1905. The ABS successfully lobbied for the creation of several public reserves in the United States, which the ABS then populated with bison from private herds and the Bronx Zoo (Coder 1975, Isenberg 2000).

In Canada, the national parks system first became involved in plains bison conservation in 1897 when three animals were purchased from Charles Goodnight in Texas. A more significant early contribution by the Canadian government occurred in 1907 when it purchased the privately owned Pablo-Allard herd in Montana. The herd was shipped first to Elk Island National Park, then on to a new park, Buffalo National Park, in the grasslands of east-central Alberta (Lothian 1981, Brower 2008). With protection, the numbers of plains bison increased rapidly, and the danger of extinction was averted in both countries (Hornaday 1927, Potter et al. 2010).

The early efforts to save the bison at a crucial time have rightfully been regarded as a conservation success story. The best current estimate is that about 430,000 plains and wood bison now exist in North America (Gates and Ellison 2010). Of these, only 20,500 plains bison and 11,000 wood bison are in publicly owned herds (Gates and Ellison 2010); the remainder are privately owned. Plains bison are classified as endangered in Mexico (Aune and Wallen 2010). Wood bison are classified as endangered under the U.S. Endangered Species Act and threatened under Canada's Species at Risk Act (Aune and Wallen 2010).

Many Indian tribes and First Nations maintain bison herds for cultural, nutritional, and commercial purposes. Some of these herds have the potential to contribute to species conservation. Most privately owned plains bison today are selected for meat production, protected from natural predators, and managed as small herds in fenced paddocks. More than 90% were founded with animals that have evidence of cattle ancestry and show significant amounts of cattle introgression. These herds are not considered wild and are not included in conservation planning for the species. Most publicly owned plains bison populations in North America are directly descended from only a few founders—an effective population size of fewer than 50 (Hedrick 2009). They constitute a critical resource for long-term bison conservation.

Department of the Interior agencies (the National Park Service and U.S. Fish and Wildlife Service [USFWS]) have a record of cooperation in bison management (see Appendix C for detailed histories of the DOI bison herds). Bison from the Pablo-Allard herd (now National Bison Range) and Goodnight herd (now Texas State Bison Herd) were provided to augment the remnant herd at Yellowstone NP in 1902 (Coder 1975, Meagher 1973). Yellowstone NP bison were provided to found a bison herd at Fort Niobrara National Wildlife Refuge (NWR) in 1913 (Coder 1975, Halbert 2003, Halbert and Derr 2007a). Similarly, in 1956 bison from Fort Niobrara NWR were the source stock used to establish bison herds within the North and South units of Theodore Roosevelt NP. This latter group of three herds constitutes a metapopulation (Halbert 2003, Halbert and Derr 2007a). The bison herd at Badlands NP was established with animals from Fort Niobrara NWR and the South Unit of Theodore NP in 1963 and augmented with bison from the former herd at Colorado National Monument in 1983 (Berger and Cunningham 1994).

The New York Zoological Park also cooperated extensively in the establishment of DOI bison herds: the bison herd at Wind Cave NP was established with bison from New York Zoological Park in 1913 and Yellowstone NP in 1916. The bison herd at Wichita Mountains NWR was established with bison from the New York Zoological Park in 1907 (Coder 1975, Halbert 2003, Halbert and Derr 2007a). The known genetic relatedness of contemporary DOI bison herds is depicted in Figure 1.

The Department of the Interior is the primary federal agency for management of bison within the United States. Currently, the Department of the Interior maintains exclusive management authority over 12 plains bison herds at 10 locations (Table 1). Two additional herds at two sites are managed under cooperative plans with the states of Montana and Wyoming, respectively (Gates and Ellison 2010, Aune and Wallen 2010). Of these, the National Park Service maintains exclusive management authority for bison within Yellowstone and Grand Teton national parks. Yellowstone bison are managed by the State of Montana beyond the park boundaries. The interagency management plan calls for more aggressive management of bison when they leave

the park when population estimates exceed 3,000 (USDI and USDA 2000, Plumb et al. 2009). Jackson bison are managed cooperatively by the National Park Service within Grand Teton NP, the U.S. Fish and Wildlife Service on the National Elk Refuge (NER), and the State of Wyoming on lands adjacent to Grand Teton NP and the NER. The target population objective for the Jackson herd is approximately 500 bison (USFWS and NPS 2007). Most herds managed by the Department of the Interior are relatively small, genetically isolated, and separated from natural predators. Some show evidence of cattle ancestry, and some do not (Table 1).

Management recommendations need to consider the consequences of small population size for genetic health as well as the prevention of further introgression of cattle genes, particularly into bison herds with no evidence of hybridization. For each major concern (genetic diversity and cattle ancestry), we present background and specific recommendations based upon our current knowledge and suggest research needs where additional information may be required. Current information on genetic variation in the DOI bison herds is summarized in Table 1. The U.S. Fish and Wildlife Service has implemented translocations of bison within herds under its management authority since completion of the assessment of genetic variation. The genetic status of the newly established herds is unknown.

General Principles for Maintaining Genetic Diversity in Bison

Effective population size (N_e) is an important measure used for the maintenance of genetic diversity. Genetic drift leads to the loss of genetic diversity, and the rate of loss is expected to correlate negatively with effective population size (Hartl and Clark 2007). Declining genetic diversity and increasing inbreeding depression may interact with the stochastic process of genetic drift (Hartl and Clark 2007) and demographic stochasticity to amplify extinction risk in small populations (Saccheri et al. 1998, Westemeier et al. 1998).

Genetic drift resulting in declining allelic diversity within populations along with reductions in gene flow between populations is of particular concern for species such as bison that evolved in large, outcrossing populations. Genetic drift leads to reduced performance in many fitness- related traits (Menges 1991, Keller and Waller 2002). Small and isolated populations are more prone to extinction than larger populations due to the consequences of demographic, genetic, and environmental stochasticity (Lande 1988).

Loss of genetic variation in bison herds is more likely when the number of breeding animals is small. Our best estimates are that bison populations can generally be considered of sufficient size for genetic purposes when the population size is 1,000 animals or more and the size of the population is stable over time. A population must have a sufficient number of mature bulls to enable breeding competition. In all populations, the expected loss of genetic diversity over time is directly related to how rapidly individuals in a population replace themselves (generation time) and to the effective population size. Most guidelines for genetic management can be understood in the context of just these two factors.

Biologists are concerned about the genetic health of bison herds because all North American herds were founded by a few individuals and have generally been maintained at small population sizes (Boyd et al. 2010). Most DOI herds were established from groups of 20–50 bison (Halbert 2003, Halbert and Derr 2008), and DOI herds have largely been managed to maintain a size of fewer than 500 animals. The relatively small size and isolation of most DOI bison herds has led

to concerns about their long-term genetic health. A summary provided by Halbert and Derr (Table 1) of the current state of bison genetic diversity indicates that genetic drift may already be causing a detectable loss of allelic diversity. For example, rare alleles present in bison at both units of Theodore Roosevelt NP are no longer present in the source population at Fort Niobrara NWR.

The status of the Texas State Bison Herd underscores the potential problems with maintaining small, isolated populations of bison. The interplay of a small number of founder animals, subsequent bottlenecks in population size, and long-term small population size with genetic drift has resulted in low levels of genetic diversity (Halbert 2003, Halbert et al. 2004). This contributed to high calf mortality and low recruitment rates. Population viability analysis predicted the demise of the herd within 50 years without the infusion of genetic material from another bison herd (Halbert 2003, Halbert et al. 2004). Bison bulls were brought in for breeding with an immediate positive effect (D. Sweptson, pers. comm., 2008)

Current Evidence of Cattle Ancestry

Bison and domestic cattle (*Bos taurus*) can produce fertile offspring from human-controlled crosses (Jones 1907; Boyd 1908, 1914; Goodnight 1914). The two species are not known to produce hybrids naturally, and even carefully controlled crosses result in a low birthrate of viable first-generation hybrid offspring (Boyd 1908, Steklenev and Yasinetskaya 1982). In addition, most viable offspring are female, as are first generation backcrosses (Boyd 1908, Hedrick 2009). This typically leads to higher levels of mtDNA than autosomal DNA in introgressed bison herds (Hedrick 2010).

Each of the ranchers involved in establishing the five plains bison foundation herds in the late 1800s either experimented with domestic cattle-bison crosses or purchased bison from others who were involved in such experiments (Garretson 1938, Coder 1975, Brower 2008). Consequently, both mitochondrial (Polziehn et al. 1995, Ward et al. 1999) and nuclear (Halbert et al. 2005) evidence of domestic cattle ancestry has been identified in both public and private plains bison herds (Halbert and Derr 2007a). In a recent study, 14 unlinked microsatellite markers with non-overlapping allele size ranges between bison and domestic cattle were used to identify bison populations with evidence of nuclear domestic cattle introgression; regions of introgression were subsequently confirmed through analysis of microsatellites linked to the original diagnostic loci (Halbert et al. 2005). To date, evidence of mitochondrial or nuclear domestic cattle gene introgression has been identified in all but six of 14 U.S. and Canadian public bison populations (Ward et al. 1999, Halbert et al. 2005, Halbert and Derr 2007a). Only one of the more than 50 private bison herds examined to date showed no evidence of cattle gene introgression (J. N. Derr, pers. comm.).

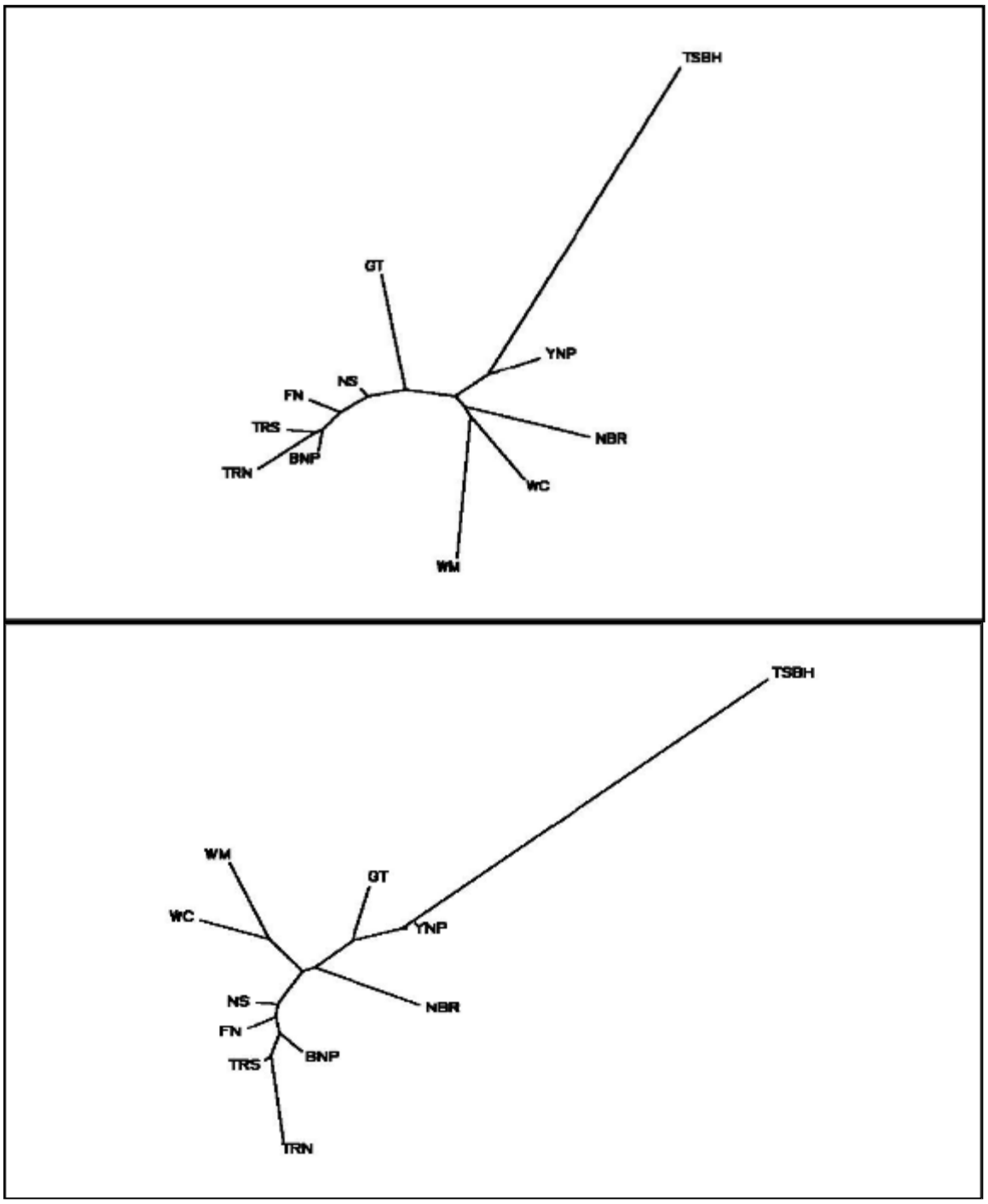

Figure 1. Neighbor-joining tree diagrams for DS (top) and $(\delta\mu)^2$ (bottom) distance measures for DOI bison herds as of 2003 (Halbert 2003:50). Herd abbreviations as in Table 1. TBSH is the Texas State Bison Herd; NS herd in these diagrams no longer exists.

Table 1. Summary of herd size and indicators of genetic diversity for U.S. Department of the Interior bison herds (after Halbert and Derr 2007a; Halbert et al. 2008; L. Jones, pers. comm. 2010, Robert Schnabel, pers. comm. 2010).

Herd name (abbreviation)	Estimated population size	Introgression present[a]	Allelic richness[c]	Expected heterozygosity[d]	Average F_{ST}[e]	Unreplicated conservation unit[h]
Fort Niobrara NWR (FN) – original herd	290	Yes	4.23	65.1	0.106	
Ft. Niobrara NWR (FNSH) – formerly located at Sullys Hill*	61	Suggested[b]	3.91	59.9	NA[f]	
Theodore Roosevelt NP – North (TRN)	312	Yes	3.16	52.2	0.139[g]	
Theodore Roosevelt NP – South (TRS)	371	Yes	3.80	58.2	0.111	
National Bison Range (NBR)	350	Yes	4.51	66.4	0.133	Yes
Neal Smith NWR (NS)**	71	Suggested[b]	4.43	66.8		
Rocky Mountain Arsenal (RMA)***	44	Suggested[b]	4.44	64.2		
Wichita Mountains NWR (WM)	650	Yes	4.16	61.2	0.149	Yes
Badlands NP (BNP)	875	Yes	3.86	57.8	0.107	
Grand Teton NP (GT)	900	Suggested[b]	3.19	53.5	NA[f]	
Wind Cave NP (WC)	350	Suggested[b]	4.29	65.2	0.123	Yes
Yellowstone NP (YNP)	3,000****	None detected	4.15	62.5	0.133	Yes

[a] Based on mitochondrial DNA typing following Ward et al. 1999 and a panel of 14 nuclear microsatellites following Halbert et al. 2005.
[b] Introgression was not directly detected in these herds using microsatellite markers, but it is highly suggested due to the source of the herd and/or initial testing using single nucleotide polymorphisms (Robert Schnabel, pers .comm.).
[c] R_A, average of allelic richness values across markers; calculated based on a minimum sample size of 15 (El Mousadik and Petit 1996).
[d] H_E, average expected heterozygosity (Nei 1987).
[e] F_{ST} averaged across clusters assigned by STRUCTURE (Evanno et al. 2005) analysis.
[f] These (composite) herds were assigned to multiple clusters. Average F_{ST} calculations not possible.
[g] The TRN herd is directly descended from the TRS herd, which was in turn derived directly from the FN herd. It is well-established from other indices that these three herds (TRN, TRS, and FN) are closely related. Drift has likely acted to drive allele frequencies within this herd and differentiation of this herd such that inflated average F_{ST} values are detected.
[h] Based on analysis of herd contribution to overall diversity, following Petit et al. 1998. These herds represent unique sources of bison diversity which is unreplicated among the DOI herds.
* The entire Sullys Hill herd was moved to Fort Niobrara NWR in 2006. They are maintained separately from the original Fort Niobrara herd.
** Based on genetic evaluation, in 2006, all bison at Neal Smith were donated to a local Native American tribe, and a new herd was established with 39 bison from the National Bison Range.
*** Established with bison from the National Bison Range in 2006–2007.
**** Yellowstone bison of are two distinct but closely related types (Halbert and Derr 2007b, Gardipee 2007).

Workshop Recommendations

Recommendations emerging from the Bison Genetics Workshop addressed the two long-term challenges facing DOI herds where genetic conservation is a primary management goal: actions to limit the effects of historical introgression and actions to maintain genetic diversity. Implementing the following actions will help sustain the genetic integrity of DOI bison herds. In addressing these challenges, research recommendations are made to resolve identified uncertainty and to allow for more informed decision-making in the future. These recommendations are summarized in Tables 2, 3, and 4.

Management to Limit Introgression

We recommend management actions that decrease or prevent the spread of cattle ancestry in any existing herds or new conservation herds.

Because of the cattle-bison hybridization that occurred in private herds when plains bison were saved from extinction in the 1800s and because animals from those herds were used to found or augment the DOI herds, no herd can be absolutely assured to have no cattle ancestry. That said, conservation herds, including those of the Department of the Interior, can be grouped into four classes: 1) those with no molecular evidence of cattle introgression; 2) those with molecular evidence of low levels of cattle introgression; 3) those with historical inference of cattle ancestry but no molecular evidence with the current DNA markers; and 4) those where molecular markers indicate high levels of cattle ancestry and/or recent hybridization with domestic cattle. We have specific recommendations for each of these classes, but all follow from the overarching recommendation to prevent the increase of bison with cattle ancestry in DOI herds.

1) No molecular evidence of cattle ancestry: Herds with no molecular evidence of cattle ancestry constitute a genetic resource that must be protected from inadvertent introgression. Yellowstone National Park has the only DOI herd where there is no suggestion of cattle introgression using all of the available molecular methods. The Yellowstone bison population requires further testing, as do non-DOI herds established with Yellowstone bison. There should be no introduction of bison to these herds from herds that show molecular evidence of cattle ancestry or for which the genetic status in unknown. High priority should be given to creating satellite herds for these herds on DOI-managed lands. Moreover, where the risk is great for inadvertent interbreeding with bison from adjacent herds that show high levels of cattle ancestry, herd boundaries should be secured by the appropriate means, trespass animals should be removed, and genetic testing should be conducted to confirm that the two herds are not mixing.

2) Molecular evidence of low-level cattle ancestry: Bison in DOI herds demonstrated to have detectable cattle ancestry at low levels have important genetic value and contain unique genetic variation that is absent from Yellowstone or other conservation herds with no molecular evidence of cattle ancestry. All DOI herds fall well below 2% of cattle genes at the current molecular markers and a threshold for conservation herds was suggested at the workshop. These herds should not be used to augment herds with no molecular evidence of cattle ancestry. While removal of individuals with cattle mtDNA haplotypes is warranted, selection on the basis of cattle alleles at nuclear loci could have unintended consequences of reducing overall variation. Herds with low levels of cattle ancestry that are not genetically unique should be the lowest

priority for herd expansion and transfer to other locations. The historical Fort Niobrara bison and the two bison herds at Theodore Roosevelt NP should be identified and managed as a metapopulation to ensure the persistence of rare alleles in all three herds.

The National Bison Range (NBR) herd is of interest because it represents a geographic lineage from the northern Montana region. An introduction of bison into this herd with molecular evidence of recent cattle introgression was reversed by DNA detection and swift management action (L. Garner, pers. comm. in Halbert 2003). Molecular evidence indicates that bison with introgressed cattle genes joined this herd prior to the 1980s (Halbert 2003, Halbert and Derr 2007a). Moreover, there are three state-owned plains bison herds in Alaska that may represent an unbranched lineage to the NBR herd that predates any introgression of cattle genes. If genetic testing identifies sufficient numbers of NBR-source bison free of cattle ancestry and with sufficient genetic variation, then the establishment of herds using these animals should be a high priority.

3) Historical suggestion of cattle ancestry: There is the possibility of cattle ancestry in all DOI herds, since those herds with no molecular evidence of cattle ancestry have Yellowstone origins and three male bison from the Goodnight herd (now Texas State Bison Herd) were introduced to Yellowstone in 1902 (Coder 1975, Meagher 1973). It is not clear whether cattle-bison breeding experiments had begun in the Goodnight herd prior to translocation of bull bison to Yellowstone NP, or whether he would have sent hybrids to Yellowstone NP. In some cases, the historical suggestion is stronger, such as with the Grand Teton/National Elk Refuge herd, which was augmented with 12 bison from Theodore Roosevelt NP, where cattle ancestry had been detected in 1964. To date there is no molecular evidence that these animals contributed to the current population (Halbert and Derr 2007a). In this case, as in others, higher resolution DNA testing may reveal traces of cattle ancestry, but the herds nonetheless have an important contribution to bison conservation.

4) Molecular evidence of higher levels of cattle ancestry: This category does not apply to any DOI herds but does apply to a number of other conservation herds that border DOI lands. Because the goal is for some DOI bison herds to move across landscapes and jurisdictions, evaluation of neighboring herds is important. When the level of cattle introgression is high, augmentation or systematic herd replacement should be considered, using animals made available from DOI herds or other sources that represent the same lineages. Genetic monitoring is a key part of management to determine the effectiveness of these efforts.

Management to Retain Genetic Diversity

We recommend that each DOI herd achieve a population size of 1,000 animals in the next 10 years. This can include identification of existing satellite and closely related herds, as well as the establishment of new satellite herds to achieve metapopulations of 1,000 bison.

With respect to the risk of losing genetic diversity, it is well understood that population size is a strong correlate of the rate of loss of genetic diversity. Therefore, we group DOI herds into three population size classes: 1) those with a population of greater than 1,000 bison; 2) those with between 500 and 1000 bison; and 3) those with fewer than 500 bison. We have specific

recommendations for each of these classes, but all follow from the overarching need to prevent the loss of genetic diversity by creating large herds. The last of these categories requires the most attention and additional research to resolve uncertainty regarding how best to slow the loss of genetic diversity.

1) Populations estimated at greater than 1,000: Yellowstone bison constitute the only DOI herd with a population size greater than 1,000, and even in this population the degree of genetic structure within the entire herd is unresolved (Halbert 2003, Gardipee 2007). In addition, the current practice of culling bison at the park's boundaries may lead to the removal of matrilineal groups and thereby allelic diversity (Halbert 2003). Further assessments of population substructure and the potential impacts of the current culling practices are recommended.

2) Populations estimated at 500–1,000: Three current herds—Wichita Mountains National Wildlife Refuge (WM), Badlands National Park (BNP), and Grand Teton/Elk Refuge (GT/NER)—have estimated population sizes greater than 500, and herd-specific management plans should be created for each within the next five years. The goal of these plans would be to manage each herd to approach 1,000 bison, either as a single herd or by creating metapopulations with formal plans for moving animals within metapopulations. The plans should ensure that there is no risk of interbreeding with other bison of uncertain genetic status or with known cattle introgression. These populations should be monitored for changes in heterozygosity and other measures of genetic diversity to ensure maintenance of genetic diversity and monitored for signs of demographic fitness changes (e.g., mating rates, reproduction, and survival).

3) Populations below 500: The remaining nine herds are at risk due to the loss of genetic diversity. We recommend immediate and aggressive actions to increase the size of these herds. A combination of actions may be needed to prevent rapid loss of diversity. Within this critical population size class, we have a set of recommended management actions and recommended research to support more effective small-population management.

Small-population management

First, because many of these small herds are limited by the size of their park or reserve, we recommend reviewing current unit management plans to explore the possibility of increasing the size of each bison herd to greater than 500. This may be achieved by establishing satellite herds to comprise a metapopulation, adjusting the abundance of other ungulate populations, and increasing bison carrying capacity by range expansion through identification of neighbors willing to have bison on their lands.

Second, intensive genetic and demographic management of the herds is vital to slowing the loss of genetic diversity. We recommend that several actions be taken until these populations can be increased:

- *Maintain stable population sizes*: Based on well-established genetic population theory, fluctuations in population size increase the rate of genetic loss. Any necessary population reductions should be small and frequent to create minor adjustments as opposed to large and infrequent adjustments.

- *Maximize the number of breeding males*: Observation has shown that there can be strong sexual selection in small bison herds. That is, the majority of offspring come from a small proportion of males, which reduces the effective population size and increases the loss of genetic diversity over time. As an initial step, we recommend using DNA methods to measure genetic contribution of individual males in small isolated herds. Restricting the breeding opportunity of successful bulls, however, should not be a routine practice.

- *Approach a 1:1 sex ratio:* We know from genetic theory that the loss of genetic diversity is slowest when the number of males approaches the number of females. In small herds, chance events (demographic stochasticity) can lead to uneven sex ratios. When the number of males drops below 40%, there is also the potential for reduced competition and loss of fitness. Culling and translocation plans should strive to approach an even sex ratio in herds, considering differential mortality.

- *Remove young animals:* When herd size is limited by carrying capacity and bison are removed annually (or every other year), more young bison should be removed to reflect natural predation mortality. In the smallest of herds, the loss of genetic diversity can be reduced by increasing the age of reproduction (Gross et al. 2006). It is suggested that herd demographics in small populations should be influenced by culling and providing young animals to establish new herds rather than through contraception.

- *Increase genetic diversity*: Finally, we recommend augmenting herds with additional animals if genetic testing for heterozygosity shows results below 0.5. No DOI herd currently approaches this threshold, but it has occurred in the Texas State Bison Herd when the herd also showed a substantial decline in reproduction. It is therefore important to also monitor fitness values and their possible decline. Augmentation with additional animals has increased genetic diversity and removed the manifestations of inbreeding depression in the Texas State Bison Herd and in other confined species**.** We recommend similar actions if any DOI herd experiences symptoms of poor genetic health, and we recommend following the guidelines in the introgression section whenever translocation is performed.

Research Recommendations

We recommend the development and application of more high-resolution molecular markers to identify the presence of cattle ancestry in existing herds, to prevent the spread of cattle ancestry to new conservation herds, and to monitor the genetic variation in DOI herds.

Continue to identify and develop a suite of molecular markers, including single nucleotide polymorphisms that are used for on-going genetic sampling of all DOI herds. Encourage other managers of conservation herds to apply the markers and protocols to their bison herds. New markers should be evaluated in peer-reviewed literature before they are added to herd genetic-sampling protocols.

Research to address uncertainty in small-population management

We know that the bison population sizes of 1,000 and 500, whether they represent survey, census, or breeding numbers, are significantly below the effective population size that many population geneticists see as necessary to secure genetic variation in bison over centuries. Theoretically the loss of genetic diversity is proportional to the effective population size (N_e, essentially, the number of individuals that contribute to breeding). We know that the effective population size of bison herds is lower than the breeding number and probably significantly lower than the estimated population size (N), but we do not know how much lower. To better manage small herds, we need more accurate estimates of the N_e/N ratio over time in existing populations and an analysis of the magnitude of the effect of factors that influence N_e/N (e.g., sex ratio, sexual selection, population age distribution, and other factors).

Intensive breeding management is being used in some of the smaller DOI herds, with all animals genetically screened and individuals selected so that all bison alleles are conserved in each generation. This strategy had support at the workshop for the elimination of cattle mitochondrial DNA haplotypes, where it is well established that selection could be occurring. Selection for particular alleles of neutral microsatellite loci would not eliminate cattle characters or change cattle ancestry and was not supported, as it could result in loss of the bison genetic variation it seeks to preserve.

Even with the existing data on bison, more informed management decisions could be made by using decision-support tools that use models to evaluate costs and benefits of management alternatives. For example, Halbert et al. (2005) created and used an individual-based model to evaluate management strategies for the Texas State Bison Herd that exhibited low genetic diversity and signs of low fitness, and Gross et al. (2006) evaluated a range of management alternatives and population targets to retain genetic diversity in bison herds. Incorporating extensive genetic data into a model would allow quantitative evaluation of a number of different strategies and provide transparency to the final decision. Other models have used stochastic simulation processes to determine which management strategies would result in the greatest genetic diversity over time for wood bison (Macfarlane et al 2006). In a structured decision process, models are essential.

Additional research to minimize potential introgression events

The risk of increasing the proportion of cattle ancestry in a herd is a major factor in selecting bison for movement between herds. It is important, therefore, to reduce uncertainty about the history of cattle ancestry in DOI and other conservation herds. The projects below are intended to provide the information necessary to minimize further introgression of livestock genes into DOI bison herds.

Develop and apply higher resolution molecular techniques to guide bison management:
Molecular methods currently utilized in bison management (mtDNA and microsatellites) are only capable of resolving hybridization at the herd level. While these measurements can determine the presence of cattle genes, the absence of detectable cattle genes does not indicate unequivocally that hybridization has not occurred historically. The development and application of new molecular methods, such as single nucleotide polymorphic (SNP) markers, can provide much higher resolution, and these markers are already being developed for other ruminants (Van Tassel et al. 2008, Pertoldi et al. 2010, Decker et al. 2009). These markers could be used to

detect recent hybridization and to reduce its effect on conservation herds by removing specific individual bison from an existing herd, or for selecting non-introgressed individuals for translocation. These markers will also have value beyond detection of cattle ancestry. They can be used to monitor genetic variation in herds and to choose animals for transfer between closely related herds, and to better understand the relation between census and effective population size. New markers should be evaluated in peer-reviewed literature before they are added to genetic-sampling protocols.

Evaluate historic lineages and spatial genetic structure: The previous century of bison management (e.g., anthropogenic movement and re-establishment of herds) has likely wiped out the plains bison historical genetic structure. Reconstructing this history is likely to provide valuable insight into resolving and maintaining lineages to allow or prevent herd mixing. We recommend studies to analyze historical structure:

- *Analyze bison samples that were collected before widespread introgression.* Sources include museums, archeologists, and historic buffalo jumps. Extract DNA from teeth, bone, and untanned capes, in that order.

- *Create mtDNA maps for historic herd structure and spatial structure* by sampling contemporary bison herds.

Conclusions

The bison herds of the U.S. Department of the Interior constitute an invaluable resource and a keystone species in prairie and woodland ecosystems. By the efforts of citizens that saved the remnant bison and of the managers that have been entrusted with them, a remarkable amount of the North American bison genome has been preserved. No emergency actions are necessary to continue that preservation, but concerted actions by researchers and managers are needed if North American bison are to be conserved in their diversity for decades and centuries.

Herd sizes must be increased, and where there is not adequate land to support larger populations, satellite herds must be established with exchange of animals to constitute metapopulations. This requires close cooperation between government agencies, including the integration of management plans. Most importantly, management of bison must be refocused to the landscape scale, where natural selection can work to preserve variation.

Table 2. Recommendations to limit bison introgression in DOI bison herds.

		INTROGRESSION	
	Recommendation	**Mechanism**	**Management**
Maintain genetic integrity	Introduce individuals to a herd only when they do not increase overall levels of cattle ancestry	Test both donor and recipient herd for cattle markers before any translocation	Perform regular sampling and routine testing of DOI herds either during handling or by remote methods
	As a very high priority, maintain genetic isolation of herds that exhibit no DNA evidence of cattle ancestry	Secure boundaries by all appropriate means. Remove or eliminate trespass animals; test to confirm origin of trespass animals whenever possible	Install secondary fencing and perform regular testing
	Minimize historic cattle ancestry when establishing new herds, while maximizing preservation of existing genetic variation	Test herds to confirm that they do not have cattle mtDNA haplotypes and for the presence of bison with cattle microsatellite alleles	Perform genetic monitoring of satellite herd to test for drift as well trespass animals
	Separate wood and plains bison herds to avoid interbreeding and to maintain morphological and behavior differences that have a genetic basis	Use genetic analysis to evaluate the current distinctiveness of wood and plains bison herds	Support Wood Bison Recovery Strategy. As more bison markers are developed, test plains and wood bison for significant differences in marker frequency

Table 3. Recommendations to retain genetic diversity in DOI bison herds.

		PRESERVING VARIATION	
	Recommendation	**Mechanism**	**Monitoring**
Population size (loss of genetic variance over time)	Achieve herd size of 1,000 bison or more at a location whenever possible	If 1,000 or more, no action (herds with more than 1,000 bison do not require active genetic management under normal conditions) If fewer, attempt to increase size/capacity	Census or survey: The goal is to move conservation herds to a size where they do not require active genetic management
	Regularly test herds of 500 to 1,000 for heterozygosity and other measures of genetic diversity. Seek ways to increase effective herd size	Develop herd-specific management plan within (5) years	
	Actively manage herds of fewer than 500 bison to sustain adequate genetic variation	Occasionally supplement with additional genetic material, following guidelines for donor animals	
Demography – effective population size	In small(er) herds, minimize fluctuations in population size to maximize N_e	For managed populations, conduct removals frequently, rather than less frequent large removals	
	In small herds, maintain a sex ratio approaching 1:1, but no more than 60% of either sex	Remove animals of relevant sex	Monitor demographics; measure genetic contribution of bulls
	In small herds, use management strategies that maintain generation interval	In the absence of predation, remove young animals in preference to old	Monitor lifetime reproductive success, particularly of bulls
Manage to minimize inbreeding	Supplement herds with additional genetic material if heterozygosity falls below 0.50 based on the 33 microsatellites	Move animals into herds based on guidelines for animal movements	Herds approaching threshold should be monitored for heterozygosity every year to avoid or alleviate signs of inbreeding depression
Facilitate adaptation and natural selection	When removing animals to control herd size, do not select for traits such as docility, body conformation, etc.	Randomly remove animals from within sex and age classes to achieve desired population structure	
	Maintain and allow the full range of natural selection pressures to operate where possible (e.g., predation, competition for mates)	Provide sufficient space for normal range of behaviors	

	To extent possible, retain spatial substructure of populations	Remove animals from all spatial segments of the population. Provide sufficient space for herds to naturally subdivide
	Maintain and allow the full range of natural selection pressures to operate where possible (e.g., predation, competition for mates)	Provide sufficient space for normal range of behaviors
	To extent possible, retain spatial substructure of populations	Remove animals from all spatial segments of the population. Provide sufficient space for herds to naturally subdivide
Minimize risk among population of losing genetic diversity to drift	Establish multiple populations of highly valued herds	
	Create guidelines for prioritizing establishment of new populations	
	When considering exchange between populations (lineages), use the best information (preferably results from historical genetic analyses) to determine and maintain historical genetic patterns and lineages of the species to the extent possible	
	If conserving lineages is important, the ideal donor herd should have a genetic, ecological, or historical link to the recipient herd	Examine genetic correspondence of potential donors and match to recipient, considering ability of donors to achieve other recommendations (e.g., achieve diversity goal)
	Attempt to replicate significant lineages (YELL, WM, WC) via satellite herd establishment	

Table 4. Recommendations for research priorities in bison genetics.

	RESEARCH		
Purpose	**Recommendation**	**Mechanism**	**Monitoring**
Resolving introgression	Identify and develop a suite of molecular markers, including Single Nucleotide Polymorphism (SNP) technology, for testing of all DOI herds	Transfer development of SNP technology from cattle to bison	Sample all DOI herds and conservation herds managed by other federal and state/provincial agencies, tribal/First Nation organizations, and NGOs in North America
	Develop models utilizing decision-support tools to evaluate costs/benefits of alternative management strategies for bison conservation	Fund model development	Use models to evaluate a range of specific management strategies prior to translocation of bison between herds and establishment of new herds
	Evaluate historic lineages and spatial genetic structure	Analyze historic samples utilizing advanced DNA methodologies, including SNPs when available	Include in decision-support models to assess bison translocations
	Estimate effective population size and N_e/N ratio in existing populations and evaluate sources of variation	Perform genetic testing and characterization of entire herds over a period of years to establish breeding success	Test all animals during management of small herds

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Appendix A. Participants in the Bison Conservation Genetics Workshop held in Nebraska City, Nebraska

Name	Affiliation	Position
Kaush Arha	Department of the Interior	Deputy Assistant Secretary Fish, Wildlife & Parks
Keith Aune	Wildlife Conservation Society	Senior Conservation Scientist
Scott Baker	Oregon State University	Associate Director, Marine Mammal Institute
James Derr	Texas A&M University	Professor of Genetics, College of Veterinary Medicine and Biomedical Sciences
Peter Dratch	National Park Service	Zoologist, Endangered Species Program Manager
Peter Gogan	U.S. Geological Survey	Research Wildlife Biologist, Northern Rocky Mountain Science Center
John Gross	National Park Service	Ecologist, Inventory and Monitoring Program
Natalie Halbert	Texas A&M University	Research Assistant Professor
Phil Hedrick	Arizona State University	Ullman Professor of Conservation Biology
Briar Howes	Parks Canada	Species at Risk Biologist
Lee Jones	U.S. Fish & Wildlife Service	Wildlife Health Biologist
Eric Lonsdorf	Lincoln Park Zoo	Director, Urban Wildlife Institute
Cecilia Penedo	University of California, Davis	Associate Director, Veterinary Genetics Laboratory
Kent Redford	Wildlife Conservation Society	Vice President, Conservation Strategies
Tom Roffe	U.S. Fish & Wildlife Service	Wildlife Disease Ecologist
Oliver Ryder	San Diego Zoo	Kleberg Associate Director, Head of Genetics Division
Danny Swepston	Texas Parks and Wildlife	Wildlife Biologist
Greg Wilson	Canadian Wildlife Service	Species at Risk Biologist

Appendix B. Workshop Agenda

Bison Genetics Workshop Lied Conference Center September 2–5, 2008

Tuesday, September 2

4:30 p.m. Gather – introductions and agreement on meeting objectives
Peter Dratch, Eric Lonsdorf

6:00 Dinner

7:00 Welcome and charge – Deputy Assistant Secretary Kaush Arha
A brief history of bison conservation – Kent Redford

Wednesday, September 3 Issue: Introgression and hybridization

6:30–8:30 a.m. Breakfast buffet

8:30 Gather and informal discussion
Genetic management plans that take a century view – Ollie Ryder The tools of the trade: molecular methods in use – Cecilia Penado

10:30 Break

11:00 Evidence of introgression in NA bison herds – Jim Derr
Hybridization of wood and plains bison – Greg Wilson

Noon Lunch

1:00 p.m. Establishing thresholds for cattle introgression – Eric Lonsdorf
Maintaining distinctness of NA bison subspecies

3:00 Break

Developing suggested guidelines on hybridization Research priorities and their implications

6:00 Dinner

7:30 Subgroups working on introgression and research meet

Thursday, September 4 ***Issue: Maintaining variation in bison herds***

6:30–8:30 a.m. Breakfast buffet

8:30 Gather and report back of subgroups
Maintaining intraspecific variation – John Gross
Methods and measures for preserving variation – Tom Roffe Heterozygosity, allelic richness, etc.
Remote biopsy sampling and genetic monitoring – Scott Baker

10:30 Break

11:00 Comparison of variation in conservation herds – Natalie Halbert
Examining relationship between herds

Noon Lunch

1:00 p.m. Establishing targets for genetic variation – Eric Lonsdorf
Minimum herd size; sex and age structure
Methods of gene exchange in a conservation framework

3:00 Break

3:30 Developing guidelines for genetic health of NA bison
Sample collection, storage and distribution

6:00 Dinner

7:30 Subgroups working on variation and sampling meet

Friday, September 5

6:30-8:30 a.m. Breakfast buffet

8:30 Gather and report back of subgroups – Eric Lonsdorf
Discussion of final recommendations on bison hybridization Discussion of final recommendations on bison variation

10:00 Break

10:30 Discussion of final recommendations on research and sampling
Closing comments

11:30 Adjourn

Appendix C. U.S. Department of the Interior Herd Histories

Badlands National Park

Bison have continued to be the dominant large herbivore of Badlands National Park (BADL) since their establishment in 1963 through the restoration of 25 bison from Theodore Roosevelt National Park in North Dakota and three bison from Fort Niobrara National Wildlife Refuge in Nebraska. All of these animals originated from the Fort Niobrara herd. Twenty additional bison were restored to BADL in 1983 from Colorado National Monument (CNM), whose original lineage was from a 1925 Denver, Colorado, herd. All animals from both lineages have had the opportunity to interbreed since 1983.

The bison herd at BADL increased dramatically from these original bison restorations in 1963 and 1983. Between the years of 1983 and 1987, an extensive research effort was conducted at BADL. The population peaked at more than 1,000 animals, and annual recruitment rates were greater than 50%. The current population is regulated opportunistically when numbers exceed 600 animals. BADL conducted annual roundups from 2002 through 2007, and bison of different ages and sexes were given to the InterTribal Bison Cooperative (ITBC) and Ogalala Sioux Parks and Recreation Authority (OSPRA). The ITBC distributes bison to Native American tribes trying to establish bison populations on their lands. Donating the bison to the ITBC and OSPRA are the main avenues that BADL uses to regulate the current population that inhabits the 64,000-acre Sage Creek Unit of the BADL Wilderness Area.

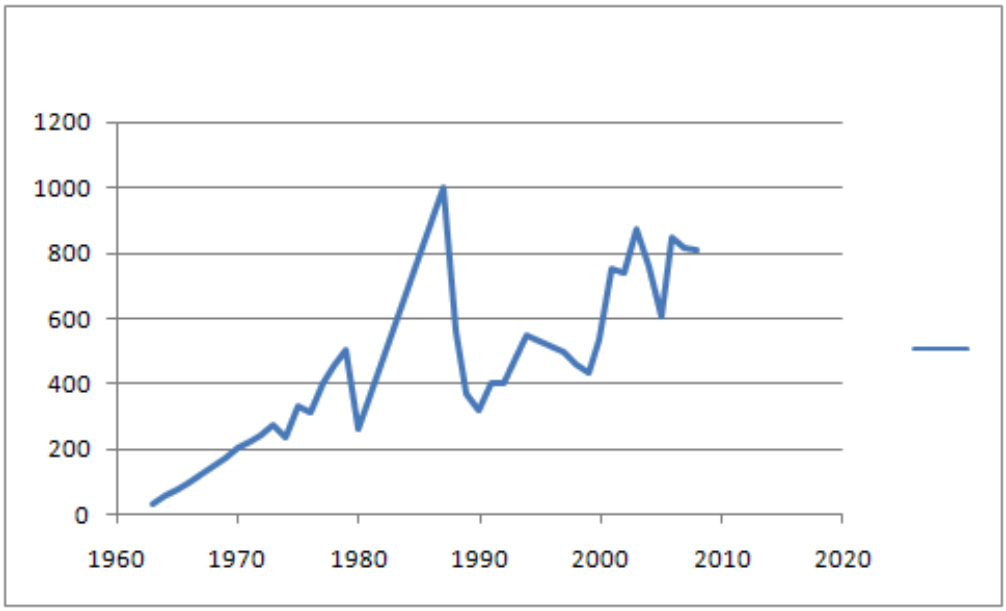


Figure 2. Badlands National Park bison herd population, 1963 to 2009.

Fort Niobrara National Wildlife Refuge

Fort Niobrara National Wildlife Refuge (NWR) consists of 19,131 acres located in north-central Nebraska along the Niobrara River. The refuge was established in 1912 as a "preserve and breeding ground for native birds." Later that same year, its purpose was expanded to include the conservation of bison and elk herds representative of those that once roamed the Great Plains. Prescribed fire and planned periods of rest, or non-disturbance, are used in combination with grazing by bison and elk in an effort to mimic historic processes that helped shape the native plant communities on the refuge. As many as 100,000 people visit Fort Niobrara NWR each year to see, appreciate, and learn about wildlife and their habitats.

The Fort Niobrara bison herd was founded in 1913 with the donation of six bison from J.W. Gilbert of Friend, Nebraska, and the transfer of two males from Yellowstone National Park. Additional introductions were made in 1935 (Custer State Park), 1937 (Custer State Park), and 1952 (National Bison Range).

Bison have been rounded up by refuge staff on horseback annually since the early 1930s to remove surplus animals, complete health testing, vaccinate, and/or mark animals. The entire bison herd tested negative for brucellosis in 1965 and was declared brucellosis-free in 1974 by the State of Nebraska. A comprehensive bison herd health monitoring program was initiated in 2003, and bison are no longer routinely vaccinated. The animals are individually identified with microchips.

Currently, both the Fort Niobrara and Sullys Hill bison herds are managed separately by fence on the refuge. In order to manage the refuge within carrying capacity (approximately 350 bison total), the Fort Niobrara herd will likely be reduced in future years to accommodate the growing Sullys Hill herd.

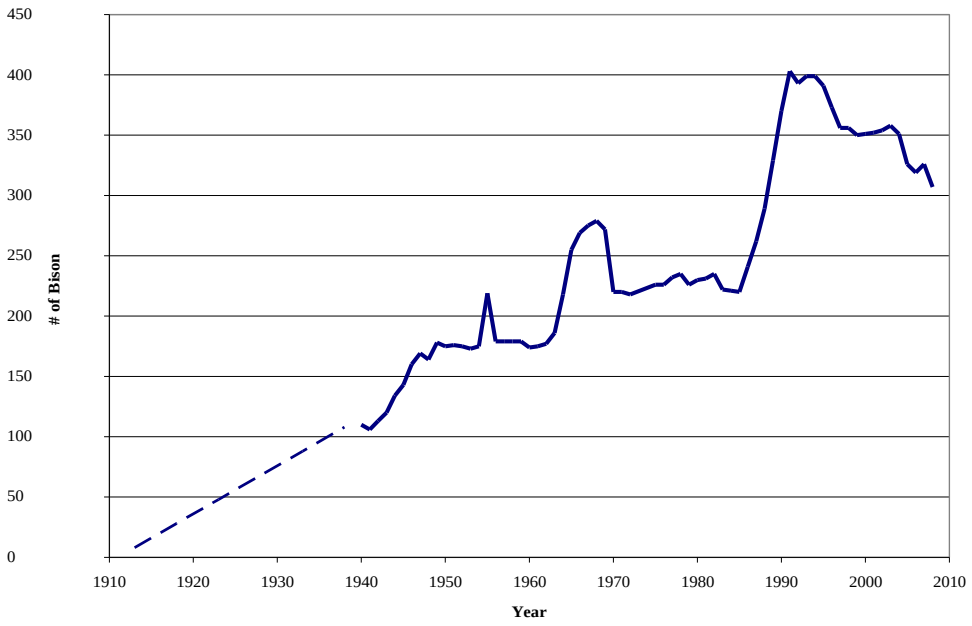


Figure C-2. Fort Niobrara National Wildlife Refuge bison herd population, 1913 to 2009.

Grand Teton National Park – National Elk Refuge (Jackson Bison Herd)

Bison were extirpated from Wyoming around Jackson Hole by the mid-1880s. In 1948, 20 bison from Yellowstone National Park were reintroduced to the 1,500-acre Jackson Hole Wildlife Park near Moran, Wyoming. A population of 15–30 bison was maintained there in a large exclosure until 1963, when brucellosis was discovered in the herd. All the adult animals were destroyed, but four vaccinated yearlings and five vaccinated calves were retained. Twelve certified brucellosis-free bison were added soon afterward from Theodore Roosevelt National Park. In 1968, the herd (down to 11 animals) escaped from the confines of the wildlife park, and a year later the decision was made to allow them to range freely. In 1975, the small Jackson Bison Herd began wintering on the National Elk Refuge, and the use of standing forage by bison on this winter range was viewed as a natural behavior and was not discouraged by managers. By 1980, however, the bison began eating supplemental feed provided for the elk, and they have continued to do so every winter since.

The discovery of supplemental feed by bison has had several consequences, including a decline in winter mortality and an increase in the population's growth rate. The Wyoming Game and Fish Department implemented a bison hunting season on lands outside Grand Teton National Park and the National Elk Refuge in 1997, but typically only 40 animals were harvested per year, and the effect on the population was minimal. The population increased approximately 10–14% per year between 1990 and 2007 and peaked at 1,059 animals in 2007. The Elk and Bison Management Plan and EIS was adopted in 2007. Under this plan the post-hunt objective is 500 bison, and the open hunting area was expanded to include the National Elk Refuge. During the 2007 harvest, 266 animals were removed, reducing the population to 920 during the 2008 winter count. The objective is to harvest 300 bison per year until the 500 objective is reached, at which time harvest levels will be reduced to maintain the population at 500.

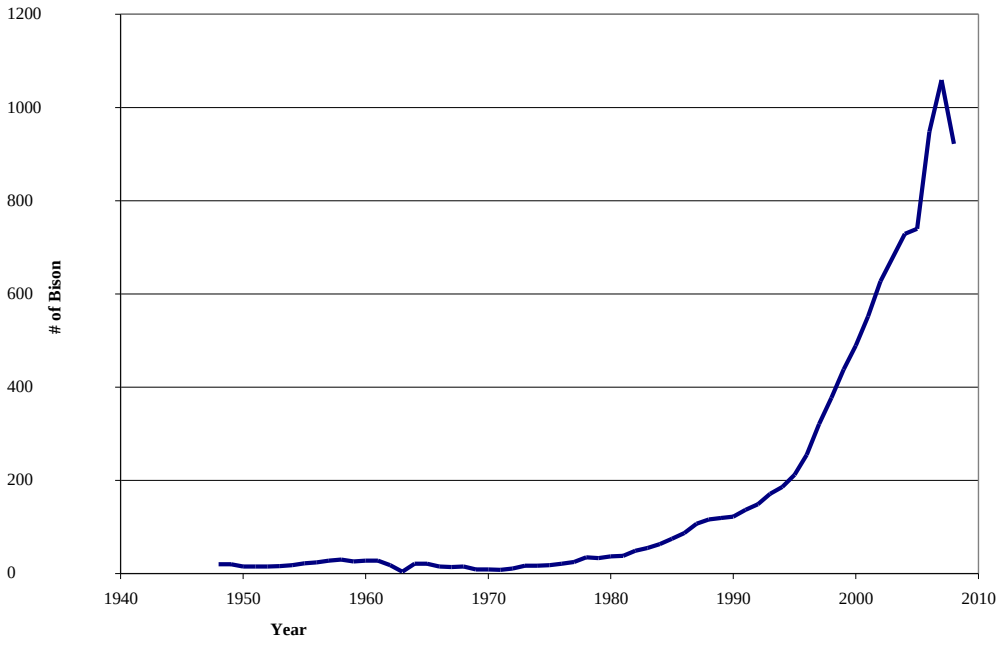


Figure C-3. Jackson Bison Herd (Grand Teton National Park/National Elk Refuge) population, 1948 to 2008.

National Bison Range

The National Bison Range, established in 1908 with the first Congressional appropriations ever made for the purchase of lands for a wildlife refuge, consists of 18,799 acres of Palouse prairie in northwest Montana. The refuge was established to provide "…for a permanent national bison range for the herd of bison…" Its purpose was expanded in 1921 to function "…as refuges and breeding grounds for birds," and again in 1958 "… to provide adequate pasture for the display of bison in their natural habitat at a location readily available to the public…" The refuge currently supports bison, elk, pronghorn antelope, Rocky Mountain bighorn sheep, mule deer and white- tailed deer, black bear, coyote, mountain lion, and more than 200 species of birds. As many as 250,000 visitors come to the refuge each year.

The herd was founded in 1909 from 34 northern plains bison purchased by the American Bison Society from the Conrad herd in Kalispell, Montana, plus two additional Conrad bison that were donated to the American Bison Society. One additional animal came from the Goodnight herd in Texas. In 1910, three additional northern plains bison were introduced from the Corbin herd. Subsequent additions include two bison in 1939 (7-Up Ranch, origin unknown); four in 1952 (Fort Niobrara); two in 1953 (Yellowstone National Park); and four in 1984 (Maxwell State Game Refuge).

The bison are rounded up annually by horseback to keep the population within the refuge carrying capacity, and a comprehensive herd health monitoring program has been in effect since 2000. The animals are individually identified with microchips, and the population is currently at approximately 320 bison.

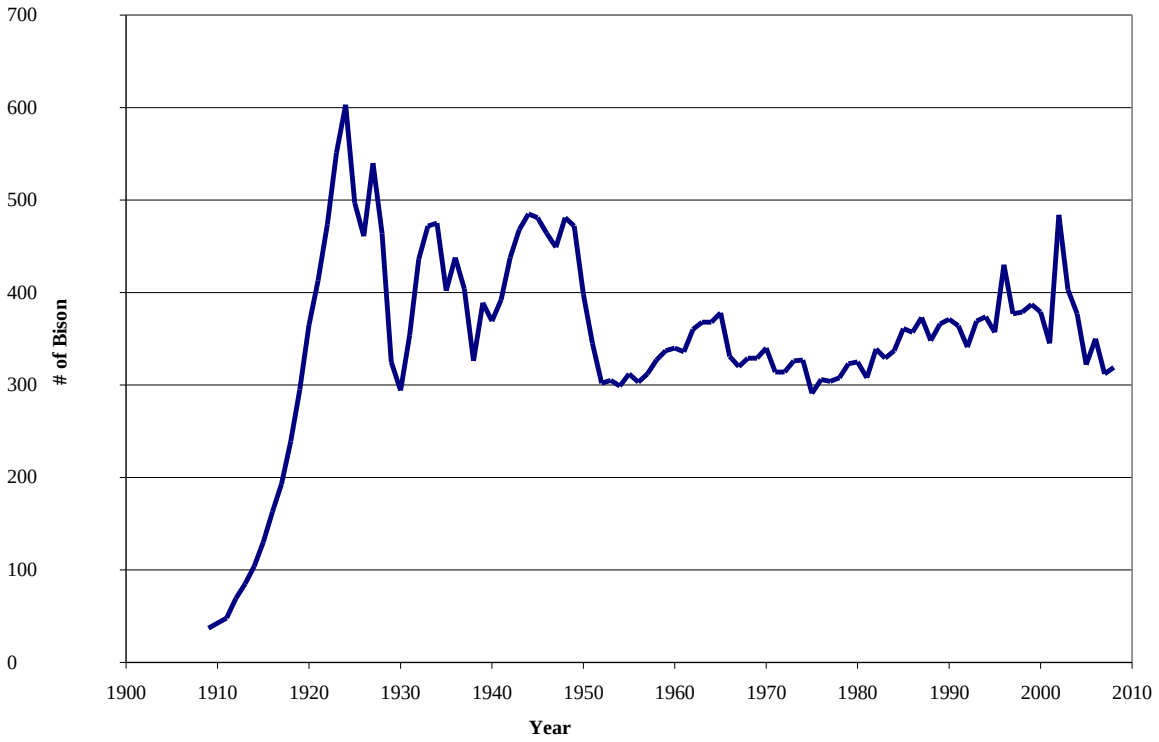


Figure C-4. National Bison Range bison herd population, 1909 to 2009.

Neal Smith National Wildlife Refuge

Neal Smith National Wildlife Refuge, located just east of Des Moines, Iowa, was established in 1991. Its mission is to re-construct tallgrass prairie and restore oak savanna on 8,654 acres of the Walnut Creek watershed and to provide a major environmental education facility focusing on prairie, oak savanna, and human interaction. Habitat management involves reclaiming agriculturally degraded land using grazing, prescribed fire, and other tools to restore tallgrass prairie and savanna habitat. Approximately 200,000 visitors come to the refuge every year. The refuge has been designated a U.S. Fish and Wildlife Service Land Management and Research Demonstration Area to facilitate development, testing, teaching, publishing, and demonstration of state-of-the-art management techniques for fish, wildlife, and plant conservation.

In 1996, bison were reintroduced from several other refuges around the country (not shown in graph below). However, recently completed genetics data suggested that the Neal Smith bison population contributed relatively little to national bison conservation efforts, and a new herd was established in 2006 with 39 animals transferred from the National Bison Range. The bison are rounded up annually to manage the population within refuge carrying capacity and to conduct health monitoring. The animals are individually identified with microchips, and the population is currently estimated at 71.

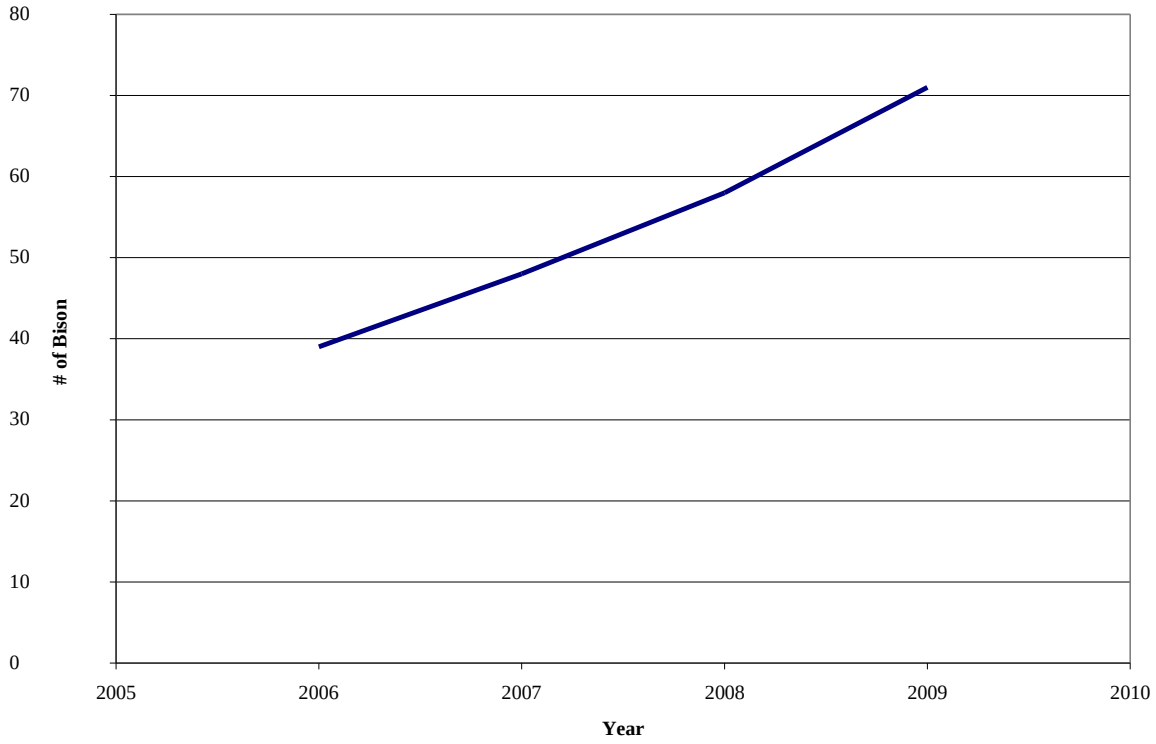


Figure C-5. Neal Smith National Wildlife Refuge bison herd population, 2006 to 2009.

Rocky Mountain Arsenal National Wildlife Refuge

In 1942, the U.S. Army bought thirty square miles of farmland to establish the Rocky Mountain Arsenal, a chemical weapons factory. After World War II, the army leased land to private companies that produced commercial pesticides. During the early Cold War of the 1950s, the U.S. Army again produced chemical weapons. While the industrial core of the site was contaminated, deer, prairie dogs, coyotes, and many species of hawks, owls, and other birds thrived in the abandoned fields, grasslands, and woodlots that had been protected from forty years of urban sprawl and development.

In 1992, Congress passed the Rocky Mountain Arsenal National Wildlife Refuge Act, designating the site as a future refuge. Since then, the U.S. Fish and Wildlife Service has managed the site "as if it were a refuge," monitoring wildlife health, restoring native prairie habitats, and providing opportunities for wildlife-dependent recreation. Located just northeast of downtown Denver, Colorado, the refuge is the largest contiguous open space in the Denver metropolitan area. The site is currently undergoing a major environmental restoration program and will become one of the largest urban national wildlife refuges in the United States.

The bison herd at the Rocky Mountain Arsenal was established in 2007 with 16 animals transferred from the National Bison Range as part of a pilot project. In spring 2008, two yearlings from Sullys Hill National Game Preserve, also of National Bison Range foundation, were added to the population. The population is currently estimated at 44, and the bison are individually identified with microchips. The refuge is planning to develop facilities to conduct annual roundups in an effort to manage the population within carrying capacity and complete herd health monitoring in future years.

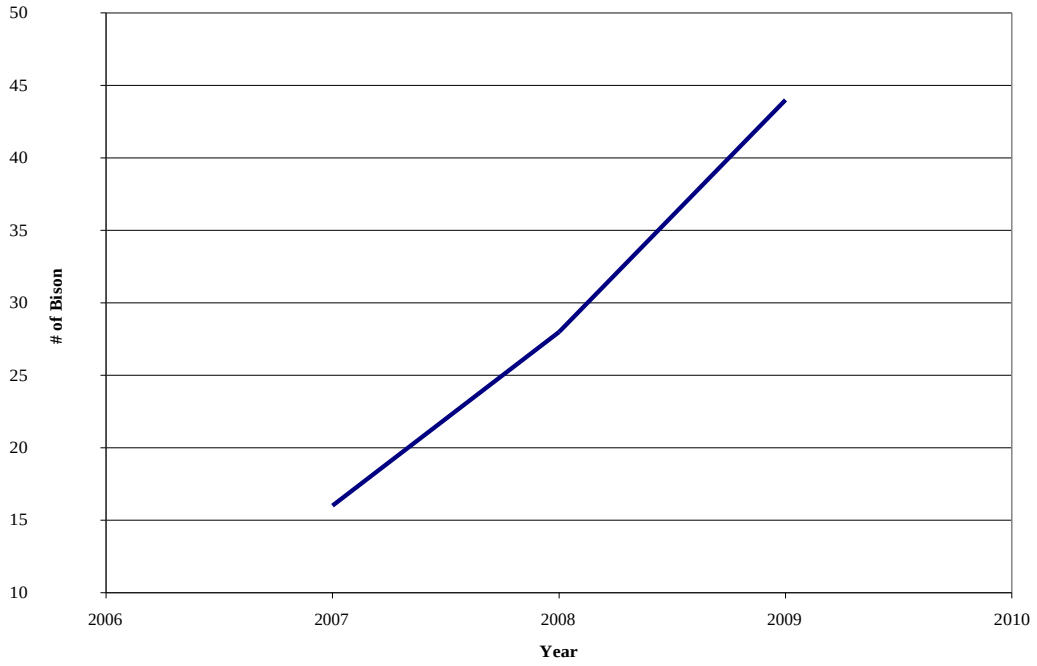


Figure C-6. Rocky Mountain Arsenal bison herd population, 2007 to 2009.

Sullys Hill National Game Preserve

Sullys Hill National Game Preserve, located on the south shore of Devils Lake, North Dakota, was established in 1904 by Teddy Roosevelt. In 1914, Sullys Hill was named a "Big Game Preserve" by Congress, and in 1921, President Warren Harding reserved the area as a refuge and breeding grounds for birds and all wildlife. Purposes include: "…a big game preserve, refuge, and breeding grounds for wild animals and birds…" and "…refuge and breeding grounds for birds." Sullys Hill National Game Preserve currently consists of 1,674 acres of wooded hills and open meadows.

Six bison were brought to Sullys Hill in October 1918 from the Portland City Park in Portland, Oregon, including the herd matriarch and her offspring. Based on historical documentation, it is believed that the herd matriarch was obtained by the Portland City Park from Ravalli, Montana, around 1906 through a trader named B.H. Denison. In 1932, the first addition to the herd, a bull from Wind Cave National Park, was made. Nine other introductions occurred between 1941 and 1997, including bison from the National Bison Range, Fort Niobrara NWR, and Theodore Roosevelt National Park.

Since 1980, average herd size has been approximately 30 animals at Sullys Hill, with about eight removed annually until 2006, when the entire herd was relocated to Fort Niobrara NWR to allow the population to expand. The population all currently contains 61 bison, and the animals are individually identified with microchips.

Seven bison from the National Bison Range were transported to Sullys Hill in 2006 to provide environmental education, outreach, and viewing opportunities for refuge visitors. This replacement herd is not included in the graph below.

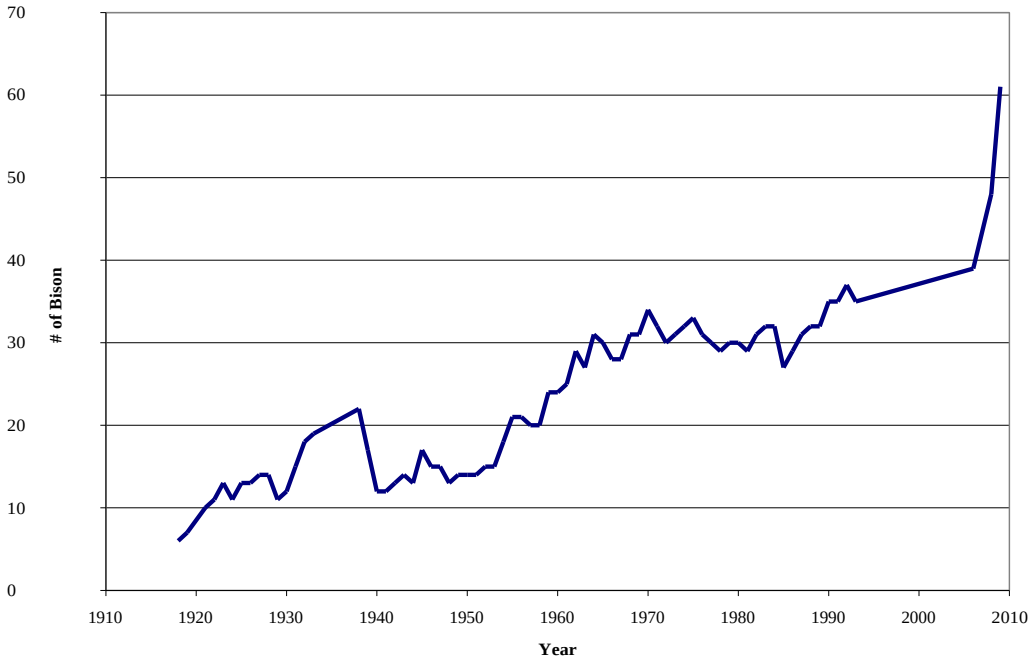


Figure C-7. Sullys Hill bison herd, 1918 to 2009 (relocated to Fort Niobrara in 2006).

Theodore Roosevelt National Park

Theodore Roosevelt National Park consists of three distinct areas totaling 70,446 acres (North Unit, 24,070; Elkhorn Ranch, 218; South Unit, 46,158). In 1956, 29 bison from Fort Niobrara NWR were reintroduced in the South Unit of the park, and in 1962, 20 bison from that population were released into the North Unit (there are no bison at the Elkhorn Ranch). Population objectives for bison in the North and South units were set at 100–300 and 200–500, respectively, using a park-specific forage allocation model, and since the initial releases, populations have ranged from 20 to 360 bison in the North Unit and from 29 to 472 in the South Unit.

Population monitoring prior to 1975 should be considered informal, and most estimates were made prior to roundups that occurred annually in the South Unit from 1962 through 1973. Records from 1975 to the present are more accurate and based on total-herd counts from complete park coverage by riders, aircraft, or both. During roundup years, the estimate reflects the population prior to culling the herd.

Each unit has its own wildlife-handling facility, holding and sorting pastures, a chute system, holding pens, and loading ramps. As bison are processed, morphometric and demographic data are collected, and each is identified with a micro-chip and federal identification tag in the right ear. Each bison is tested for brucellosis (*Brucella abortus*), and additional samples are archived for other studies (e.g., genetic purity, heterozygosity, etc.). No bison from either unit has tested positive for brucellosis.

The decision for culling an individual is based on population and demographic goals for that unit. Theodore Roosevelt National Park does not have sale authority for bison. Under a cooperative agreement, bison culled from the park are brokered through the Inter-Tribal Bison Cooperative, and other federal, state, and non-profit entities.

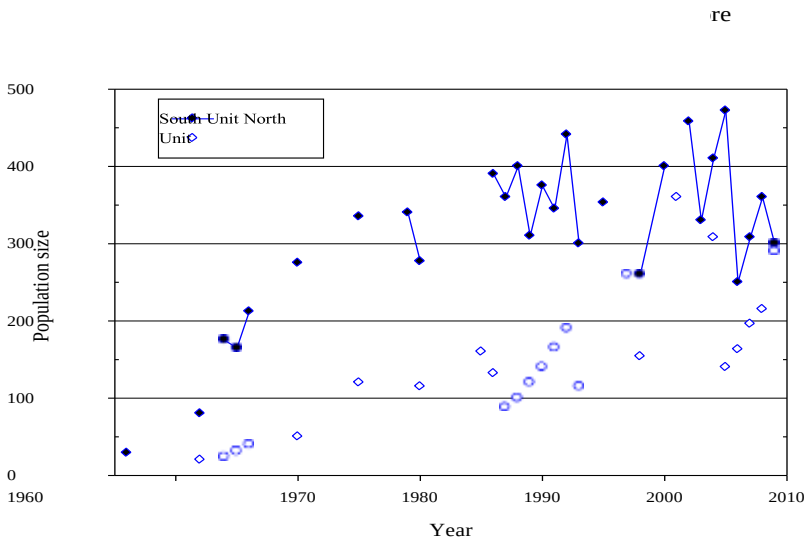


Figure C-8. Theodore Roosevelt National Park bison herd population, 1956 to 2009.

Wichita Mountains Wildlife Refuge

Wichita Mountains Wildlife Refuge, established in 1901, consists of 59,020 acres of mixed grass prairie in the Wichita Mountains of southwest Oklahoma. The refuge provides habitat for large native grazing animals such as bison, Rocky Mountain elk, and white-tailed deer. Texas longhorn cattle also share refuge rangelands as a cultural and historical legacy species. More than one million visitors come to the refuge each year.

Through the efforts of the American Bison Society and the New York Zoological Society, an offer was made to donate 15 bison to the Wichita National Forest and Game Preserve in the early 1900s. Congress set aside $15,000 for this purpose, and on October 11, 1907, 15 bison from the New York Zoological Park were shipped by rail to the refuge. Four bison from the Fort Niobrara NWR were added to the herd in 1940.

The current population is approximately 650 bison, and an annual roundup is conducted to keep the population within refuge carrying capacity and to conduct herd health monitoring. The refuge began inserting microchips in 2007 to identify individuals, and approximately 90% of the bison herd has been microchipped to date.

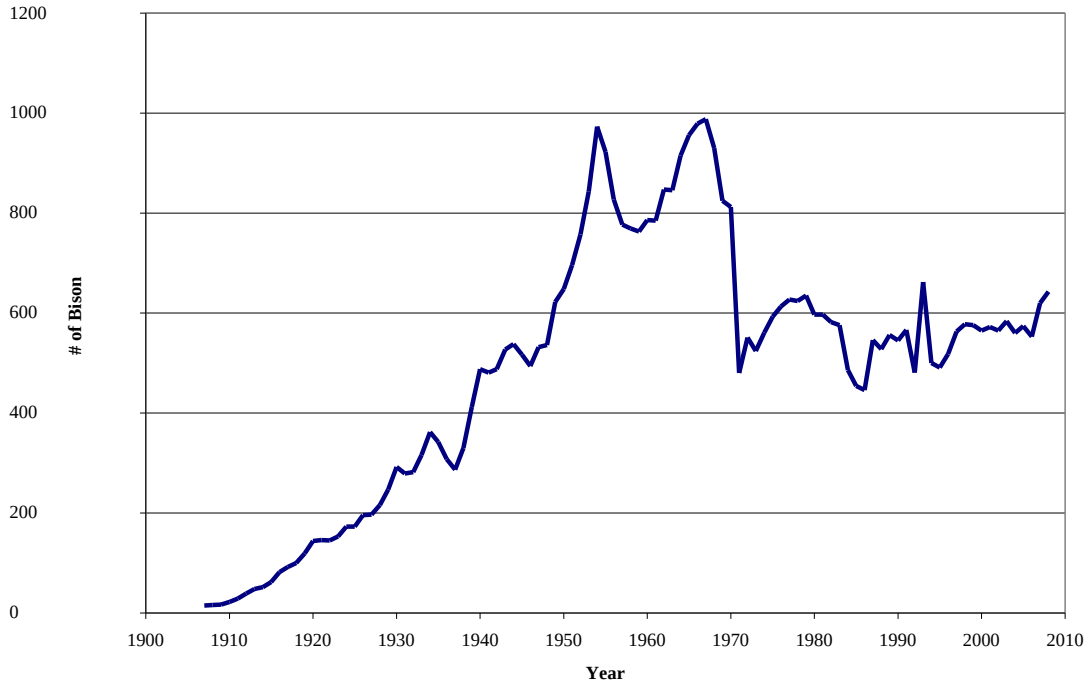


Figure C-9. Witchita Mountains Wildlife Refuge bison herd population, 1907 to 2009.

Wind Cave National Park

The Wind Cave National Park bison herd was originally established in 1913 on the Wind Cave Game Preserve, administered by the U.S. Department of Agriculture (USDA) Bureau of Biological Survey. This initial group consisted of 14 bison (six bulls and eight cows) and was a gift from the New York Zoological Society through the American Bison Association. Six more bison (two bulls and four cows) were brought to the game preserve from Yellowstone in 1916. These 20 animals were the founders of the current Wind Cave bison herd. In 1935 the Wind Cave Game Preserve was transferred from administration by the USDA to the Department of the Interior, and became part of Wind Cave National Park. A 1938 law authorized the park to sell or otherwise dispose of surplus buffalo and elk, and until 1943 bison were sold live or culled. Under an agreement with South Dakota in 1952, bison were baited into Custer State Park (CSP). This was the major means of disposing of bison until 1961 when the agreement to bait the bison into CSP was terminated in 1964 due to the high incidence of brucellosis in the Wind Cave herd, and the initiation of a calf-hood vaccination program by CSP.

As the park was expanded from 10,500 to 28,295 acres, the bison herd was allowed to increase. In the mid-1960s, the park established a target bison management population of between 350 and 500 animals. In 1960, brucellosis test results revealed approximately 75% of 52 bison tested were reactors. This lead to the initiation of a brucellosis control program in 1964 in which 220 bison were shot in the field, reducing the herd from 440 to 220. The park was placed under quarantine by South Dakota from 1982 to 1986. There have been no positive brucellosis reactors from 1985 to the present.

When a roundup is conducted, as many bison as possible are captured, tested, and released back into the park or shipped to various Native American tribes, non-profit organizations, and state and federal agencies. From 1965 to 1987, the bison herd was reduced by sending to slaughter the first bison to be rounded up regardless of age or sex. Since then, the park primarily reduces the herd by live shipment of yearlings and sometimes two-year-olds, keeping 8–10 of each sex and age class. A total of 1,489 have been distributed live between 1987 and 2007. Bison are allowed to die naturally, and their remains are left on the landscape.

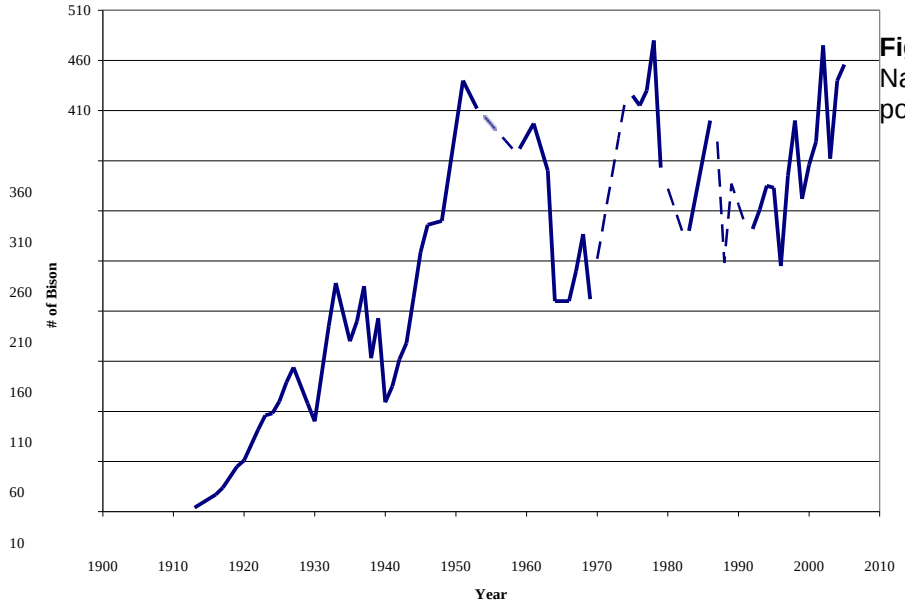


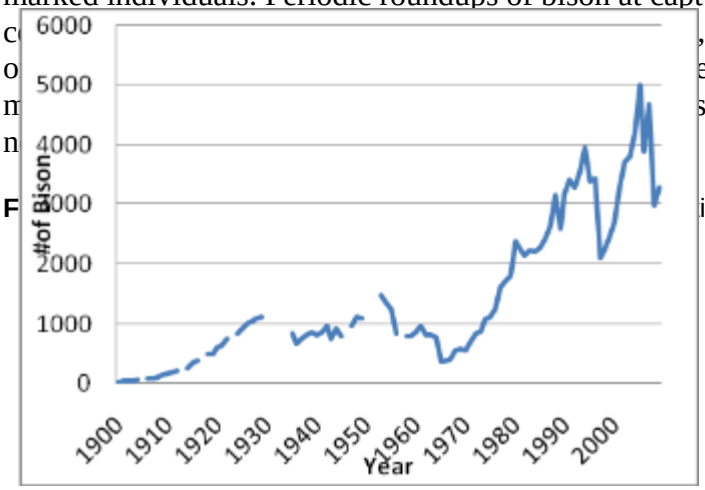
Figure C-10. Wind Cave National Park bison herd population, 1913 to 2009.

Yellowstone National Park

Yellowstone bison historically occupied approximately 20,000 km^2 in the headwaters of the Yellowstone and Madison rivers. Historical accounts of wild bison adjacent to and within the present-day Yellowstone National Park note that substantial numbers occupied the high plateaus in all seasons. When the park was established in 1872, the population of bison likely numbered in the several hundreds, but by 1900 the population had declined in abundance to less than 50 (actual count of 23) individuals located in the interior valley of Pelican Creek.

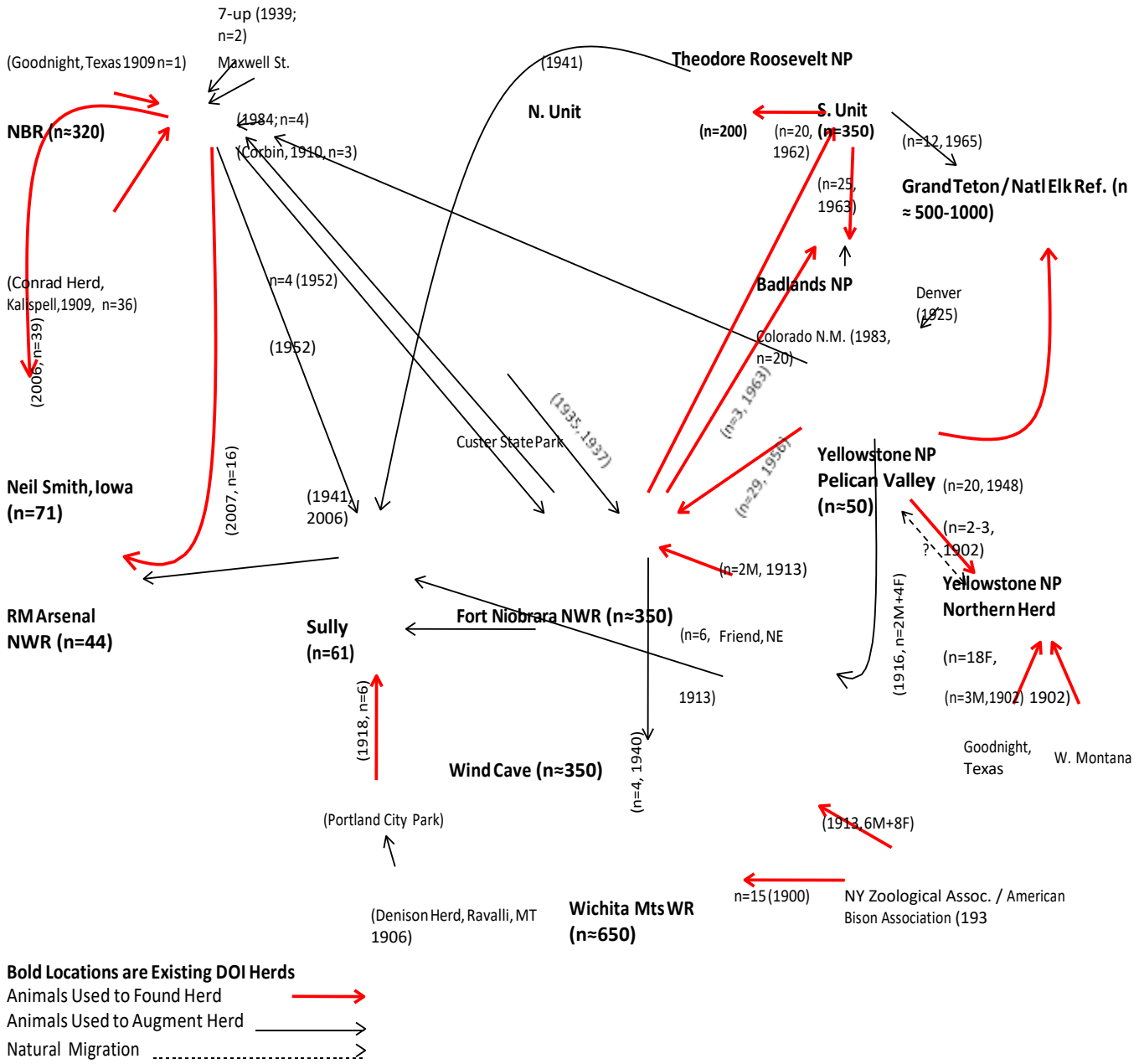
A restoration program on the northern range of Yellowstone was initiated in 1902 by translocating three adult males from Texas and 18 females from western Montana. This population was supplemented with a few calves from the Pelican Valley herd. The restoration program actively managed the bison by growing and feeding hay until the early 1950s and removing bison to manage abundance and sex ratio until the mid 1960s. Following a new 1968 management policy, the population increased to 4,000 by 1994 and to 5,000 bison in 2005. Conservation of Yellowstone bison is complicated by relatively high rates of *Brucella abortus* infection, their spring migratory behavior to low-elevation ranges along and outside the national park boundary, and especially with brucellosis detections in greater Yellowstone area livestock. The moderate to high population growth rate exacerbates the issue in the conflict zone at the conservation area boundary. The conservation area boundary was designated through negotiations with the State of Montana and does not include fencing to contain bison.
Yellowstone bison occupy a range of about 2,300 km^2.

The current Yellowstone bison management program is a collaborative effort with four other state and federal management agencies, directed by a long-term management plan signed by the Secretary of the Interior in 2002. The program uses a conservation strategy to manage for fluctuations in population abundance between 2,500 and 4,500 bison in order to balance the influence bison have on the park's forage base, conservation of the genetic integrity of the bison population, protection of migratory tendencies that wild bison exhibit, meeting brucellosis risk management responsibilities negotiated with state wildlife managers, and other constraints that influence human tolerance for wild bison outside Yellowstone National Park. An active surveillance program includes annual monitoring of the population to track demographic rates, brucellosis exposure, and brucellosis sero-conversion rates by maintaining a cohort of radio-marked individuals. Periodic roundups of bison at capture pens at the perimeter of the c ,000 bison are removed per year depending o er conditions. Removals are focused on m son that are found to be brucellosis sero-n



F ion, ca. 1900 to 2009.

Appendix D. Sources and Movement of DOI Bison (M. Schwartz 2010)



ARIZONA BISON MANAGEMENT PLAN

NPS 999/105815, October 2010

National Park Service
U.S. Department of the Interior

Natural Resource Program Center
1201 Oakridge Drive, Suite
150 Fort Collins, CO 80525

www.nature.nps.gov

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Appendix 4. Memorandum of Understanding between the Commission and KNF creating HRWA

MEMORANDUM OF UNDERSTANDING

We the undersigned, when all have signed, agree that the following conclusions were reached by us at the buffalo-livestock conference held at Jacob Lake, Arizona, on May 19, 1950, and further agree that the various parties, to the extent concerned, will carry out the necessary final arrangements with each other as rapidly as possible.

This agreement will be binding on all parties hereto, their heirs, executors and, or assigns.

The U. S. Forest Service agrees to the following:

1. To set aside the South Canyon and Fence Canyon allotments on the Kaibab National Forest as shown on a map in the office of the Forest Supervisor as an area for the grazing of buffalo and deer as long as the Arizona Game and Fish Commission continues to use the aforementioned area for the grazing of buffalo.

2. It is understood and agreed that no domestic livestock will be permitted to graze the Fence Canyon and South Canyon allotments of the Kaibab National Forest as long as the area is used for the grazing of buffalo.

3. To accept a waiver of grazing privileges to be signed by Mr. Woolley and to cancel Mr. Woolley's cattle preference and permit on the South Canyon and Fence Canyon allotments of the Kaibab National Forest.

The Arizona Game and Fish Commission agrees:

1. To lift the existing withdrawal of land from the public domain covered by Executive Order No. 5522.

2. To maintain the water pipe line and appurtenances now owned by the U. S. Forest Service from the water source to the state owned pipe line in Fence Canyon allotment; they further agree to maintain the pipe line owned by them from its junction with the Forest Service owned pipe line to the National Forest Boundary on the North side of Fence Canyon allotment.

3. To leave in place the pipe line and trough owned by them from the National Forest Boundary to its termination on the Bureau of Land Management lands.

4. To pass sufficient water for 200 head of cattle to the pipe line on the Bureau of Land Management lands when available at the source, but in the event of a water shortage for all uses served by the pipe line one-half of the total supply will be passed to the Bureau of Land Management lands.

5. To maintain an adequate fence on the north boundary of the buffalo allotment on the Kaibab National Forest and to keep the buffalo confined to their designated range on the Kaibab National Forest.

The Bureau of Land Management agrees:

1. To grant at this time to Mr. Royal B. Woolley a grazing license on the Bureau of Land Management lands in House Rock Valley for 200 cattle year long, subject to such future adjustments as may be necessary for conservation purposes.

2. To recognize the allotment of water which the Arizona Game and Fish Commission will pass through their pipe line to the Bureau of Land Management lands as adequate base property for a license or permit for Mr. Woolley.

The interested stockmen agree:

The undersigned livestock men now holding a grazing license on Bureau of Land Management lands in House Rock Valley agree to the granting of license by the Bureau of Land Management to Mr. Royal B. Woolley for 200 cattle year long in lieu of the permanent removal of all buffalo from the Bureau of Land Management lands in House Rock Valley by the Arizona Game and Fish Commission.

Mr. R. B. Woolley agrees:

1. To the cancellation of his grazing permit and preference for livestock on the South Canyon and Fence Canyon allotments on the Kaibab National Forest and to signing a waiver of grazing privilege for that preference.

2. To accept a grazing license for 200 cattle year long on the Bureau of Land Management lands in Houserock Valley in lieu of his grazing permit on the South Canyon and Fence Canyon allotments on the Kaibab National Forest.

3. To keep his cattle confined to the territory on which he has a permit or license.

Dated this 8th day of August, 1950.

Forest Supervisor - Kaibab National Forest

Chairman, Arizona Game and Fish Commission

Member, Arizona Game and Fish Commission

Member, Arizona Game and Fish Commission

Regional Administrator - Bureau of Land Management

Royal B. Woolley, Stockman

Alex Findlay, Stockman

John Schoppman, Stockman

Cecil Cram, Stockman (Representing his mother Mrs. Maggie Cram)

Subscribed and sworn to
before me this _____ day of _____, 1950

Appendix 5. MOA between the Department of Interior and AGFD for bison translocation to RWA

Agreement# G1560-15-001

Memorandum of Agreement
between
The United States Department of the Interior
National Park Service, Wind Cave National Park and
The Arizona Game and Fish Commission

1. PURPOSE:

This Agreement is entered into by and between the Arizona Game and Fish Commission (Commission) and the United States of America, U.S. Department of the Interior, National Park Service (NPS), by and through the Superintendent, Wind Cave National Park (WICA) (collectively "Parties" and singularly "Party") for the purpose of establishing a partner Plains Bison Conservation Herd at the Commission-owned Raymond Wildlife Area (RWA) in northern Arizona.

2. BACKGROUND AND OBJECTIVES

Considerable evidence now suggests that additional conservation and management efforts are needed to ensure the long term health of the Plains Bison as a species (DOI 2008). Generally, bison herds are threatened by small herd size, unnatural culling practices, and cattle gene introgression. Among Plains Bison, the only public herds known for which there is a good probability of genetic purity are Henry Mountains, Yellowstone National Park (YELL), Wind Cave National Park (WICA) (Halbert 2003), and Elk Island National Park (Alberta; Ward et al. 1999). Unfortunately, with the exception of YELL, all of these herds are limited to small population sizes. Previous and recent work (Gross and Wang 2005) directed specifically at federal herds indicates that: 1) Bison herds with fewer than about 400 animals are unlikely to meet a long-term goal of achieving a 90% probability of retaining 90% of genetic heterozygosity for 200 years, and 2) A moderate bison population size - about 1000 animals – is necessary to meet a long-term goal of achieving a 90% probability of retaining 90% of allelic diversity for 200 years.

Halbert (2003) indicated that in addition to being free of cattle introgression, both WICA and YELL herds also have high levels of unique genetic variation in relation to other federal populations. As such, these populations should be given conservation priority and be maintained in isolation from those populations identified in this study and by Ward (2000) as containing domestic cattle introgression.

Since both the YELL and WICA populations contain high levels of genetic variation and no evidence of domestic cattle introgression, consideration should be given to starting additional conservation herds using stock from these populations (Boyd 2003, Halbert 2003, Gross and Wang 2005) (hereinafter "Conservation Herds"). The founding and maintenance of new herds managed for conservation of the species will help to ensure the future preservation of genetically diverse bison by both expanding the total metapopulation size and building redundancy into the network of populations thereby insulating against risk.

Because of the need to conserve the Plains Bison and the conservation values of the WICA bison herd, the objectives of the Commission are 1) to maintain bison populations at levels which provide maximum and diverse recreational opportunities while avoiding adverse impacts to the habitat, 2) to establish an

ecologically restored Conservation Herd at Raymond Wildlife Area (RWA) using WICA Plains Bison as the source herd for herd establishment and growth, and (3) to support the long term conservation of genetically diverse WICA bison.

RWA has the infrastructure necessary to manage WICA bison without threat of interbreeding with bison from other lineages. The Department plans to use its Commission-owned and state-leased grazing capacity to manage the herd size at RWA within the habitat capacity.

The goal of this Agreement is to facilitate the establishment at RWA of a Conservation Herd of WICA lineage bison and to conduct periodic transfers of bison between the WICA and RWA herds to facilitate genetic exchange and to promote the long-term conservation objectives for the species.

This Agreement will facilitate cooperative work to expand and disperse the extant known genetically diverse bison genome within the original range of Plains Bison and meet Commission goals for management of bison in Arizona and NPS goals across North America (DOI 2014). Specifically this agreement aligns with Action 26 of the 2010 NPS Call to Action, "Return the American bison, one of the nation's iconic species, to our country's landscape. To achieve this we will restore and sustain three wild bison populations across the central and western United States in collaboration with tribes, private landowners, and other public land management agencies."

Long-term conservation objectives

1. Establish a Plains Bison Conservation Herd that ensures a 90% probability of retaining 90% of genetic heterozygosity for 200 years.
2. Establish an ecologically functioning population of bison possessing the Wind Cave lineage on Commission leased or fee-title owned lands comprising Raymond Wildlife Area. Establish a WICA lineage bison population that serves as a source of animals for bison restoration.
3. Establish a population at RWA that enhances the long-term survival of the species genetically, behaviorally, and ecologically and that promotes range health and biodiversity.
4. Maintain a bison population at RWA capable of sustaining a variety of consumptive (hunting) and non-consumptive uses and contributing to the cultural, aesthetic, economic, and social well-being of the public regionally and nationally.
5. Disseminate scientific information on reintroduction techniques and the ecological requirements for successful Plains Bison restoration.
6. Contribute to restoring and maintaining natural ecological processes and native biological diversity.
7. Periodically transfer live bison between WICA and RWA to facilitate genetic exchange between the RWA and WICA herd lineages and to accomplish mutual management and conservation goals.

It is the purpose of this Memorandum of Agreement to assign and define responsibilities of each Party regarding establishing a partner Plains Bison Conservation Herd at RWA. The Agreement includes provisions for roundup, transfer of responsibility, transportation, and management of bison.

3. AUTHORITY

The Act of August 25, 1916, as amended, 16 *U.S.C. § 1, 2-4 (1988),* declares that the NPS will promote and regulate the use of the various federal areas known as units of the national park system by such means and measures as conform to the fundamental purpose of the national park system,

which purpose is to conserve the scenery and natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.

16 U.S.C. Sec. lg. provides: "the National Park Service may in fiscal year 1997 and thereafter enter into cooperative agreements that involve the transfer of National Park Service appropriated funds to State, local and tribal governments, other public entities, educational institutions, and private nonprofit organizations for the public purpose of carrying out National Park Service programs, pursuant to 31 U.S.C. 6305."

The Arizona Game and Fish Commission has primary statewide responsibility for management actions related to fish and wildlife within the state of Arizona and is authorized to enter into this Memorandum of Agreement pursuant to A.RS. § 17-231 (B)(7). The Arizona Game and Fish Department (Department) and its Director (Director) act under the authority of the Commission.

To satisfy the mutual responsibilities and interests and to derive mutual benefits, WICA and the Commission agree to engage in a number of activities as detailed in the following Statement of Agreement.

4. STATEMENT OF AGREEMENT

A. The Commission agrees to:

1. Provide appropriate locations for establishment of a Plains Bison Conservation Herd at RWA.
2. Cull the current RWA bison herd prior to receiving WICA bison.
3. Ensure maintenance of the Wind Cave lineage, unless collaborative consultation with experts and the Commission recommends a different management strategy at which time this MOA will be updated accordingly.
4. Maintain and manage the RWA herd at a population level that is consistent with Department management goals, the Commission's goals for bison conservation, and those conservation objectives outlined in this MOA.
5. For the transfer of WICA bison to the Commission, the Department shall:
   a. Accept all responsibility for the bison from the point the bison are loaded into transportation vehicles at WICA for shipment to RWA, at which time the bison become the management responsibility of the Commission. The Department shall assume all costs of transportation and care of the animals whether shipped directly to RWA, a holding agency or other disposition based on disease testing as determined and directed by State and Federal Veterinarians.
   b. Ensure that transportation vehicles (trucks and trailers) used to transport bison have the required strength and capacity for the species. Vehicles for this purpose must have metal reinforced enclosed sides, enclosed tops and have a suitable loading gate (sliding). Vehicles transporting over ten (10) animals must have partitions or gates, operable from outside the truck, or individual pens, capable of dividing the space into at least two compartments. Transport vehicles must arrive at WICA clean and not have manure or hay from previous livestock operations.

c. Provide a representative at the WICA site during the roundup with the authority to accept and sign for transferred animals.

d. Conduct additional tests and provide vaccinations and disease prevention treatments (at Commission's expense) to meet federal and state interstate livestock movement requirements, and to provide for general wildlife disease prevention, beyond those normally completed by WICA.

B. The National Park Service agrees to:

1. Provide approximately 60 WICA bison in the fall of 2017 at no cost to the Commission for the establishment of the RWA Plains Bison Conservation Herd.

2. Ensure that WICA maintains the Wind Cave bison lineage.

3. Maintain and manage the WICA herd at a population consistent with goals for bison genetic conservation and consistent with NPS goals and directives, and to include the RWA herd in genetic testing research and studies, and recommendations for herd management.

4. For the transfer of WICA bison to the Commission, the Superintendent shall:

a. Organize and conduct all operations necessary for roundup, holding, and processing of animals for delivery into transportation vehicles at WICA for transport to RWA.

b. Arrange for veterinary services necessary to insure compliance with U.S. Department of Agriculture and State regulations pertaining to exporting bison from South Dakota, specifically providing a certificate of veterinary inspection and acquiring an Arizona permit for importation. Provide handling facilities and base salary costs of National Park Service employees involved in the operation.

c. Keep the Commission informed of schedules relating to the roundup and the location and time that animals can be picked up.

d. WICA will make every effort to furnish the number, age and sex of animals agreed to but is under no obligation to fulfill exact requests.

5. For the transfer of Commission bison to WICA:

a. Accept all responsibility for the bison from the point the bison are loaded into transportation vehicles at RWA for shipment to WICA, at which time the bison become the management responsibility of the NPS. The Superintendent shall assume all costs of transportation and care of the animals whether shipped directly to WICA, a holding agency or other disposition based on disease testing as determined and directed by State and Federal Veterinarians.

b. Ensure that transportation vehicles (trucks and trailers) used to transport bison have the required strength and capacity for the species. Vehicles for this purpose must have metal reinforced enclosed sides, enclosed tops and have a suitable loading gate (sliding). Vehicles transporting over ten (10) animals must have partitions or gates, operable from outside the truck, or individual pens, capable of dividing the space into at least two compartments. Transport vehicles must arrive at RWA clean and not have manure or hay from previous livestock operations.

c. Provide a representative at the RWA site during the roundup with the authority to accept and sign for transferred animals.

d. Conduct additional tests and provide vaccinations and disease prevention treatments (at NPS expense) to meet federal and state interstate livestock movement requirements, and to provide for general wildlife disease prevention, beyond those normally completed by RWA.

C. The Parties mutually agree:

1. That all bison capture operations at WICA are under the direction of WICA, and in the event of disagreement in the field, the decision by WICA shall prevail.
2. That all bison capture operations at RWA are under the direction of the Department, and in the event of disagreement in the field, the decision by the Department shall prevail.
3. That all bison management operations on RWA lands are under the authority of the Commission.
4. The Commission shall develop a detailed plan for the establishment and management of a RWA Bison Conservation Herd, the content of which shall be within the Commission's sole discretion. The plan will include:
   - Management goals and objectives; and strategies to reach the objectives at RWA;
   - Management Procedures detailing how bison will be managed;
   - Bison rotation schedule with other WICA herds forming a larger meta population of bison for genetic maintenance purposes; and
5. To periodically collect blood samples for DNA analysis and disease monitoring.
6. To periodically transfer, on an as-needed basis, live bison from RWA to WICA lineage herds, and from WICA lineage herds to RWA in order to facilitate adequate genetic exchange between the respective herd lineages and to achieve the management and conservation goals of the Parties.
7. To collaborate on data collection, analysis and writing of reports from this work so results can be communicated to the scientific and lay communities.

5. TERMS OF AGREEMENT

a. This MOA shall be effective upon the date of the last signature and shall remain in effect for a period of five years.

b. Modifications within the scope of this MOA shall be made by mutual consent of the Parties, by the issuance of a written modification, signed, and dated by all Parties prior to any changes being performed.

c. Either Party may terminate this MOA by providing the other Party with 60 days advance written notice. In the event that one Party provides the other Party with notice of its intention to terminate, the Parties shall meet promptly to discuss the reasons for the notice and to try to resolve their differences amicably. The Parties commit to using every reasonable means available, including the use of a neutral mediator if necessary to avoid terminating this MOA.

d. All terms and conditions of the September 10, 2013 Master Memorandum of Understanding between the United States Department of Interior, National Park Service, Intermountain Regional Office and the State of Arizona, Arizona Game and Fish Commission are incorporated herein by reference.

e. In accordance with A.R.S. § 35-214, all books, accounts, reports, files, electronic data, and other records relating to this MOA shall be subject at all reasonable times to inspection and audit by the State of Arizona for five (5) years after completion of this Agreement.

f. Every obligation of the Parties under this Agreement is conditioned upon the availability of funds appropriated or allocated for the payment of such obligation. If funds for the continuance of this MOA are not allocated or are not available, this Agreement shall terminate automatically on the date of expiration of funding. In the event of such termination, the Parties shall incur no further obligation or liability under this MOA other than for payment of services rendered prior to the expiration of funding.

g. This Agreement is subject to termination for conflict of interest pursuant to A.R.S. § 38- 511.

h. Nothing in the MOA prevents either Party from participating in similar activities with other public or private agencies, organizations, or individuals.

1. All work performed pursuant to this MOA shall be in compliance with all applicable state and federal laws and regulations.

J. In the event that any provision of this MOA thereof shall be severed from this Agreement and shall have no effect on the remaining provisions of this Agreement, which shall remain in full force and effect.

k. Information exchanges between the Parties shall be in compliance with State and Federal public records laws.

1. The Parties agree to engage in any alternative dispute resolution procedures authorized by their statutes and regulations, including, but not limited to, 5 U.S.C. § 575 and A.R.S. § 12-1518.

6. KEY OFFICIALS

The key officials specified in this Agreement are considered to be essential to ensure maximum coordination and communication between the Parties and the work being performed. Upon written notice, either Party may designate an alternate to act in the place of the designated key official, in an emergency or otherwise.

1. For the NPS:

Greg M. Schroeder
Chief of Resource Management
Wind Cave National Park 26611
US Highway 385
Hot Springs, South Dakota 57747
E-mail: greg_schroeder@nps.gov
Telephone: (605) 745-1190
Facsimile: (605) 745-4207

2. For the Commission:

Larry D. Voyles
Director
Arizona Game and Fish Department
5000 W. Carefree Highway
Phoenix, AZ 85086
1voyles@azgfd.gov
623-236-7278

7. SIGNATURES

IN WITNESS HERETO, the Parties have executed this Agreement on the date(s) set forth below.

Arizona Game and Fish Commission
5000 West Carefree Highway
Phoenix, Arizona 85086

8.14.15

Larry D. Voyles Date
Director

National Park Service
Wind Cave National Park
Hot Springs, South Dakota 57747

Superintendent Date
National Park Service

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Appendix 6. Exert from a report by Hedrick on DNA testing from both House Rock and Raymond bison herds

MOLECULAR ECOLOGY

Molecular Ecology (2010) 19, 3328–3335 doi: 10.1111/j.1365-294X.2010.04752.x

Cattle ancestry in bison: explanations for higher mtDNA than autosomal ancestry

PHILIP W. HEDRICK

School of Life Sciences, Arizona State University, Tempe, AZ 85287, USA

Estimated cattle ancestry for mtDNA (mt) (ranked in order) and autosomal (A) genes (sample size N) for six herds with more than 10% cattle mtDNA and 16 other herds that have been surveyed (Hedrick 2009; data from Ward et al. 1999; Halbert et al. 2004, 2005; b; Wakeling 2006; Vogel et al. 2007; C. Penedo, (personal communication)

Herd name	Location	mtDNA (*N*)	Autosomal (*N*)	Ratio (mt/A)
Williams Ranch (WR)	Texas	1.000 (11)	0.000 (11)	¥
Houserock Ranch (HR)	Arizona	0.975 (40)	0.019 (40)	51.0
Santa Catalina Island	California	0.449 (98)	0.006 (98)	74.8
Custer State Park	S. Dakota	0.206 (34)	0.015 (39)	13.7
Maxwell Game Refuge	Kansas	0.180 (39)	0.011 (40)	16.4
Texas State Bison Herd	Texas	0.167 (36)	0.000 (40)	¥
16 other herds		0.0053	0.0050	1.1
All 22 herds		0.1392	0.0060	23.2
20 herds (not WR or HR)		0.0543	0.0056	9.7

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APPENDIX 7. Sample bison hunter letter and authorization form for either Raymond or House Rock Wildlife Areas.

August 28, 2019

Raymond Wildlife Area Bison Hunter:

Congratulations on drawing a bison permit for Raymond Wildlife Area (RWA). The purpose of this letter is to provide you important information about your upcoming hunt and to assist in making your hunt safe and successful.

There are two hunts with five total permits this December on Raymond Wildlife Area. Your hunt is the second of these hunts with two "Designated bull bison" permits. These are the second time hunts are being offered for the new Raymond bison herd that arrived in October 2017. This new herd is from Wind Cave National Park (WICA) in South Dakota and is managed with other WICA bison in other states that together form one large national conservation bison herd. As planned from the beginning, hunting is continuing as a primary management tool for this new Raymond herd.

Please arrive at RWA headquarters no later than 7:30 AM on December 13, the first day of your scheduled hunt. RWA is approximately one hour driving time east of Flagstaff off I-40. To get to RWA take I-40 east to exit 225, the "Buffalo Range" exit. Proceed south of I-40 following the signs approximately 10 miles to the RWA headquarters. At 7:30 AM, we'll have a short hunter meeting where we'll discuss your hunt, including what you can expect and how the hunt will be conducted. Please contact me upon receipt of this letter and give me your best contact phone number, so we can remain in contact in case of inclement weather.

Department employees will accompany you during your hunt and will designate which bison to take (see Commission Rule R-12-4-306 D). Each hunter will be allowed to have one helper accompany you on the actual harvest. Other help is welcome to stay at RWA headquarters until the harvest has been completed. Lawful weapons for bison at RWA are centerfire rifles or muzzleloaders only (see Commission Rule R12-4-304 A.4.b). Please ensure your firearm is functioning properly and is sighted in prior to your hunt. Be aware that accurate shooting at extended distances may be necessary. Firearms safety is our number one priority, please keep this in mind at all times. Typically shooting is at approximately 200 yards or less at a stationary animal. However, many variables can affect how this will actually occur in the field.

There is a requirement to test fire your rifle at RWA the morning of your hunt to ensure it is sighted in properly. This will take place after the hunter meeting and prior to your hunt. It will consist of verifying your ability to hit an 8 inch steel plate at 100 yards from a bench or tripod rest. The bison to be harvested are selected based on management objectives for the Raymond herd and will be designated by the employee directing your hunt. Just like any other big game hunt in Arizona, these hunts are not guaranteed. If you are successful in

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harvesting your bison though, you are responsible for processing it, so please plan accordingly. The Department will not be assisting in the processing of any harvested bison.

Camping is allowed on RWA. There are four designated campsites (no RV hookups) to the west of headquarters, if you want to camp on site. Also, if you have time and the interest, there is a new visitor's center at headquarters available for your use to learn more about bison history and management.

ATV's, UTV's and side by side use on RWA is prohibited due to complications managing these bison on the wildlife area. You may drive a vehicle other than an ATV, UTV or side by side to retrieve your bison once you have harvested though.

It is important to read the attached form and bring it signed with you the morning of your hunt. This signed form actually validates your bison permit. All forms will be collected prior to your hunt at the hunter meeting.

Again, please contact me upon receipt of this letter at the number listed below to coordinate your hunt and answer any questions you may have about your upcoming hunt. I look forward to meeting and helping you with your hunt.

Sincerely,

Matt Lewis

Raymond Wildlife Area Manager

928-699-5273 cell

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Raymond Wildlife Area Bison Hunter:

A new rule went to effect on July 1, 2013 pertaining to Raymond Wildlife Area bison hunts. Portions pertinent to Raymond in R12-4-306 are reprinted below. **To validate your Raymond bison permit you must read R12-4-306; agree to comply with this rule; sign and date this form signifying that you have read and agree; and turn this form in to the Department the morning of your hunt.**

R12-4-306. Bison Hunt Requirements

A. When authorized by Commission Order, the Department shall conduct a hunt to harvest bison from the state's bison herds.

B. A hunter with a bison permit-tag or non-permit tag shall:

1. Provide a signed written acknowledgment that the hunter received, read, understands, and agrees to comply with the requirements of this Section.
2. Be accompanied by an authorized Department employee, when required, and
3. Take only the bison designated by the Department employee, when required.

C. *Applies to House Rock bison hunts*

D. For the Raymond Herd (Units 5A and 5B):

1. A hunter with a permit-tag shall *(which is your hunt)*:

a. Hunt in the order scheduled, and

b. Be accompanied by an authorized Department employee who:

i. Shall designate the bison to be harvested, and

ii. May assist in taking the bison if the hunter fails to dispatch a wounded bison within a reasonable period.

E. A hunter issued a bison permit-tag or non-permit tag shall check out no more than three days after the end of the hunt, regardless of whether the hunter was successful, unsuccessful, or did not participate in a bison hunt.

4. When accompanied by an authorized Department employee, the employee shall conduct the check-out at the end of the hunt.

F. Failure to comply with the requirements of this Section shall result in the invalidation of the hunter's permit-tag or non-permit tag, consistent with the written acknowledgment signed and agreed to by the hunter.

_____

Hunter Printed Name **Hunter Signature** **Date**

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APPENDIX 8

Meeting Notes Concerning Water Allocation from South Canyon Pipeline on House Rock Wildlife Area

October 23, 2013

Present: Matt Williamson of Grand Canyon Trust (GCT)

Mike Hannemann of Kaibab National Forest

Carl Lutch of Arizona Game and Fish Dept (AGFD)

Purpose- To reach agreement on the intent of the 1950 MOU between the U.S. Forest Service, Arizona Game and Fish Commission, Bureau of Land Management, Mr. Woolley and three other interested stockmen in gallons/per delivery rather than unambiguous language used in the 1950 agreement to avoid future disagreements and arguments that occurred during the winter of 2012/2013 between GCT and AGFD employees.

The 1950 agreement established the House Rock Wildlife Area (HRWA) on the Kaibab National Forest specifically for bison and remove bison from all the BLM lands to the north of HRWA. The Grand Canyon Trust now owns and grazes cattle on the allotment previously owned by Mr. Woolley.

Specifically, the 1950 agreement states the Arizona Game and Fish Commission agreed:

1. To lift the existing withdrawal of land from public domain covered by Executive Order No. 5522.
2. To maintain the water pipe line and appurtenances now owned by the U. S. Forest Service from the water source to the state owned pipe line in Fence Canyon Allotment; they further agree to maintain the pipe line owned by them from its junction with the Forest Service owned pipe line to the National Forest Boundary on the North side of Fence Canyon allotment.
3. To leave in place the pipe line and trough owned by them from the National Forest Boundary to its termination on the Bureau of Land Management lands.
4. To pass sufficient water for 200 head of cattle to the pipe line on the Bureau of land management lands when available at the source, but in the event of a water shortage for all uses served by the pipe line one-half the total supply will be passed to the bureau of Land Management lands.
5. To maintain an adequate fence on the north boundary of the buffalo allotment on the Kaibab National Forest and to keep the buffalo confined to their designated range on the Kaibab National Forest.

Mr. Woolley agreed:

1. To the cancellation of his grazing permit and preference for livestock on the South Canyon and Fence Canyon allotments on the Kaibab National Forest and to signing a waiver of grazing privileges for that preference.
2. To accept a grazing license for 200 head cattle year long on the Bureau of Land Management lands in House rock Valley in lieu of his grazing permit on the South Canyon and Fence allotments on the Kaibab National Forest.
3. To keep his cattle confined to the territory on which he has a permit or license.

Today we agreed:

1. Mr. Woolley's agreement is conveyed to the Grand Canyon Trust (current BLM permittee).
2. The South Canyon pipeline in the agreement supplies water to the buffalo pasture on BLM land.
3. GCT is authorized by BLM to graze the buffalo pasture from Oct 15-May 30 each year (7.5 months) and not year round.
4. 15 gallons per day per cow is the standard water use for cattle we will use.
5. Year round use for 200 head of cattle @ 15 gallons per day equates to 1,095,000 gallons annually (200 head X 15 gallons/day X 365 days).
6. We believe AGFD would be legally required to deliver this total amount of water annually to the BLM land.
7. GCT desires to run up to 250 cows for up to 7.5 months within in the buffalo pasture. Typically, cattle will not be grazed for the full 7.5 months, but rotated to other pastures over the winter.
8. BLM allows 930 AUM's in the buffalo pasture. For 250 cattle that equates 7.4 months.
9. 7.4 months/12 months= .6166 X 365 days= 225 days
10. 250 head X 15 gallons/day X 225 days= 843,750 gallons max annually needed for 250 head of cattle for 7.4 months (compared to the 1, 095,000 gallons annually)
11. 225 days X 24 hr/day X 60 minutes= 324,000 minutes in 225 days
12. 843,750 gallons/324,000 minutes= 2.6 gallons/minute
13. **We settled on 3 gallons/minute** delivered to the buffalo pasture when cattle are present. At this rate: 3 gallons/min X 60 min X 24 hrs X 225 days = 972,000 gallons would be delivered to GCT's buffalo pasture in 225 days. This total is less than the 1,095,000 gallons total annual requirement for AGFD to deliver to the BLM land per the 1950 agreement.
14. When cattle are not present in the buffalo pasture, we discussed sending 1 gallon/minute to keep the GCT water lines primed, storage tanks full and have water available for pronghorn year round. However, AGFD is not obligated to deliver this amount.
15. If the South Canyon Spring water production drops below 6 gallons/minute, then AGFD and GCT would split the water 50/50.

16. AGFD in lieu of a water meter at South Canyon Spring will measure spring production at Tank 2 on HRWA.
17. GCT will measure water delivery at Buffalo water (the first water tank north of HRWA in buffalo pasture).
18. Discrepancies in water deliveries will be worked through respective supervisors for both the AGFD and GCT rather than through respective employees.
19. Specific timing of water delivery will be worked out annually as soon as possible before the grazing season. This advanced planning will help to ensure that the BLM Buffalo Pasture water troughs are full before the cattle arrive and help the AGFD plan for water needs within the HRWA. If adjustments in the water delivery schedule are needed during the cattle grazing season, these adjustments will be made through respective supervisors.