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Where the buffalo roam:



Figure 1. Bison in Wind Cave National Park, South Dakota.
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THE ROLE OF HISTORY AND GENETICS IN THE CONSERVATION OF BISON ON U.S. FEDERAL LANDS

By Natalie D. Halbert, Peter J. P. Gogan, Ronald Hiebert, and James N. Derr

History of bison

As an emblem of the Great Plains, American Indians, and wildlife conservation, the American bison (*Bison bison*) is one of the most visible and well-known of wildlife species in North America (fig. 1). Species of the genus *Bison* originally entered the continent via the Bering land bridge from northern Eurasia in the Illinoian glacial period of the Pleistocene epoch (125,000–500,000 years ago). Bison are the largest species in North

America to have survived the late Pleistocene–early Holocene megafauna extinction period (around 9,000–11,000 years ago), but likely experienced a dramatic population reduction triggered by environmental changes and increased human hunting pressures around this time (Dary 1989; McDonald 1981). The modern American bison species (*Bison bison*) emerged and expanded across the grasslands of North America around 4,000–5,000 years ago (McDonald 1981).

As the major grazer of the continent, bison populations ranged from central Mexico to northern Canada and nearly from the east to west coasts (fig. 2; McDonald 1981), with 25–40 million bison estimated to have roamed the Great Plains prior to the 19th century (Flores 1991; McHugh 1972; Shaw 1995).

By the 1820s, bison in North America were already in a state of continuous decline, especially in the South and East (Flores 1991; Garretson 1938). Evidence on many fronts indicates the initial decline was due to both natural and anthropogenic (human-induced) forces (Flores 1991; Isenberg 2000). For example, the introduction of nonnative animal species led to increased hunting efficiency by aboriginal peoples with the proliferation of the horse culture, spread of exotic diseases (e.g., tuberculosis and brucellosis from cattle), and competition for grazing and water sources with growing populations of cattle, horses, and sheep. Natural pressures including fire, predation by wolves, and severe weather events such as droughts, floods, and blizzards also served to limit historical bison population sizes (Isenberg 2000). Uncontrolled hide hunting by both aboriginal and Euro-American hunters, facilitated by advances in firearms and transcontinental rail transportation, advanced the rapid decline leading to the well-documented, precipitous population crash of the late 1800s (Coder 1975; Garretson 1938). A preference for young female bison hides likely added to the population decline by disrupting herd social structure and natality (birth) rates. Fewer than 1,000 American bison—including both the plains and wood bison types—existed in the world by the late 1880s, and the species appeared to be at risk of extinction (Coder 1975; Soper 1941). The timely formation of six captive herds from 1873 to 1904 by private individuals and governmental protection of two remnant wild herds in the United States (Yellowstone National Park, established in 1872) and Canada (Wood Buffalo National Park, federally protected from 1893, park established in 1922) effectively served to save

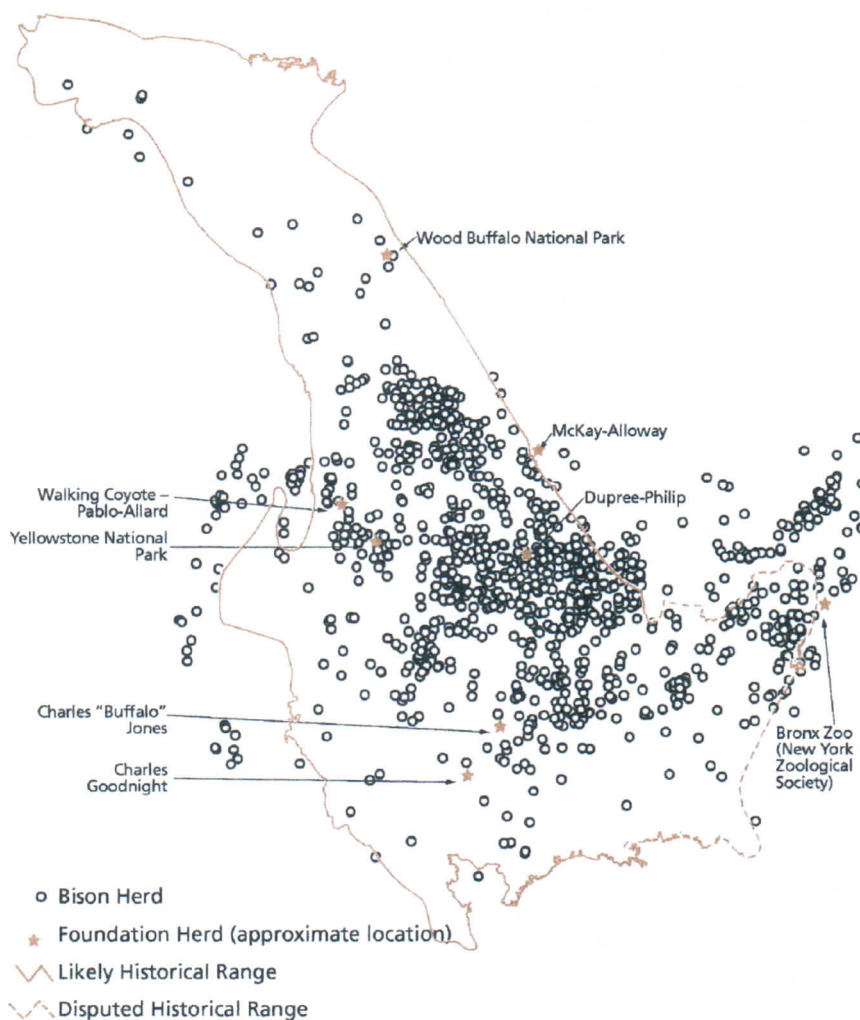


Figure 2. Historical distribution of *Bison bison*, with locations of foundation herds indicated (see table 1 for foundation herd histories). WILDLIFE CONSERVATION SOCIETY

the species from extinction (table 1, page 25; locations indicated on fig. 2). The individuals involved in the early bison conservation movement were primarily cattle ranchers concerned with the disappearance of large, free-roaming bison herds. For example, the Texas cattle rancher Charles Goodnight (fig. 3, page 24), at the behest of his wife (Haley 1949), captured bison in the panhandle of Texas during the late 1870s and early 1880s to form a small captive herd. From these few herds, a combined total of fewer than 500 bison served as the foundation stock from which all bison in existence today are derived (Coder 1975; Soper 1941).

Fewer than 500 bison served as the foundation stock from which all bison in existence today are derived.



Establishment of federal bison herds

Despite the significant population crash experienced in the late 1880s, bison in captivity thrived and by the turn of the 20th century, surplus bison were being sold off by private owners (Coder 1975). In contrast, the bison herd in Yellowstone National Park, representing the only continuously wild herd in the United States, was declining during this period due to unabated poaching; by 1902 only 30–50 bison persisted in the park (Garretson 1938; Meagher 1973). A critical shift in the bison conservation movement would occur, however, with new legislation in the United States and Canada providing for the protection of wildlife and the formation of additional federal bison herds (Coder 1975). The famous naturalist, William Hornaday, and the American Bison Society, founded in 1905, were instrumental in lobbying the U.S. government for such protective legislation and in procuring bison through the New York Zoological Park (see table 1) to establish new federal herds. At present, approximately 8,500 bison are maintained in five units administered by the National Park Service (NPS) and six units administered by the U.S. Fish and Wildlife Service (USFWS) (table 2). The bison in these 11 herds were derived almost exclusively from the 6 foundation herds and the continuously wild herd in Yellowstone National Park and, therefore, serve as an important reservoir of bison germplasm (genetic content).

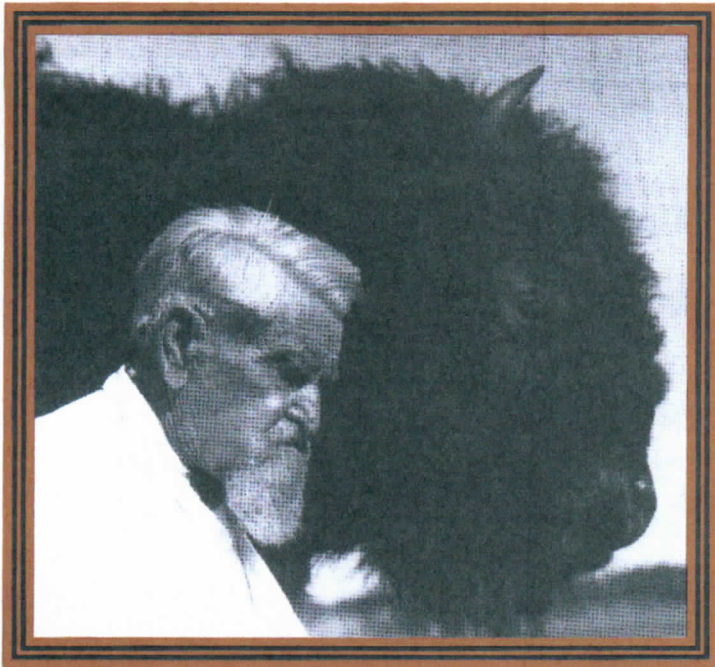


Figure 3. The famous Texas cattle rancher Charles Goodnight, who captured wild bison in the panhandle of the state to form one of the six foundation herds (see table 1) from which many extant bison are derived. In 1902, Goodnight gave three bison bulls to the U.S. federal government to supplement the small, wild herd in Yellowstone National Park (see table 2).

PANHANDLE-PLAINS HISTORICAL MUSEUM AND THE TEXAS STATE BISON HERD ARCHIVE PROJECT

Need for genetic information for bison management

The U.S. Department of the Interior (DOI) Bison Conservation Management Working Group has met annually since 1997 to gather and share information on bison management techniques, policy issues, animal health, genetics, and demographics. Early on, the group recognized the need for genetic information to guide management and specifically wanted to know: (1) the present levels and patterns of genetic variation within and among herds; (2) if it is more appropriate to manage DOI bison herds as separate populations or as a meta-population; (3) the effects of various culling practices on the maintenance of genetic variation; and (4) levels of domestic cattle (*Bos taurus*) introgression (introduction of foreign DNA fragments into a genome) in the DOI bison herds.

With funding from the U.S. Geological Survey Natural Resource Preservation Program and the U.S. Fish and Wildlife Service, a cooperative project was initiated with Texas A&M University. A summary of the results of this project and management implications follows.

Genetic architecture of bison herds

Knowledge of the genetic architecture of federal bison herds is critical to proper management, long-term maintenance of genetic diversity (that is, for the next 100+ years), and species conservation. For instance, genetic technologies can be used to assess the effects of the historic 19th century population crash (genetic bottleneck) and foundation of herds with few individuals (founder effect), levels of inbreeding and diversity in herds, sub-population structure within herds (nonrandom mating), and genetic relationships among herds. Such information is of great value to managers in determining appropriate herd sizes, sex ratios, and culling strategies.

To address these issues, polymorphic DNA markers—those having more than one allele or “form” of a gene/DNA sequence—are commonly employed to obtain genotypic information on individuals from populations. One such polymorphic marker is called a microsatellite, which is a type of simple sequence repeat (SSR). Microsatellites have several advantages in population genetic studies in that they are relatively inexpensive to use, simple and reliable to score (i.e., obtain genotypes), highly polymorphic, and abundant throughout the genomes of mammals.

Using a panel of 49 microsatellites dispersed throughout the bison genome, we recently completed an evaluation of the genetic structure of the 11 U.S. federal bison herds. (For complete study details, see Halbert (2003); Sully’s Hill National Game Preserve herd data is from

Halbert and Derr, unpublished data.) Blood, hair, or tissue samples collected by DOI personnel from 2,260 individual bison were shipped to Texas A&M University for DNA isolation and genetic evaluation. From these analyses we identified differences among herds in the average number of alleles per microsatellite (a measure of diversity) and calculated an average across all herds of 4.36 and a range from 4.96 (National Bison Range herd) to 3.55 (Theodore Roosevelt National Park, north unit herd) alleles per microsatellite. Herds also differed in levels of heterozygosity (an indicator of the breeding history of a herd), with an average across all herds of 59.1% and range from 65.7% (Wind Cave National Park herd) to 51.9% (Theodore Roosevelt National Park, north unit herd) heterozygosity. In general, higher levels of both heterozygosity and genetic diversity (alleles per microsatellite) are desirable, as these measures correlate with population stability and viability. The U.S. federal bison herds appear to have relatively high levels of both heterozygosity and genetic diversity, especially considering the significant population bottleneck experienced in the late 1800s and small numbers of founders used to establish the herds. In comparison, the Texas State Bison Herd, which is directly descended from the original Goodnight herd (table 1) and has remained a small, closed population for many generations, has an average of 2.61 alleles/marker and 38.5% heterozygosity (Halbert et al. 2004). As is often found in populations suffering from low levels of genetic diversity, the Texas State Bison Herd has a history of inbreeding, low natality rates, and high juvenile mortality rates compared with other bison herds (Halbert et al. 2005a).

The genotypic information obtained in this study was used to evaluate relationships among herds (fig. 4, page 27). While some herds are closely related, such as those in Fort Niobrara National Wildlife Refuge, Badlands National Park, and Theodore Roosevelt National Park (south and north unit herds), others are more distantly related, such as those in

Wichita Mountains National Wildlife Refuge and Grand Teton National Park. Overall, the identified genetic relationships follow closely the history of establishment of these herds (table 2, page 26). For example, the Wichita Mountains National Wildlife Refuge and Wind Cave National Park herds share a historical link through their establishment (at least in part) from New York Zoological Park herd bison (table 2), and the genetic data indicate that this relationship persists, as the two modern derivatives of these herds are more closely related to each other than either is to any other herd examined (fig. 4). As another example, the Badlands National Park and Theodore Roosevelt National Park north unit herds were both established with bison from the south unit herd of Theodore Roosevelt National Park, which was in turn derived from Fort Niobrara National Wildlife Refuge stock (table 2); this relationship is also evident based on the genetic data (fig. 4).

In other cases, genetic analyses shed new light on the relative contributions of various founder sources. For instance, the Grand Teton National Park herd was originally established with bison from Yellowstone National

Table 1. Captive bison herds providing founding stock for U.S. and Canadian federal herds

Herd	Source	Year	Number of bison
James McKay-Charles Alloway	Saskatchewan	1873–1874	5
Charles Goodnight	Texas	1878	5
Frederick Dupree	Montana	1882	6–7
Michel Pablo-Charles Allard	Montana	1879	4 ^a
Charles Jones	Jones herd	1893	44
	Texas	1886–1889	56
	McKay-Alloway herd (through Samuel Bedson)	1888	86
New York Zoological Park ^b	Kansas, Nebraska (various)	unknown, prior to 1893	10
	Nebraska	1888	2
	South Dakota	1889	4
	Pablo-Allard herd	1897	3
	Mix ^c	1904	4

Source: Derived from Coder 1975, Garretson 1938, and Seton 1937.

Note: Wild bison captured within their native range were used as initial stock for each captive herd and were later pivotal in providing founding stock for U.S. and Canadian federal herds. In addition to these herds, remnant wild herds existed in Yellowstone National Park (reaching a low of 30–50 bison in 1902; Garretson 1938; Meagher 1973) and the area now protected as Wood Buffalo National Park (with a low of 300 bison around 1891; Soper 1941).

^aWild bison originally captured by Walking Coyote (Samuel Wells), a Pend d'Oreille Indian in 1879; the herd grew and 12 head were sold to Pablo and Allard in 1883.

^bHerd formation largely due to efforts of William Hornaday and the American Bison Society (Coder 1975).

^cDerived from Wyoming, Manitoba, and the Jones herd.



Park in 1948. In 1963, the infectious disease brucellosis was discovered in the herd and all 13 adults were killed (National Park Service 1996). To the remaining 4 yearlings and 5 calves, 12 adult (6 male and 6 female) bison from the Theodore Roosevelt National Park south unit herd were added in 1964 (National Park Service 1996). The modern Grand Teton National Park herd appears to be more closely related to the Theodore Roosevelt National Park south unit herd than the Yellowstone National Park herd (fig. 4), most likely as a result of preferential breeding for a number of years by the adult Theodore Roosevelt National Park south unit bison while the herd was small. Genetic drift, or random changes in

allele frequencies, which is especially powerful in small populations, might also have played a part in shaping the modern genetic structure of the Grand Teton National Park herd. Regardless, the genetic data in this case reveal relationships not clearly apparent from herd history alone.

A common concern in wildlife management is inbreeding, which can lead to decreased heterozygosity, adaptive response (ability of a population to adapt to environmental changes), and population viability (Franklin 1980). Indeed, the history of formation of these herds from a handful of individuals (table 2) and continued maintenance of federal bison in relatively small (with the

Table 2. Establishment of U.S. federal bison herds

Herd	Location	Year	Founding Stock Number – Source ^a
Badlands NP	South Dakota	1963	3 – Fort Niobrara NWR; 50 – Theodore Roosevelt NP south unit
		1983	20 – Colorado National Monument (unknown origin)
Fort Niobrara NWR	Nebraska	1913	6 – private ranch, Nebraska; 2 – Yellowstone NP
		1935	4 – Custer State Park, South Dakota
		1937	4 – Custer State Park, South Dakota
		1952	5 – National Bison Range
Grand Teton NP	Wyoming	1948	20 – Yellowstone NP
		1964	12 – Theodore Roosevelt NP
National Bison Range	Montana	1908	1 – Goodnight herd; 3 – Corbin (McKay-Alloway); 34 – Conrad (Pablo)
		1939	2 – 7-Up Ranch (unknown origin)
		1952	4 – Fort Niobrara NWR
		1953	2 – Yellowstone NP
		1984	4 – Maxwell State Game Refuge, Kansas (Jones)
Neal Smith NWR	Iowa	1996	8 – Fort Niobrara NWR; 8 – Wichita Mountains NWR
		1997	6 – Fort Niobrara NWR; 8 – National Bison Range
		1998	3 – Fort Niobrara NWR
Sully's Hill National Game Preserve ^b	North Dakota	1919	6 – Portland City Park, Oregon (unknown origin)
		1932	1 – Wind Cave NP
		1941–1979	7 – Fort Niobrara NWR
		1987	3 – National Bison Range
		1994–1997	2 – Theodore Roosevelt NP
Theodore Roosevelt NP ^c	North Dakota	1956	29 – Fort Niobrara NWR to found Theodore Roosevelt south unit herd
		[1962]	[20 – Theodore Roosevelt south unit bison to establish north unit herd]
Wichita Mountains NWR	Oklahoma	1907	15 – New York Zoological Park
		1940	2 – Fort Niobrara NWR
Wind Cave NP	South Dakota	1913	14 – New York Zoological Park
		1916	6 – Yellowstone NP
Yellowstone NP	Wyoming, Idaho, Montana	1902	approximately 30 indigenous; 18 – Pablo-Allard herd; 3 – Goodnight herd

Source: Halbert and Derr 2007; copyright 2007 by the America Genetic Association.

^aSee table 1 for description of six foundation herds.

^bHistory of introductions provided by C. Dixon, personal communication.

^cTheodore Roosevelt National Park hosts two herds: south unit and north unit.

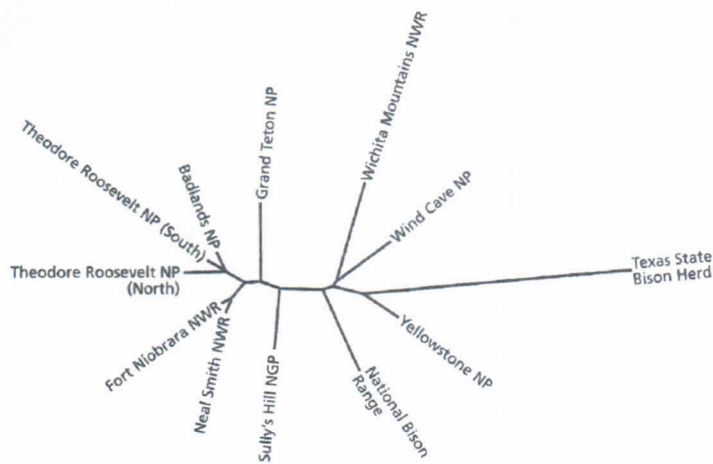


Figure 4. Genetic relationship tree based on 49 polymorphic microsatellites. Populations and sample sizes indicated in table 2. Figure derived from DS genetic distances (Nei 1972), which is based on the infinite alleles model of evolution. Branch lengths correlate with the amount of genetic similarity identified between herds.

exception of Yellowstone National Park), closed herds (table 3) would suggest that inbreeding may be adversely impacting the genetic architecture and trajectory of these herds. However, the genetic data described herein do not indicate inbreeding (Halbert 2003), and phenotypic indicators of inbreeding depression (e.g., decreased birth rates, abnormal physical characteristics, increased mortality) have not been observed in these herds. Although genetic data from pre-bottleneck bison herds are currently not available to make direct measurements of changes in genetic diversity over time, these herds appear to have maintained moderate levels of genetic diversity despite the bottleneck event of the late 1800s and subsequent small founding population sizes. In fact, compared with cattle and related species, bison in general appear to have levels of genetic diversity and heterozygosity similar to other nondomesticated bovids (e.g., MacHugh et al. 1997; Navani et al. 2002; Rendo et al. 2004).

Historical—and in some private herds, recent—hybridization between bison

and their close relative, domestic cattle, has complicated bison conservation efforts due to introgression of domestic cattle DNA into the bison genome. The two species do not naturally interbreed, and, in fact, viable first-generation hybrids are somewhat difficult to produce (Boyd 1914; Goodnight 1914). However, most of the people involved in saving bison from near-extinction in the 1880s were cattle ranchers interested in producing harder breeds of cattle. Various records of successful attempts by ranchers to hybridize the two species exist (e.g., Coder 1975; Jones 1907), and the remnants of these crosses are evident today. Domestic cattle DNA has been detected in both the mitochondrial (Polziehn et al. 1995; Ward et al. 1999) and nuclear (Halbert and Derr 2007; Halbert et al. 2005b) genomes of bison in state, federal, and private herds in the United States. In U.S. federal bison herds, levels of detected introgression are low, and probably constitute less than 1% of the total nuclear DNA (Halbert and Derr 2007). No evidence of introgression has been detected in the Yellowstone and

Wind Cave national park herds, where several hundred bison have been tested (Halbert and Derr 2007). Conversely, some private and state herds have substantially higher levels of introgression, with up to 100% of the bison in one private herd harboring domestic cattle mitochondrial DNA (Halbert and Derr, unpublished data).



Table 3. Nuclear microsatellite sampling regimen for federal bison herds

Population	Collection year(s)	Census ^a	Total sampled
Badlands NP	2002	875	312
Fort Niobrara NWR	2001–2002	380	167
Grand Teton NP	1999–2000	600	39
National Bison Range	1999–2002	350	152
Neal Smith NWR	2001	63	49
Sully's Hill National Game Preserve	2004	35	31
Theodore Roosevelt National Park, north unit	2000	312	270
Theodore Roosevelt National Park, south unit	2001	371	324
Wichita Mountains NWR	1999, 2002	600	35
Wind Cave National Park	1999–2001	350	293
Yellowstone National Park	1997, 1999–2002	3,000	488
Sum		6,936	2,160

Note: A total of 2,160 bison were scored for 49 nuclear microsatellites.

^aApproximate census population size, as estimated by individual herd managers. When possible, estimates are given of total census population size at time of collection for this study (or average across collection years).



Implications for future management

The human-aided recovery of bison from the brink of extermination in the late 1800s is among the first and best known conservation success stories. With more than 500,000 American bison in the world today, the recovery of the species would indeed seem secure. However, only 5% of these bison are in conservation herds (maintained by federal, state, or private conservation groups); all other bison are maintained on private ranches (Boyd 2003). While some ranchers with private bison herds are interested in and committed to conservation, others raise bison as semidomesticated livestock subjected to intensive management, handling, herd structure manipulation, and artificial selection. Artificial selection on phenotypes (traits), such as weight or hump size, effectively selects for or against alleles at one or more genes in the genome that control the trait; this type of selection leads to changes in the genetic architecture of a herd that are difficult to predict, alter the genome (in many cases irreversibly) from its “natural” state, and can lead to reduced fitness due to decreased genetic variation or inadvertent selection on nearby “fitness-related” genes. Arguably, therefore, the primary—though possibly not exclusive—burden of the long-term preservation of bison as a distinct species falls on the managers of conservation herds. Before a complete picture of the modern bison germplasm can be understood and most effectively conserved, however, further evaluation using methods such as those presented here is needed to assess the genetic architecture of several conservation herds in both the United States and Canada for which such information is poorly understood or altogether unknown.

The current and future management of U.S. federal bison herds has been debated and scrutinized from many perspectives. As is the case with many other wildlife species, anthropogenic changes to the environment and landscape have forced the primary existence of bison into fragmented herds of relatively small size (<1,000 individuals). Small populations are prone to losses of genetic diversity, or genetic erosion, which in turn can lead to decreased fitness and adaptive response. Migration among populations is the principle process that can counteract genetic erosion. For modern bison, opportunities for natural migration do not exist. Movement of bison among herds only occurs artificially. Extreme caution must be practiced when moving animals in this way, however, to prevent the inadvertent transmission of disease and further dilution of the bison genome with introgressed domestic cattle DNA.

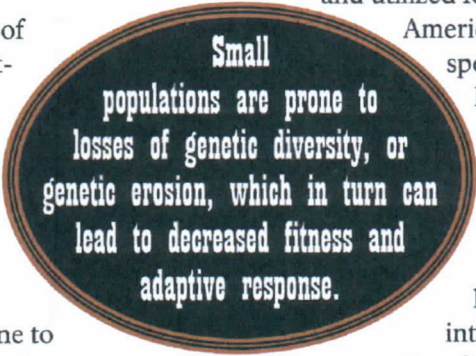
Probably the most pressing genetic issue facing U.S.

federal bison herd management today is the general need for increased herd sizes. Recent simulation modeling based on the genetic data presented herein indicates that effective population sizes of at least 1,000 individuals are necessary for the long-term maintenance of both genetic diversity and heterozygosity (Gross and Wang 2005). Effective population sizes reflect the effective number of breeding individuals and are generally only a fraction of the census population sizes. A “population” need not be contiguous, and several herds from the same genetic stock might be considered in the effective population size calculation. In fact, the creation and maintenance of such herds is recommended to prevent genetic erosion and decrease chances of catastrophe (e.g., devastating disease, flood, fire) leading to the loss of irreplaceable germplasm. The Yellowstone National Park herd is the only U.S. federal herd that likely meets the effective population size criteria directly, although the continued presence of brucellosis in the herd greatly complicates efforts to create satellite herds outside of the park boundaries. The Fort Niobrara National Wildlife Refuge herd and direct satellite herds in Theodore Roosevelt National Park (south and north units) combined likely also meet the effective population size criteria. The establishment and proper management of disease-free satellite herds from various U.S. federal bison herds, especially those with unique lineages and no historic or genetic evidence of introgression (e.g., Wind Cave and Yellowstone National Park herds), will serve to not only decrease genetic erosion, but also support long-term species conservation efforts.

More genetic information has been gathered, analyzed, and utilized for the study and conservation of

American bison than for any other wildlife species. Collectively, genetic technologies have given us a detailed snapshot of the current architecture of both public and, to a lesser degree, private bison herds. Conservation herd data gaps still exist, especially with regard to largely unexamined herds (e.g., private conservation herds, Canadian public herds) and to intrapopulation dynamics (e.g., subpopulation division, effects of age and sex structure on

genetic diversity). The long-term preservation of the bison genome will depend upon the responsible use of available data in the management of conservation herds. Like bison, many other species currently exist in fragmented populations, in limited habitats, and with continuous anthropogenic pressures. Genetic technologies such as those described here should be considered in the assessment of population structure and relationships as tools to assist management efforts and promote long-term species conservation.



Small populations are prone to losses of genetic diversity, or genetic erosion, which in turn can lead to decreased fitness and adaptive response.

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The ecological future of North American bison

By Michael A. Soukup

Editor's Note:

Following are remarks of Mike Soukup, NPS associate director for Natural Resource Stewardship and Science, on the occasion of the Wildlife Conservation Society meeting on the ecological future of North American bison, held in Denver, Colorado, 23 October 2006. His address rounds out the discussion of bison management in North America by sharing a context for the scientific findings of our cover article on the history and genetics of federal bison herds and examining several other important and interrelated management considerations.

**Bull bison,
Yellowstone National Park,
Wyoming.** COPYRIGHT DAN NG

Bison as symbol

Few symbols, and no other animal, are so associated with our national parks as the American bison. These great beasts were amidst the geysers of Yellowstone and an integral part of the vista that inspired creation of the first national park in 1872.

It is part of our emblem to this day. It is on the arrowhead of every National Park Service employee uniform, and at the entrance of every national park unit. The bison is the emblem for the Department of the Interior—suggesting that the bison also has a claim on the vast lands of the Bureau of Land Management and the U.S. Fish and Wildlife Service. At least two states feature the bison on their new state quarters (Kansas and North Dakota). It is part of the psyche of generations of Americans, especially as their daily lives were more circumscribed in suburbs and cities, that it is their birthright to see wild bison in a wild setting. Indeed it is the Park Service mission to fulfill that need. And for many more generations bison have been central to the culture of many Native Americans.

The reason that I was delighted to accept your invitation and join you for this meeting is that my responsibility in the National Park Service, as the associate director for Natural Resource Stewardship and Science, is to ensure that the bison and the processes under which it evolved are both understood and not lost to future generations. We are justly proud of our long record of sponsoring observations and studies that provide understanding of the bison in its natural habitat. The process part—that's the rub—as you well know. Our task is not simply to provide herds of bison for viewing at a safe distance, on a visit to Yellowstone, or Badlands, or Theodore Roosevelt national parks. That would seem simple enough. But we must keep some part of the nation's bison wild, subject to the same selection pressures that made the animal—that is our real challenge.

I want to spend my few minutes here on how we must face that challenge on three fronts: providing a National Park Service perspective on genetics, disease, and behavior of bison. And underlying both our understanding and our management practices in all of these fields is the issue of boundaries. The idea of discrete boundaries has been clearly drawn for the National Park Service by the Congress. (Congress has had less success impressing this upon the bison.) Bison once roamed freely across the western landscape, and evolved without regard to boundaries. That hasn't changed. Our vision for the future must realize and address that reality.

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Genetics

Thanks to the breakthrough in molecular genetics we know a great deal about the genetics of the NPS bison herds. They are not all equal from a genetic value. Some like the Yellowstone and Wind Cave herds, by good fortune of how they were saved or how they were collected, have significantly more variation. (Genetic studies are very recent, and were jointly supported by the U.S. Geological Survey, National Park Service, and National Science Foundation.)

Some herds have significantly less variation, but they contain genetic differences that are important to bison conservation and recovery. But some herds have too much variation; that is, they have genes that show they descend from historical crosses between *Bison* and *Bos*—between bison and domestic cattle.

Before we think about what we can do with this knowledge, it is worth remembering how we have it. The enzyme that allows us to identify these DNA markers through the process of polymerase chain reaction (PCR) originally came from a thermophilic bacterium found in the Yellowstone hot springs. And we have access to so many polymorphic markers because of the work of Drs. Natalie Halbert and Jim Derr (Texas A&M University) precisely because of the close relation between bison and cattle, and the gene map being developed for domestic cattle.

It is not enough to know where the significant variation in our bison herds resides; we must know what it takes to maintain it. This we get from the modelers—those who can look at what we have in the genetics, life history, and ecology of the bison and tell us what we need. The National Park Service was fortunate to hire one of the best ecological modelers in the business, John Gross. These models make clear that to maintain genetic variation you need to have large herds—herds numbering in the many hundreds, or better yet, thousands.

For some small parks, the only way to achieve a sustainable population size is to manage herds at a broader scale, by moving bison between herds. But we can't do that today because of disease. The silver lining is we're lucky that we didn't do this in the past because we didn't really understand the genetics.



Disease

The National Park Service is now collaborating with the U.S. Department of Agriculture and the states of Idaho, Montana, and Wyoming to continue long-term planning processes for the eventual elimination of brucellosis from Greater Yellowstone Area bison and elk.

Why? Because just as it is troubling for us to be shooting bison that turn up in national parks because there is reason to suspect they carry cattle genes, so it is bad news to shoot bison that roam outside of national parks because they could be brucellosis carriers.

We need veterinary medical breakthroughs to remove these barriers. So the National Park Service is instigating research “for more effective vaccines, more effective vaccine delivery techniques for free-ranging wildlife, and better diagnostic techniques for identifying infection in live animals—all are priority research and development needs.” That is our commitment, as Mary Bomar, the new director of the National Park Service, pledged to Senator Thomas in her confirmation hearings.

Behavior

A visitor to Hayden Valley in August is likely to get stopped by bison rutting on the road. Recently more than 2,000 bison from Yellowstone gathered with the snorting, and dust rolling, and hundreds of massive bulls competing for mates. This spectacle—this process—is one of the selection factors that influenced bison survival for eons.

Less often seen, but now well documented by biologists working year-round in Yellowstone is increasing predation by wolves on bison. Molly’s Pack in Pelican Valley has lived on bison in winter, and three years ago a second pack formed in Hayden Valley makes bison its exclusive winter diet. At least two other packs also make bison part of their diet. Hunting bison with fang and claw is especially dangerous because, unlike elk, bison stand their ground. There is an innate elegance in natural systems where predator and prey constantly test each other’s mettle, and each other’s fitness, as they vie for survival. One of the many positive aspects of wolf restoration to Yellowstone National Park is a strong, wild bison that can match any future vision we have for this species.

Selection pressures on commercial bison are obviously quite different, where competition between bulls may be secondary to weight gain, and good behavior may be docility rather than avoiding predation by wolf packs. (I think of wild animals as the pros, and domestic animals as the couch potatoes.)

So the behavioral and genetic differences between domestic and wild bison are likely to increase this century, even as we blur those distinctions in the public perception. Bison on the plains can help sell bison in the market, but they are not the same.

Wild bison for the future

Which brings me back to this matter of boundaries. We in the National Park Service must be diligent in observing our boundaries. But bison are notorious in their disrespect for fences and other human-defined boundaries. As we treat them as more than symbols of the wide-open West, as we learn more about them, we can change some of our practices as well. I am confident we can do this. We began a pilot project a couple of years ago in the Southeast called the Seamless Network of Parks, which seeks common, biologically based, management practices regardless of the blend of federal and state agency lands. Perhaps one day, wild bison will freely graze the public lands set aside as bison habitat.

Our vision for the future of bison should be great herds that roam across vast expanses without detecting agency jurisdictions. Accomplishing this will take better cooperation on public lands. Strong partnerships with private landowners can make this vision a reality. We could have bison conservation areas, as we do now for bears in the Rocky Mountains. Perhaps some day bison conservation lands can be connected as corridors so that bison can move freely, and gene frequencies will not need to be managed by trucking bison from place to place. Genetically true bison that increase in these areas can provide for disease-free replenishment of bison herds whenever opportunities arise in their former native home range.

The National Park Service has and will continue to support restoration of bison as an important part of the heritage of North American cultures, and as a key species in North American ecosystems. This workshop is a key step toward achieving a common vision of restoration of bison in North America.

With a wide-reaching vision, the time could come when bison also have a visible role in the daily lives of many more Americans in the West. In some places bison will be hunted by wolves, in some places by humans, but keeping them wild will be the principle that drives decisions. If we can do that, we all will be keeping faith with those who saved these great animals from extinction. Our part is to ensure that bison have not just survived, but remain an authentic part of our heritage. **P**
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