

THE EVOLUTION OF PROPERTY RIGHTS: A Conference Sponsored by the Searle Fund and Northwestern University School of Law: The Extermination and Conservation of the American Bison

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* Professor of Economics, Montana State University, and Visiting Professor of Law, University of Virginia. I have received helpful comments from Benito Arrunada, Dave Buschena, Rick Geddes, Andy Hanssen, Gary Libecap, Kathy Miller, Randy Rucker, an anonymous referee, and participants in the conference Evolution of Property Rights, Northwestern University Law School, April 20-22, 2001. Comments from and discussions with biologists Peter Gogan, Mary Meagher, and James Shaw were especially helpful. The title is given in deference to William T. Hornaday, who, in 1889, published *The Extermination of the American Bison*, the greatest nineteenth-century history of the bison.

Highlight

ABSTRACT

The dramatic near extinction, and subsequent recovery and restoration, of the American bison during the late nineteenth century is examined using a property rights model of renewable resource production. The paper considers the implications of bison exploitation under open-access, common-ownership, and private-property regimes and further examines how these regimes are determined. Implications are tested against historical and anthropological data on bison populations, robe and hide prices, cattle-stocking rates, American military behavior, Indian tribal territories, federal land policy, the costs of harvesting bison, and formal and informal property rights regimes. The study uncovers the details of this famous story in American wildlife conservation and sheds light on the role of markets in extinction and preservation and the evolution of property rights to such large-scale natural resources.

Text

I. INTRODUCTION

PRIOR to European exploration and settlement of North America, the buffalo, or American bison, inhabited vast stretches of the continent. According to the nineteenth-century bison chronicler William T. Hornaday:

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The range of the American bison extended over about one-third of the entire continent of North America. Starting almost at tide-water on the Atlantic coast, it extended westward through a vast tract of dense forest, across the Allegheny Mountain system to the prairies along the Mississippi, and southward to the Delta of that great stream. Although the great plains country of the West was the natural home of the species, where it flourished most abundantly, it also wandered south across Texas to the burning plains of northeastern Mexico, westward across the Rocky Mountains into New Mexico, Utah, and Idaho, and northward across a vast treeless waste to the bleak and inhospitable shores of the Great Slave Lake itself. ¹

At its greatest moment, the total numbers for the continent may have been as high as 25-30 million before white settlement. ² On the Great Plains, where the bison were most suited and most plentiful, their population is estimated to have been 20 million as late as 1800. Even by 1850, more than 10 million bison roamed the plains. Yet, by 1890, these plains held just 1,000 bison. ³

The near extermination of the bison remains the most powerful story used by conservationists to condemn the greed of the marketplace. Unfettered markets in hides and robes, the story goes, led to the destruction of a seemingly endless wild population. To most economists, the bison's demise seems simple enough. The bison were an open-access resource, and their exploitation under these conditions predictably led to their demise. However, to those familiar with Harold Demsetz's ⁴ theory of the evolution of property rights, the bison's rapid demise presents a puzzle. Demsetz's classic argument is that an increase in the value of an asset will increase the value of ownership and thus lead to the creation of property rights, which will lead to conservation of the resource. Property rights, it seems, never emerged for the bison, in the wild at least, despite the emergence of the bison hide market. In fact, it is precisely during the period of the most intense market activity, roughly 1870-84, that the bison's demise was swiftest.

Numerous studies support Demsetz's basic thesis. ⁵ Demsetz himself discusses the emergence of rights to beaver grounds by the Montagne Indians in response to the beaver fur trade. ⁶ Terry Anderson and Peter Hill study the emergence of rights to rangeland, livestock, and water in the American West as asset values increased. ⁷ John Umbeck and Gary Libecap similarly study the establishment of rights to gold and silver fields in California and Nevada, respectively. ⁸ Douglass North suggests that the general rise of agricultural societies, with private-

¹ William T. Hornaday, *The Extermination of the American Bison, with a Sketch of Its Discovery and Life History* 376-77 (1889).

² Until the last quarter-century, many writers had estimated bison numbers to be as high as 60 million. See Andrew C. Isenberg, *The Destruction of the Bison: An Environmental History, 1750-1920* (2000), for a discussion of the various estimates, which now seem to begin at 25 million for the continent.

³ In his famous survey for the Smithsonian Institution, Hornaday, *supra* note 1, at 525, actually puts the number at 1,091.

⁴ Harold Demsetz, *Towards a Theory of Property Rights*, 57 *Am. Econ. Rev.* 347 (1967).

⁵ Thrainn Eggertsson, *Economic Behavior and Institutions* (1990), summarizes this literature. The articles in this issue offer an updated summary.

⁶ John McManus, *An Economic Analysis of Indian Behavior in the North American Fur Trade*, 32 *J. Econ. Hist.* 36 (1972), however, contends that the Canadian beaver population plummeted with the advent of the fur trade. Terry L. Anderson & Peter J. Hill, *Cowboys and Contracts*, in this issue, at S489, also documents dramatic declines in beaver populations during the beaver fur trade. To be fair, Demsetz (*supra* note 4) devotes just three pages to the beaver and uses it as an example of his proposed approach. Demsetz (*supra* note 4, at 353) does briefly discuss the "southwestern plains" as a case in which rights did not emerge but does not mention the hide trade, nor the traditional hunting territories, such as those enforced by the Comanche.

⁷ Terry L. Anderson & Peter J. Hill, *The Evolution of Property Rights: A Study of the American West*, 17 *J. Law & Econ.* 163 (1975).

⁸ John Umbeck, *The California Gold Rush: A Study of Emerging Property Rights*, 14 *Explorations Econ. Hist.* 197 (1977); Gary D. Libecap, *Economic Variables and the Development of the Law: The Case of Western Mineral Rights*, 38 *J. Econ. Hist.* 338 (1978).

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property rights in land, is consistent with this view of emerging rights.⁹ Indeed, one might argue that the settlement of North America is broadly consistent as well. Over time, rights to land, water, minerals, and even air in recent times have been established as asset values have increased.¹⁰ Compared to the resources studied in the literature above, the bison stands out. Property rights to wild stocks of bison were never really established, nor do there seem to have been any substantial attempts to do so.

Despite the dramatic killing of the bison and despite the fact that just 1,000 remained in 1890, the bison did not become extinct like the passenger pigeon.¹¹ The bison has never been listed as an endangered species. In fact, there are nearly 350,000 bison in parks, refuges, and private ranches, though nearly all of these are fenced rather than free roaming. Private herds now actually comprise the overwhelming majority of these bison.¹² Live bison and bison products, such as meat and leather, are sold around the United States and Canada. The North American Bison Cooperative, established in 1993, has over 400 members who own a plant that processes over 12,000 bison annually.

In this paper, I examine the economic history of the bison in North America by merging the theory of property rights with the theory of renewable resource use. I show how changes in property rights regimes (between open access, common property, and private property) affect bison harvest rates and population levels and how changes in market forces (for example, output prices and harvest costs) affect the relative value of alternative property rights regimes. I show how changes in the market for prairie grassland (the bison's prime habitat) also change the value of various property rights regimes by changing the population dynamics of the bison herds themselves and how the costs of establishing ownership of bison are influenced by bison behavior, land policy, technology, and politics. By bringing together the effects of market forces on bison exploitation and on bison habitat, I am able to generate predictions for bison harvests and populations under different situations and thus explain the details of the bison's economic history. With respect to Demsetz's thesis, I show that it was a confluence of factors--among them, the bison's inherent aversion to domestication, the breakdown of Native American hunting territories, the value of the bison's habitat for wheat and cattle production, and the presence of an extensive hide market--that led to the near extinction of bison and that the actual evolution of property rights to bison followed a path from common property to open access and then, finally, to private property.

Section II is a brief discussion of bison ecology and history. Section III examines bison exploitation using models from property rights economics and renewable resource economics. Section IV empirically examines the economic history of bison in North America, distinguishing between the major periods of extermination and conservation and confronting implications from the models in Section III. Section V is a summary.

II. NATURAL AND ECONOMIC HISTORY OF THE AMERICAN BISON

A brief overview of bison biology-ecology and bison history is necessary to understand the economic setting. Table 1 summarizes the important historical events, and Figure 1 shows important locations on the Great Plains, where most of the key events took place.

A. Natural History

⁹ Douglass C. North, *Structure and Change in Economic History* (1981).

¹⁰ Work by Gary Libecap, however, indicates that rights sometimes do not emerge for highly valued assets (for example, some fisheries and petroleum reservoirs) because of contracting costs and political incentives that arise among claimants with heterogeneous interests. See Gary D. Libecap, *Contracting for Property Rights* (1989).

¹¹ A. W. Schorger, *The Passenger Pigeon: Its Natural History and Extinction* (1955).

¹² According to the National Bison Association, bison in private herds number 244,000 in the United States and 100,000 in Canada. There are also 13,000 in public herds and 7,000 in Native American herds, with the remainder in zoos and locations outside North America. See the Bisoncentral Web page, <http://www.bisoncentral.com/history/whereroam.asp> (visited July 18, 2001)).

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It is well known that the American bison (*Bison bison*) is not a buffalo.¹³ Biologists distinguish the genus *Bison* from the genus *Bos*, which includes domestic cattle (*Bos taurus*), gaur, and yak. Biologists believe bison and cattle have a common, extinct, Eurasian ancestor and that one species of bison (*B. priscus*) migrated to North America from Eurasia with many other large mammals during the early-middle Pleistocene Epoch, at least 10,000 years ago. Some forms became extinct thousands of years ago, but by A.D. 1,000, *B. bison* seems to have been as extensive as Hornaday suggests.¹⁴

TABLE 1
ECONOMIC HISTORY OF THE BISON IN NORTH AMERICA

Date	Event
1700	Bison present in eastern forests
1804-6	Lewis and Clark expedition travels the upper Missouri River
1820	Bison extinct east of the Mississippi River
1828	Fort Union established at the confluence of the Yellowstone and Missouri Rivers (North Dakota). Robe market begins in the 1820s
1820-80	Robe trade on the Northern Plains
1860-80s	Railroad reaches Cheyenne in 1867 and Salt Lake City in 1869 (effectively dividing bison into northern and southern herds), Denver in 1870, Dodge City in 1872, Bismarck in 1873, El Paso in 1881, Miles City in 1881
1871-74	Southern herd (Colorado, Kansas) decimated by hide hunters
1872	Yellowstone National Park established. Sharp's .50 caliber rifle developed
1874	Comanche are defeated by Texans at Adobe Walls. This opens up more bison range for hide hunting
1874-80	Bison decimated in Texas and Oklahoma
1876	Battle of Little Bighorn (Montana) in June. Plains Indians suffer many defeats later that year
1880-84	Northern herd (Dakota Territory, Montana, Wyoming) decimated by hide hunters

¹³ Authoritative descriptions are Margaret Mary Meagher, *The Bison of Yellowstone National Park* (National Park Service Scientific Monograph Series No. 1, 1973); Mary Meagher, *Bison bison*, 266 *Mammalian Species* 1 (1986); Jerry N. McDonald, *North American Bison: Their Classification and Evolution* (1982); and James H. Shaw, *Bison*, in *Rangeland Wildlife*, ch. 14 (Paul R. Krausman ed. 1996). There are actually two subspecies of the bison, the plains bison (*B. bison bison*) and the slightly larger wood bison (*B. bison athabasca*), though this distinction as subspecies has been questioned recently (see Meagher, *Bison bison*, *supra*, at 6).

¹⁴ McDonald, *supra* note 13, at 102-4, presents paleontological evidence that shows the bison's extent was even greater than that described by Hornaday and largest just prior to European contact in North America.

TABLE 1
ECONOMIC HISTORY OF THE BISON IN NORTH AMERICA

Date	Event
1886	Smithsonian hunting expedition to Montana, led by William F. Hornaday, kills 25 bison for exhibit in Washington, D.C.
1889	William F. Hornaday's survey found 1,091 bison in North America, including those in captivity
1905	American Bison Society organized (William Hornaday was first director)
1907-13	First bison refuges established at Wichita Mountains Wildlife Refuge (Oklahoma in 1907), the National Bison Range (Montana in 1908), and Wind Cave National Park (South Dakota in 1913)
1936	American Bison Society stops collecting dues and begins to disband (bison population estimated at 22,000)
1994	North American Bison Cooperative establishes a slaughtering plant in New Rockford, North Dakota

Bison are physically similar to domestic cattle, although their larger heads and shoulders, with thick, dark coats, and relatively small hindquarters, distinguish them. ¹⁵ An adult bull can easily stand 6 feet at the shoulder and weigh over 2,000 pounds. An adult cow is about half the size, typically weighing between 800 and 1,200 pounds. Cows become mature at age 3 and in the wild deliver a single calf (twins are rare) 2 out of every 3 years, from April to June. ¹⁶ Bulls typically do not become mature breeders until age 6. Bison rely almost exclusively on grasses and grasslike plants such as sedges for sustenance, even more so than cattle, whose forage is composed of slightly more forbs (nongrass herbs) and shrubs. In this regard, the bison occupy a niche unlike deer, elk, pronghorn, and horses, all of which rely much less on grass. ¹⁷

Bison can live to age 30 or more, though in the wild 20 years is unusual, and mature adults are nearly free from predators in the wild. Wolves, however, are known to successfully prey on bison calves, the aged, and infirm and, in relatively rare occasions, even healthy adults. Bison have a stolid temperament that accompanies a general

¹⁵ Bison and cattle, like antelope, sheep, and goats, belong to the family of cloven-hoofed ruminants called Bovidae. Bison and cattle also belong to the same tribe, Bovini. The European bison (*B. bonasus*), also known as the wisent, is a separate but closely related and slightly smaller species that has a surviving population of just a few thousand.

¹⁶ Their gestation is about 280 days, and calves weigh about 35-45 pounds, substantially less than the calves of domestic cattle. See Meagher, *Bison bison*, *supra* note 13; Shaw, *supra* note 13; see also the Bisoncentral Web page, <http://bisoncentral.com/raising/default.asp> (visited July 18, 2001); and National Bison Association, *Bison Breeder's Handbook* (3d ed. 1993).

¹⁷ Ranchers and range scientists treat bison and cattle as equals in terms of forage consumption, but Shaw, *supra* note 13, at 229-31, reports that bison forage is usually 90 percent grass while cattle forage is around 80 percent grass.

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indifference to nonhuman predators, which ultimately proved costly for the bison, as they tended to be relatively unafraid of long-distance rifle hunters.

As awesome as individual bison are, it was the bison herds that made wild bison a truly incredible sight. From the late fall to the spring, bison often were grouped into relatively small sexually segregated herds (typically 50-200), but they formed great herds during the summer breeding season (the rut), or what Hornaday called the "running season." During the summer, it was not uncommon to see herds in excess of 100,000, although close observers tended to notice the smaller groups (of 50-200) moving separately within these large herds. In 1871, in one of the most famous documented accounts, Colonel Richard Dodge reported a herd extending 25 miles by 50 miles, composed of groups of 50-200. Dodge estimated the herd to be 500,000, but Hornaday suggests it may have been several times larger.¹⁸ They were truly a powerful and imposing spectacle, as described by Hornaday: "They lived and moved as no other quadrupeds ever have, in great multitudes, like grand armies in review, covering scores of square miles at once. They were so numerous they frequently stopped boats in the rivers, threatened to overwhelm travelers on the plains, and in later years derailed locomotives and cars."¹⁹

Although Hornaday and many others originally described bison as migratory, they are better characterized as grassland nomads, being difficult to locate even when they were plentiful.²⁰ Migratory populations move in more predictable and often seasonal patterns to well-defined food sources or places for specific activities such as breeding or calving. For example, some caribou herds can be counted on to be on the north slope of Alaska during the summer and in the Yukon Territory during the winter. Nomadic populations, however, move in ways that appear almost random to human observers, in search of food and other specific needs. Bison clearly exhibit nomadic behavior in search of grass, and they may travel long distances.²¹ They did not, as some early observers suggested, migrate in grand north-south routes across the plains, like waterfowl or passenger pigeons. Frank Roe summed it up best by noting that there are "inscrutable fluctuations of buffalo movement which all students of the species have recognized" and that even the Indians often had difficulties in finding bison. For example, in January 1834,²² a Mandan Indian hunting party unsuccessfully searched for a week, only to return and find a herd just 6 miles from its villages. The nomadism of bison is an important characteristic in determining the ownership and exploitation of bison. In addition to their nomadism, bison groups are fluid in their composition of individuals and are typically led by an adult cow when they are moving.

Bison, like many species, exhibit density-dependent population dynamics; that is, as a population increases within a well-defined environment, the rate of population growth declines. Because of this characteristic, bison can be usefully described by a logistic growth function.²³ This population model makes it possible to generate historical

¹⁸ Hornaday, *supra* note 1, at 389-91, provides a detailed description.

¹⁹ *Id.* at 388.

²⁰ Meagher, *Bison bison*, *supra* note 13; Shaw, *supra* note 13. For descriptions of their nomadic behavior in their natural state, see Joel Asaph Allen, *The American Bisons: Living and Extinct* (1876); and Frank Gilbert Roe, *The North American Buffalo: A Critical Study of the Species in Its Wild State* (1951).

²¹ Bison can exhibit migratory behavior under certain conditions, as in mountain valleys with great altitudinal differences in habitat (Meagher, *Bison bison*, *supra* note 13). The plains, however, had no such differences to exploit in a routine, seasonal fashion.

²² Roe, *supra* note 20, at 199, 369.

²³ R. A. Fredin, Levels of a Maximum Net Productivity in Populations of Large Terrestrial Mammals, in *Proceedings of the Conference Cetacean Reproduction: Estimating Parameters for Stock Assessment and Management* 381 (Rep. Int. Whal. Comm., Special Issue 6, William F. Perrin, Robert L. Brownell, & Douglas P. Demaster eds. 1984), shows logistic growth for bison on the National Bison Range, 1911-28. Density dependence also may occur as range expansion; see Mark L. Taper, Mary Meagher, & Chris L. Jerde, *The Phenology of Space: Spatial Aspects of Bison Density Dependence in Yellowstone National*

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population estimates and understand the details of the bison's extermination and conservation. Using the standard notation, let $x(t)$ be the stock (or population) of bison at time t , $K > 0$ be the ecological carrying capacity of the habitat, and $[\gamma] > 0$ be the intrinsic growth rate of the stock. ²⁴ The rate of growth of the stock is $dx/dt = F(x; [\gamma], K)$ [identical to] $[\gamma] x(1 - x/K)$. This formulation generates a maximum sustainable yield (MSY) of $[\gamma] (K/4)$ and a corresponding stock of $(K/2)$. ²⁵ Using forage requirements of bison and forage capacity on the plain grasslands, James Shaw estimates the carrying capacity of the Great Plains to be roughly 25 million bison. ²⁶ Estimates of bison population growth rates indicate a maximum annual increase of 15-25 percent. ²⁷ Thus, letting $K = 25$ million and $[\gamma] = .20$ implies a maximum annual harvest (MSY) of 1.25 million animals and a sustainable population of 12.5 million bison. ²⁸ Figure 2 shows a growth-stock relationship from logistic growth with these parameters. This means that under pristine conditions (K is at its maximum) with stable populations, the Great Plains bison herds could have provided an annual harvest of 1.25 million bison in perpetuity.

B. Economic History

By the time Europeans began inhabiting the Americas, the bison was widespread in the Northern Hemisphere. Most historical accounts ²⁹ indicate that the Spaniard Hernan Cortes was the first European to see a bison in 1521 when visiting a menagerie kept by Montezuma, the Aztec king. Later, numerous Spanish, English, and French explorers observed bison throughout the continent. Even though the presence of the bison was well known, the English settlements on the eastern coastal plains of America were appreciably east of the bison's most important range, so there was limited contact until the western migration of humans during the eighteenth century. Compared to the plains, the population density of bison was sparse in the eastern forests (bison primarily using glades and meadows), and no bison-hunting culture emerged among the Indians, nor did there emerge extensive markets in bison hides or flesh. In a rather slow process, the bison became extinct east of the Mississippi by 1820, save Wisconsin, where they are said to have survived until 1832.

The history of the Great Plains and the West is strikingly different from that of the eastern forests, both before and after European contact. The Great Plains was essentially free of whites until 1800, and various Indian groups had carved up the plains from Canada to Texas (refer to Figure 1). The region was dominated by nomadic hunter-gathering societies: the Assiniboin were in Saskatchewan and Manitoba, the Blackfeet were in northern Montana,

Park (Final report, USGS-BRD contract 1445-CA09-95-0072, October 2001). For a treatment of logistic growth in economic models, see Colin Clark, *Mathematical Bioeconomics: The Optimal Management of Renewable Resources* (2d ed. 1990).

²⁴ I assume a completely homogeneous population (thus ignoring age and sex classes within the population) with logistic growth: $x(t) = k/(1 + e^{-[\gamma]t})$. This specification is symmetric and exhibits pure compensation (proportional growth is always decreasing in stock size) and thus ignores "critical depensation" or the possibility of a minimum viable stock size (see Clark, *supra* note 23). As the success of private herds shows, minimum viable stock size seems not to have been a problem. I do not consider interactions between populations and metapopulations, nor do I consider stochastic forces. All major historians note that cows were more often killed, and this specification would underestimate the effects of harvest on growth rates. I use the concept of ecological carrying capacity, even though many biologists are skeptical because it ignores stochastic forces and oscillations toward equilibrium. See John McNab, *Carrying Capacity and Related Slippery Shibboleths*, 13 *Wilderness Soc'y Bull.* 403 (1985).

²⁵ The term MSY, of course, is not an economic optimum but simply a useful benchmark.

²⁶ James H. Shaw, *How Many Bison Originally Populated Western Rangelands?* 17 *Rangelands* 148 (1995).

²⁷ Shaw, *supra* note 13. Fredin, *supra* note 23, at 382, finds rates consistent with this range.

²⁸ This means $F(x) = .2x - (.008)x^2$. At 10 percent intrinsic growth, MSY falls to 675,000.

²⁹ Key historical accounts include Allen, *supra* note 20; George D. Coder, *The National Movement to Preserve the American Buffalo in the United States and Canada between 1880 and 1920* (unpublished Ph.D dissertation, Ohio State Univ. 1975); David A. Dary, *The Buffalo Book* (1974); Martin S. Garretson, *The American Bison* (1938); Hornaday, *supra* note 1; Tom McHugh, *The Time of the Buffalo* (1972); and Roe, *supra* note 20.

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the Crow were in the Yellowstone River country of Montana and Wyoming, the Sioux were in the Dakotas, the Arapaho and Cheyenne were in eastern Colorado-Wyoming and Nebraska, the Kiowa were in Kansas and Oklahoma, and the Comanche were in western Texas. ³⁰ All of these groups controlled and used rather expansive hunting territories. Three other groups--the Mandan, Hidatsa, and Arikara--were larger and wealthier village-dwelling tribes inhabiting the upper Missouri River in the Dakotas. ³¹ All of these groups hunted the bison, but before they had horses, they seem to have had relatively little impact on bison populations. Horses, of course, changed everything, and once they were well established by the early 1700s, the nomadic horse hunting cultures developed, and groups once living on the eastern fringes of the Great Plains moved west to exploit the bison. Within a century, a specialized bison-hunting culture emerged. These societies not only killed bison for their own use but also traded meat (tongue was important early on) and robes (hides with hair) to the village-based horticultural-hunting tribes. Andrew Isenberg suggests an estimate of 400,000 bison taken annually on the plains during the eighteenth century, for subsistence and limited trade among tribes. ³²

Shortly after the Lewis and Clark expedition, the establishment of private trading posts on the upper Missouri River and in Canada established a widespread market for bison products. Around 1820, Indians began to sell bison robes to white traders on the northern plains. The American Fur Company had a series of trading posts along the upper Missouri (most notable was Fort Union, where the Yellowstone River joins the Missouri), and the Hudson Bay Company had trading posts in the Red River country at Fort Garry, near present-day Winnipeg, where the Assiniboine River meets the Red River. Robes were most valuable on the northern plains because of the heavy coat the bison developed in response to the cold weather. ³³ This trade in robes lasted for roughly 60 years until the hide trade dominated bison exploitation in 1880. Although as many as 100,000 bison robes were bought annually by the American Fur Company alone, the bison population seems not to have been seriously reduced. Plains Indians had killed bison for robes long before the white robe market emerged, and during this period too, the vast majority of the robe hunters were Indians, not whites. ³⁴

After the Union Pacific Railroad reached Cheyenne, Wyoming, in 1867, hunters supplying the railroad workers and settlers had split the Great Plains bison into northern and southern "herds" as they intensively hunted along the railroad corridor. It was also during this period of early railroad development that members of European royal families visited the Great Plains to pursue the bison in extravagant hunts. For example, in 1872, Alexis the Grand Duke of Russia visited Colorado and Kansas and was hosted by General Philip Sheridan and guided in the hunt by William F. "Buffalo Bill" Cody. ³⁵

³⁰ Robert H. Lowie, *Indians of the Plains* (1954); and Clark Wissler, *North American Indians of the Plains* (1934). None of these territories were fixed over the period from the seventeenth to nineteenth centuries (see Isenberg, *supra* note 2). For example, the Crow did not exist as a separate group until they broke off from the Hidatsa in the late seventeenth century.

³¹ When Lewis and Clark wintered with the Mandan (near present-day Bismarck) in 1804-5, the village numbered between 3,000 and 4,000, which is still a substantial community in the Dakotas.

³² Isenberg, *supra* note 2, at 83.

³³ There were limited markets on the southern plains, but they were primarily local and seem to have had little impact on bison stocks. Before 1870, cows were nearly always taken for robes because, compared to bulls, their skin was thinner and easier to tan, and their hair was thicker and covered the hindquarters. Meat from young cows was also preferred to bulls that had just gone through the rut. Allen, *supra* note 20, at 184. Robes tended to fetch from two to three times the prices fetched by hides (Roe, *supra* note 20, at 422).

³⁴ As in the premarket hunts, men did the hunting and women undertook the elaborate process of preparing the robes. In the Red River region of Dakota Territory and Canada, the Metis (or "Red River half-breeds" as Hornaday and others called them) did much of the robe hunting. See Roe, *supra* note 20, also on the Red River hunt.

³⁵ Dary, *supra* note 29, at 104-5.

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By 1870, two railroads (the Kansas Pacific and the Atchison, Topeka, and Santa Fe) cut through Kansas into the heart of the southern plains, making the southern herd of bison accessible to thousands of hide hunters. The hide trade did not emerge until 1871, after railroads reached Kansas and when new tanning (preparing hides after skinning) techniques opened up the market for bison hides. Hides were used for leather in clothing and in manufacturing (for example, belts for machines). By 1876 (the year Custer died at Little Bighorn some 1,000 miles north in Montana), the bison were extinct in Kansas, Oklahoma, and eastern Colorado. A smaller hunt occurred thereafter in western Texas and all but extinguished the bison there by 1880.

Because the western terminus of the railroad on the northern plains was fixed at Bismarck on the Missouri River from 1873 to 1879, the northern herd remained untouched by the hide market while the southern herd was being routed. The U.S. Army's war with the plains tribes prevented rapid progress of the railroad, so the Northern Pacific Railroad did not reach deep into bison country until it reached Montana, at Glendive in 1880 and Miles City in 1881. From this point, the experience of the southern herd was repeated. The hide trade quickly overwhelmed the robe trade, and the last substantial herd (over 10,000 bison) was wiped out in November 1883 on the plains between the Cannonball and Moreau Rivers in Dakota Territory. The herd was attacked initially by the last, large Sioux bison hunting party led by Sitting Bull and later by a series of smaller groups of white hunters.³⁶ In the spring of 1884, the last carload of bison hides left Dickinson (in Dakota Territory between Bismarck and Miles City) for the hide tanneries in the east.

After this, only a few scattered herds of less than 50 animals remained on the plains, plus perhaps 200 in Yellowstone National Park (see Figure 1, the dark area in northwest Wyoming). Indeed, Hornaday counts just 1,091 bison in North America as of 1889, and other chroniclers agree that the number was certainly less than 2,000.³⁷ I would be remiss here if I did not note that this number would have been higher by 25 bison had not Hornaday himself led a Smithsonian expedition to Montana in 1886 to find and bring back specimens for the National Museum. Some 250 of these surviving bison were scattered about on private ranches, the progeny of bison calves that had been live captured at various locations since the early 1870s. For instance, by 1900, the Pablo-Allard herd in western Montana had 600 head. Meanwhile, poachers at Yellowstone had reduced the herd there to just 23 by 1902,³⁸ and all of the other wild and free-roaming populations had been similarly decimated, but the private herds were thriving. In 1905, Hornaday and others established the American Bison Society, which successfully lobbied for the creation of bison refuges on the western plains and then privately secured funds for the purchase of private bison to restock these refuges. The first of these were in southwest Oklahoma (Wichita Mountains Reserve) and western Montana (National Bison Range). The American Bison Society slowly disbanded, collecting no more dues after 1935, having nurtured bison to a population estimated at 22,000.³⁹

It comes as no surprise to most commentators on the bison's near extinction that it coincided almost simultaneously with the Plains Indians' demise. Conservationists and historians, often one and the same, decried the greed of the white marketplace for hides and robes, the lust for Indian land by farmers, ranchers, and miners acting with the assistance of the military, and the indifference of the government. In recent years, however, historians have added new interpretations.⁴⁰ The "new environmental historians" add the forces of ecology (for example, disease, drought, and predation) and Indian participation in markets to the traditional story. As Isenberg notes, bison are a "species seemingly connected to everything: grasses, drought, wolves, horses, smallpox, steamboats, railroads, the

³⁶ Garretson, *supra* note 29 at 155.

³⁷ Hornaday, *supra* note 1, at 525, counts 550 near Great Slave Lake in the Canadian northwest (these are wood bison), just 85 wild bison in the United States outside Yellowstone, 200 in Yellowstone, and 256 in private hands.

³⁸ Meagher, *Bison of Yellowstone*, *supra* note 13, at 16-19.

³⁹ Coder, *supra* note 29; and Dary, *supra* note 29.

⁴⁰ Most notable in this group are Isenberg, *supra* note 2; and Dan Flores, *Bison Ecology and Bison Diplomacy: The Southern Plains from 1800 to 1850*, 78 J. Am. Hist. 465 (1991). See also Shepard Krech III, *The Ecological Indian* 123-50 (1999).

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European conquest of North America, the expansion of the market, industrialization, and cultural constructions of gender. Accordingly a host of environmental and human factors contributed to the destruction of the bison." ⁴¹ By this view, Indians are no longer the innocent noble savages but are instead accomplices, along with nature and whites, in a complex web of unstoppable events. Even the U.S. Calvary, long implicated in the bison's demise, is mostly exonerated as an important factor in bison depopulation. ⁴²

III. THE ECONOMICS OF BISON EXPLOITATION

While historians and conservationists have told and retold the story of the bison, economists have had little to say. Only John Hanner's discussion of the government's role in the hide trade, Scott McGee's textbook discussion of the hide hunting firm, and John Farrow's discussion of extinction models have explicitly examined the bison using economic analysis. ⁴³ The exploitation of the bison can be examined using a framework that combines models of renewable resources with models of property rights and land use. I examine the effects of changing parameters within a property rights regime and examine the forces that cause property rights regimes to change. Both the market for bison and bison products and the market for land (the bison's habitat) are considered in the analysis. ⁴⁴

A. Bison as a Renewable Resource

Assume there is a single bison stock (a well-defined herd). The model does not consider the population to be the same as the species (the collection of all herds) or the possibility of metaherds that describe the interaction among separate herds. The single stock produces a single good (for example, hides or robes) sold in a competitive market at the constant price $p > 0$. The initial bison stock is $x[0] > 0$, and the stock $x(t)$ grows according to the logistic growth function $F(x; [\gamma], K)$ [identical to] $[\gamma] x(1 - x/K)$. The cost of harvesting bison at the rate $h(t)$ given a stock size of $x(t)$ is given by $c(x(t), h(t); w)$, with the standard assumptions $c[h] > 0$, $c[x] < 0$, $c[hx] < 0$, where $w > 0$ is the constant price of a single variable input (for example, hunting effort).

When $r > 0$ is the discount rate, the first-best, full-information problem is to maximize the net present value of the continuous rent, $R(t)$:

[SEE FORMULA IN ORIGINAL] (1)

where $x^*([\gamma], K, p, r, w)$ is the steady-state stock level. The steady-state solution for the harvest and stock are given by $h = h^*([\gamma], K, p, r, w)$ and $x = x^*([\gamma], K, p, r, w)$.

⁴⁵ The first-best value of the asset in the steady-state equilibrium is

[SEE FORMULA IN ORIGINAL] (2)

which would be generated under perfectly enforced ownership of the live bison herd.

⁴¹ Isenberg, *supra* note 2, at 193.

⁴² General Sherman used inflammatory rhetoric in Congress about destroying the "Indians' commissary," but there is little evidence that the military either directly killed many bison or indirectly subsidized their killing (see Isenberg, *supra* note 2, at 128-29). David D. Smits, *The Frontier Army and the Destruction of the Buffalo: 1865-1883*, 25 *West. Hist. Q.* 312 (1994), argues that the U.S. Army was an important factor, leading civilian hunts, but Isenberg says that these hunts were small and unimportant.

⁴³ John Hanner, *Government Response to the Buffalo Hide Trade, 1871-1883*, 24 *J. Law & Econ.* 239 (1981); Scott Farrow, *Extinction and Market Forces: Two Case Studies*, 13 *Ecological Econ.* 115 (1995); John S. McGee, *Industrial Organization* 388-94 (1988).

⁴⁴ The approach is related to Timothy M. Swanson, *The Economics of Extinction Revisited: A Generalized Framework for the Analysis of the Problems of Endangered Species and Biodiversity Losses*, 46 *Oxford Econ. Papers* 800 (1994).

⁴⁵ This model is developed in Michael Caputo & Dean Lueck, *Natural Resource Exploitation under Common Property Rights*, 16 *Nat. Resource Modeling* (forthcoming 2003).

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The results of open-access exploitation of a renewable resource are well known and result in complete rent dissipation when agents with homogeneous costs exploit the resource.⁴⁶ Figure 3 shows the steady-state equilibrium for (perfect) private ownership and for open access.⁴⁷ The figure shows that the stock size will be larger under private ownership; that is, $x^* > x_{oa}$. Although the figure shows private ownership harvest to be smaller than that under open access, this may not always hold. Rent is dissipated through the excessive harvest effort because there are no property rights to the live stock of bison, so $R(t) = 0$ for each period and $V_{oa} = 0$ too.⁴⁸ Extinction is also possible under open access, especially when the marginal costs of harvest are low and the population has a minimum critical level.⁴⁹ Since the model assumes a single population, herd extinction is not the same as species extinction. Species extinction requires extinction of all separate populations.

An alternative property regime is group ownership of the bison, or common property. Under common property, groups hold exclusive access to the bison stock and allocate its use among members subject to the costs of policing those members. A number of models show that common property may be a cheaper alternative than private property because of economies of enforcement and use of a relatively large-scale resource.⁵⁰ These models also show that positive rents will be generated, unlike under open access. Even with a renewable resource, common-property exploitation can generate rents by limiting access and yield steady-state harvest and stock levels that lie somewhere between those for idealized private property and full-dissipation open access depicted in Figure 3.⁵¹

The comparative statics of the steady-state equilibrium have been developed elsewhere and are only summarized here.⁵² An increase in the price of the output will increase harvest effort (and reduce the stock size) and increase the rent. An increase in marginal harvest costs will decrease harvest effort (and increase the stock size) and

⁴⁶ Scott Gordon, *The Theory of a Common Property Resource: The Fishery*, 62 J. Pol. Econ. 124 (1954); Clark, *supra* note 23; and Robin Brooks *et al.*, *When Is the Standard Analysis of Common Property Extraction under Free Access Correct?* 107 J. Pol. Econ. 843 (1999).

⁴⁷ The curve [ILLEGIBLE TEXT] is the isocline for the stock, and the $h = 0$ curves are the isoclines for the harvest rate. The figure shows the case in which there are stock effects on harvest cost; that is, marginal harvest costs are decreasing in stock. If these are not present, then the steady-state equilibrium will yield a stock less than $K/2$ (Caputo & Lueck, *supra* note 45).

⁴⁸ In detail, [ILLEGIBLE TEXT]. Open access need not always result in dissipation from overexploitation. If investment is important for productive activity (for example, farming versus cattle grazing), underinvestment, and underexploitation, will result. See Henning Bohn & Robert T. Deacon, *Ownership Risk, Investment and the Use of Natural Resources*, 90 Am. Econ. Rev. 526 (2000).

⁴⁹ Clark, *supra* note 23. Dynamics may be important in the transition to a steady state (Caputo & Lueck, *supra* note 45). For example, rents may be positive or negative on the path to the steady state. Also, with critical stock sizes, extinction is possible during a transition phase.

⁵⁰ See, for example, Martin J. Bailey, *The Approximate Optimality of Aboriginal Property Rights*, 35 J. Law & Econ. 183 (1992); Dean Lueck, *Common Property as an Egalitarian Share Contract*, 25 J. Econ. Behav. & Org. 93 (1994); and Elinor Ostrom, *Governing the Commons* (1990).

⁵¹ See Caputo & Lueck, *supra* note 45. Like many of the static common-property models, that by Caputo and Lueck includes economies of large group enforcement of property.

⁵² See Caputo & Lueck (*supra* note 45). For the harvest rate, comparative statics depend on the size of $x^*([PHI])$ relative to x_{MSY} , while those for the resource stock are unambiguous. In the open-access steady state, the harvest rate is independent of the discount rate while the stock is independent of the biological parameters and the discount rate. The steady-state harvest rate is an increasing function of the biological parameters (K , $[\gamma]$), but the effect of the market parameters (p , r , w) on the steady-state harvest rate depends on the size of x_{oa} relative to x_{MSY} . The steady-state stock is a decreasing function of the output price and an increasing function of the input price. The comparative statics of common property are similar. For a related dynamic analysis, see Marc Nerlove, *Procreation, Fishing, and Hunting: Problems in the Economics of Renewable Resources and Dynamic Planar Systems*, 74 Am. J. Agric. Econ. 59 (1993).

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decrease the rent. Changes in the biological parameters (K , $[\gamma]$) operate slightly differently and, as shown below, are linked to changes in the market for land. An increase in the carrying capacity (K) will increase harvest effort (but increase the stock size) and increase the rent. An increase in the intrinsic growth rate of the stock ($[\gamma]$) will increase harvest effort (but may not increase the stock size) and increase the rent. Changes that lead to increases in the periodic rent (R)--increases in p , K , and $[\gamma]$ and decreases in c --and thus the discounted stream of perpetual rents (V) will, in Demsetz's model, lead to increases in property rights delineation. And as the analysis above shows (Figure 3), a switch from open access to private rights or common property will lead to less harvest effort and larger stocks of bison. ⁵³

B. Establishing Ownership of Bison

The previous section takes the ownership regime as given, but ownership, as Demsetz shows, is also an economic choice. To start, assume the herd of bison is not owned or exploited by anyone and that the (potential) rent, $R(h(t))$, grows over time at the continuous rate $g < r$, so the value of the bison herd grows over time. As shown in the renewable resource model above, growth in the value of the rent can occur because of increases in p , K , and $[\gamma]$ or decreases in c . The first-best full-information value of the asset is given by a slight adjustment to (2), which allows for growth in rental value over time

[SEE FORMULA IN ORIGINAL] (3)

where $h^*(t)$ is the optimal harvest level in period t .

In general, V_{fb} is not attainable because there are costs of both establishing and enforcing rights that efficiently allocate use of the resource. Like many resources, bison ownership could be established by first possession. ⁵⁴ Under first possession, ownership goes to the first (person or perhaps group) to obtain possession of the entire stock. The first claimant thus obtains exclusive rights, from t into the indefinite future, to the flow of rents, [ILLEGIBLE TEXT], generated by the bison herd. Since establishing an enforceable claim will be costly and because $g < r$, rights may not be worth enforcing. Property rights to the bison herd will emerge, as Demsetz suggests, after an initial period without ownership, as the value of the asset increases. Assume there are one-time costs, C , of establishing enforceable rights or demonstrating possession that give the claimant exclusive right to the stream of production for all time. At this point, no distinction is made concerning whether the claimant is an individual or a group such as an Indian tribe. The decision to claim the stock is given by

[SEE FORMULA IN ORIGINAL] (4)

The optimal time to establish ownership to the stock of bison is t^* , which occurs when the marginal return from waiting (the present value of the asset's rental flow) equals the marginal cost of waiting (the present value of the opportunity cost of establishing rights). ⁵⁵ First-best value is not possible ($V(t^*) < V_{fb}$) because the net value of the asset must now account for the costs of establishing ownership and because of the fact that these costs delay ownership and production to t^* from $t = 0$. ⁵⁶

The comparative statics of optimal claiming time are straightforward. As the costs of claiming (C) the herd increase, the later will be the optimal time to establish ownership to the herd. As the rent (R) from the herd increases, the

⁵³ This seems to be inconsistent with the Montagne beaver case discussed in Demsetz, *supra* note 4, at 351-53. Perhaps beaver were not intensively exploited before the fur trade, so stocks were near carrying capacity before property rights were established.

⁵⁴ Dean Lueck, The Rule of First Possession and the Design of the Law, 38 J. Law & Econ. 393 (1995).

⁵⁵ This satisfies $Re^{-(r-g)t^*} = rCe^{-rt^*}$ and implies $t^* = (\ln r + \ln C - \ln R)/g$.

⁵⁶ If there is a competitive race among homogeneous claimants, rights are established prematurely and the rental stream is fully dissipated, so $V = 0$.

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earlier will be the optimal time to claim the herd. As the rate of growth of rent (g) from the herd increases, the earlier will be the optimal time to establish ownership to the herd. As the interest rate (r) increases, the later will be the optimal time to claim the herd. ⁵⁷

The costs of claiming a biological asset, such as a herd of large mammals, will depend on the ability of a party to enforce ownership to a large tract of land (the habitat) and on the ability of the party to maintain control over the herd within this tract. In practice, this depends on several things. First, claiming costs will depend on the animal's behavior and ecology because this will influence the cost of husbandry, or control over the animals. Second, claiming costs will depend on land ownership institutions such as tribal customs and government policy. Institutions that allow or reduce the costs of claiming and enforcing rights to large tracts of habitat will lower the costs of claiming. Third, claiming costs will also depend on technological advances, such as fences and horses, that can lower the costs of controlling land and animals. ⁵⁸

With respect to animal behavior and ecology, large wild mammals vary greatly in their predisposition to control by humans. ⁵⁹ Some animals are easy to control and can be captured individually and raised in captivity as livestock, where humans tightly control feeding and breeding. Other animals cannot easily be captured alive and thus can be owned only by controlling access to hunting, which implies that a live population must be claimed. Ecology impacts claiming costs by determining the size of the populations and the amount of habitat required. Populations with relatively small habitat requirements, of course, will have the lowest claiming costs, *ceteris paribus*. Nomadic species will have higher claiming costs than either migratory or territorial species. Territorial species (such as beaver) are the easiest to claim because they occupy a well-defined space. Both migratory and nomadic species tend to require larger spaces, but migratory species still have well-defined habitats compared to nomadic species.

There will also be costs of continuing possession once ownership is established. Analytically, such costs can be viewed as a reduction in the asset's rent, thus implying later claiming. If a specialized third party (for example, sheriff, hired gun, or tribal police society) is charged with maintaining rights, continued possession costs fall and claiming will come earlier. For bison, it is also conceivable that collective action may be required to claim and enforce possession for a herd and the large tracts of land that sustain it. Forces that lower the costs of such action will increase the probability of successful claiming. ⁶⁰

If the costs of claiming the herd are prohibitive and the costs of simply claiming a single bison are low, then first possession becomes the rule of capture, and open-access exploitation ensues. ⁶¹ As the model in Section IIIA shows, open access can lead to overharvest, low stock levels, dissipation of potential rent ($V = 0$), and possibly extinction of the herd ($x = 0$). ⁶² This can happen without modification of the habitat and regardless of whether possession of a single bison is made by killing or live capture. Here too, the costs of possession by killing and

⁵⁷ These follow from $\frac{\partial}{\partial t} C = 1/(Cg) > 0$, $\frac{\partial}{\partial t} R = -1/(Rg) < 0$, $\frac{\partial}{\partial t} g = -1/(g^2) < 0$, and $\frac{\partial}{\partial t} r = 1/(rg) > 0$.

⁵⁸ Douglas W. Allen, *The Rhino's Horn: Incomplete Property Rights and the Optimal Value of an Asset*, in this issue, at S339, and Umbeck, *supra* note 8, assume that claiming costs depend on the asset's rent because of potential theft. This implies that $C = C(R)$ and $C' > 0$. Allen further examines the implications of $C' > 0$. Allen actually assumes that C depends on V , but this ignores the fact that V also depends on the time at which rights are established.

⁵⁹ Jared Diamond, *Guns, Germs, and Steel* 157-75 (1997). Diamond notes, for example, that only 14 large terrestrial herbivorous mammals out of 148 "candidates" have been effectively domesticated. Of these, just "the major five" (cattle, goats, horses, pigs, and sheep) are now widely distributed beyond the range of their wild ancestors. All five are native to Eurasia.

⁶⁰ This would include member homogeneity suggested by Libecap, *supra* note 10.

⁶¹ Lueck, *supra* note 54. If both costs are prohibitively high the bison will remain unexploited ($x = K$).

⁶² Extinction of the herd, of course, is not the same as extinction of the species.

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capture are likely to differ, with killing being substantially cheaper. Live capture, however, also allows the possibility of establishing a new stock and recovering the gains from biological growth.⁶³

C. Alternative Uses of Bison Habitat

The bison's home on the Great Plains had obvious alternative uses, primarily for cattle grazing and grain farming.⁶⁴ The allocation of land between bison and agriculture will directly determine the carrying capacity (K) and biological growth ($[\gamma]$) of a bison herd and thus indirectly affect the exploitation of the bison herd and the potential rent available. This allocation, in turn, will affect the net value of bison under various property rights regimes. With these considerations, ownership of bison is now more complex because it depends on the ownership of land--an asset with two attributes--and because optimal ownership of such an asset may result in well-specified rights over some but not all attributes of the asset.⁶⁵

Assume L is the total amount of land that can be devoted to the habitat for a single bison herd (B) or agricultural use (A) and the two uses are mutually exclusive. The value of the land, net of production costs, is given by $V(A, B)$, where $V[A]$ and $V[B]$ are the respective marginal values of land used for agriculture and bison. The term $V(A(0), B)$ is simply the value of the bison from the previous model. The optimal allocation of land will be defined by the solution to

[SEE FORMULA IN ORIGINAL] (5)

The first-best allocation (A^*, B^*) must satisfy $V[A](A^*, B^*)$ [identical to] $V[B](A^*, B^*)$. Increases in the relative value of agricultural uses of the land will increase the allocation of land toward agriculture and directly reduce the carrying capacity of the land for bison and, most likely, also reduce the herd's intrinsic biological growth rate ($[\gamma]$). When no land is used for agriculture, then $B = L$ and the carrying capacity for the bison is its greatest, so $K = K_{\max}$. If, however, some land is used for agriculture, then $K < K_{\max}$. As the renewable resource model showed, reductions in K and $[\gamma]$ reduce the potential rent from private ownership and thus reduce the incentive to establish ownership of the herd, thus prolonging a period of open access.

In order for (A^*, B^*) to be generated by a land market, the property rights to these uses of land must be perfectly defined. Consideration of the costs of claiming and enforcing rights is important, and these costs are expected to be lower for agriculture than for bison because of the smaller territories required.⁶⁶ To see the effect of this addition, let $C(A, B)$ be the cost of claiming and enforcing rights to the two uses, where $C[A]$ and $C[B]$ are the respective marginal costs and $C[A] < C[B]$. The optimal allocation of land will now be defined by the solution to

[SEE FORMULA IN ORIGINAL] (6)

The second-best optimal allocation ($A_{<C>}, B_{<C>}$) must satisfy $V[A](A_{<C>}, B_{<C>}) - C[A](A_{<C>}, B_{<C>})$ [identical to] $V[B](A_{<C>}, B_{<C>}) - C[B](A_{<C>}, B_{<C>})$, which generates less land in bison habitat compared to first best, $B^* > B_{<C>}$, and fewer bison since $K^* > K_{<C>}$. More important, as the relative claiming and enforcement costs for agriculture decline, the smaller will be the allocation toward bison habitat. Even if $C[B]$ is large enough to prohibit explicit claims for bison habitat, it may often be the case that $V[A] = 0$ for some $A \leq L$, so that some fraction of the

⁶³ Dynamics also may be important if the starting point is common property and economic changes increase the costs of continued possession so that the rule of capture and open access arise. For example, it is possible that extinction might result during the transition from a common-property steady state to an open-access steady state (see Caputo & Lueck, *supra* note 45).

⁶⁴ In Demsetz's (*supra* note 4) analysis of the beaver, there was no competing use for the land.

⁶⁵ Yoram Barzel, *Economic Analysis of Property Rights* (2d ed. 1997).

⁶⁶ Dean Lueck, *The Economic Nature of Wildlife Law*, 18 J. Legal Stud. 291 (1989).

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land simply has no value in agriculture, and habitat (*B*) and carrying capacity (*K*) remain positive even without private ownership. ⁶⁷

IV. EMPIRICAL ANALYSIS: EXTERMINATION AND CONSERVATION

Three issues were examined in the models above: (1) how bison harvests and bison stocks depend on property rights, (2) what determines the effort and timing of claims on bison stocks, and (3) how changes in the value of alternative uses of the bison's habitat affect bison ownership and exploitation. The models and their implications can be used to explain the details of the economic history of the bison in North America. To do so, I divide the history into two periods: extermination and conservation. Table 2 summarizes my characterization of the property rights regime and economic conditions for the specific times and places I examine.

A. Bison Extermination

Before the Euro-American Markets. Prior to European exploration and settlement, property rights to bison can best be described as a combination of tribally controlled common property (the plains) and open access (the eastern forests). Indians living in the eastern forests were often engaged in agriculture and thus tended to have property rights to land defined over relatively small territories. Like the white settlers who followed, Indians killed bison when the opportunity arose but did not rely on them as a primary source of food and clothing. During the 1700s, land became relatively highly valued for uses other than bison habitat. Settlers killed them for food and to mitigate damage to crops, fences, and buildings. Bison were thus extinct by 1820 from a combination of habitat conversion and open-access hunting, or in what Hornaday called "desultory destruction." ⁶⁸ Hornaday's famous map of "The Extermination of the America Bison" actually marks a boundary for the areas of "desultory extirpation" and "systematic destruction." The latter region is almost exactly what geographers now call the "Great Plains."

The relationship between bison and man on the Great Plains was more complicated. Before the horse, much of the Great Plains, especially the western short-grass prairie, was largely unexploited by humans. Here bison herds would have approached carrying capacity and perhaps even were still expanding their range before they met the horse hunters. Without the horse, even though many bison herds were subjected to open-access hunting, the effects were limited because of the relatively high cost of pedestrian hunting.

TABLE 2		
PROPERTY RIGHTS TO BISON OVER TIME AND ACROSS SPACE		
Location/Period	Property Rights	Economic Conditions
Northern plains (1700s)	Tribal control of common property	Limited markets, relatively high harvest costs (few horses, no rifles)
Eastern forests (1700s)	Open access (settlers)	Habitat conversion, limited market for bison products
Northern plains (1800-1860)	Common property	Robe market controlled by

⁶⁷ Even though "leftover" habitat might be available for bison, they remain governed by open access, so there is no guarantee that bison stocks will remain positive.

⁶⁸ Hornaday, *supra* note 1, at 484. Although the records are not detailed, this is likely what happened to the European bison over many centuries.

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TABLE 2

PROPERTY RIGHTS TO BISON OVER TIME AND ACROSS SPACE

Location/Period	Property Rights	Economic Conditions
		large buyers and Indian hunters, no habitat conversion, stable harvests, falling harvest costs in latest period
Northern plains (1860-80)	Open access (displaced tribes compete with prior tribes)	Robe market, limited habitat conversion
Southern plains (1871-74)	Open-access hunting	Hide market raises bison value, habitat conversion reduces carrying capacity, harvest costs fall with railroad and new rifles
Texas (1874-80)	Open-access hunting	Comanche defeated, condition similar to southern plains but bison habitat is less productive, transportation costs higher
Northern plains (1880-84)	Open-access hunting	Hide market raises bison value, habitat conversion reduces carrying capacity, harvest costs fall with railroad, summer hunting, and new rifles; robe market vanishes
Live capture in various locations (1870-90)	Open-access capture	Small, isolated herds allowed for live capture of calves in the early summer
1900-30	Private and government	Preservation movement

TABLE 2
PROPERTY RIGHTS TO BISON OVER TIME AND ACROSS SPACE

Location/Period	Property Rights	Economic Conditions
	ownership	establishes secure habitat for small herds
2000	Private and government ownership	Extensive market for live bison and bison products, containment costs are relatively low

Upper Missouri tribes had control of bison territory immediately west of their villages, in western Dakota, perhaps as early as the seventeenth century and held it until roughly 1820.

The arrival of the horse allowed tribes from the eastern plains-woodland interface (such as the Sioux) to move west and exploit the bison and establish tribal claims in a manner consistent with the timing model above. For example, the Crow split from the Hidatsa and claimed the territory along the Yellowstone River in southeastern Montana. Similarly, the Comanches "began to take possession of the Southern Plains by the early 1700s" after they got the horse.⁶⁹ The Sioux moved west into the Dakotas, and after smallpox devastated the Upper Missouri tribes, they moved north.

Tribal organization mirrored that of the bison: small groups in the winter and spring and large groups in the summer and early fall when the bison were also congregated into the massive herds.⁷⁰ The development of the horse hunting culture not only opened up bison stocks to hunting but also changed the technology of the hunt and the culture of the tribes. With horses, summer bison hunting became a highly centralized affair that required strong tribal control over methods and timing.⁷¹ For summer bison hunts, hundreds of hunters would chase and surround a large herd and kill animals with arrows (and later rifles). Organization of such a hunt was a military-style hierarchy, enforced by tribal police. For example, no one was allowed to hunt alone, and obedience to the leader's orders were strictly enforced by whipping, property confiscation, and sometimes death.

Common-property regimes have been widespread among aboriginal peoples and have been especially common among hunting groups.⁷² The evidence reported by anthropologists and ethnologists suggest relatively stable tribal territories, and the evidence of relatively stable bison population are also consistent with this. The fur trader Pierre Chouteau reported 400,000 bison per year killed by nomadic Indians in the 1850s.⁷³ Using $K = 25$ million and $[\gamma] = .2$, $F(x) = .2x - (.008)x^2$, a harvest of 400,000 implies two possible solutions: $x^* = 22.8$ million or

⁶⁹ Flores, *supra* note 40, at 469.

⁷⁰ Lowie, *supra* note 30; Wissler, *supra* note 30.

⁷¹ Allen, *supra* note 20, at 207, Lowie, *supra* note 30, and Wissler, *supra* note 30, all describe Plains bison hunts this way and are key sources for Plains Indians behavior and culture.

⁷² Bailey, *supra* note 50; Ostrom, *supra* note 50; and Lueck, *supra* note 50.

⁷³ Isenberg, *supra* note 1, at 83.

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$x_{MSY} = 2.2$ million. The best estimates of bison populations at that time are much closer to the $x^* > x_{MSY}$ number, suggesting well-defined rights.⁷⁴

Other features of tribal behavior and organization show the benefits and costs of enforcing property rights to large herds of bison. For example, Roe notes that many tribes did not hunt during the summer and the soldier societies protected bison during calving. Instead they tended to hunt in the fall (with limited summer hunting to procure "summer skins" for teepees and clothing) when the weather was still good and winter robes were developed.⁷⁵ This alone indicates a significant investment in property rights protection. Evidence of intertribal conflict over hunting territories suggests both enforcement of common-property rights and the existence of border areas (for example, the Powder River basin in Montana and Wyoming) essentially governed by open access.⁷⁶ Given the inscrutable nomadism of bison herds, it is also likely that tribal territories never completely overlapped the territory of a single well-defined bison stock, so even here ownership was imperfect. Still, it is evident that hunting pressure moved herds, which both made rights enforcement effective and affected bison under open access. For example, David Dary reports that Sioux activity kept bison west of the Missouri River in Dakota, and many have noted how Kansas hide hunters pushed bison into the Texas Panhandle.⁷⁷

By the mid-to-late nineteenth century, many tribal rights had broken down as eastern tribes were forced west, as white settlers encroached, as disease devastated native human populations, and as the U.S. military defeated them in battle. For example, the Upper Missouri tribes lost as much as 80 percent of their populations to diseases in the 1830s and 1840s. This creation of open access was ultimately important in shaping the behavior of hide hunters after 1870 and is expected to have caused reductions in bison stocks.⁷⁸ In the case of the Sioux, however, their strong resistance to white encroachment actually protected bison from white hunters until the late 1870s.

The Robe Market: 1820-80. The robe market can be characterized as being governed by common property for the first 50 or so years and perhaps by open access for the last 10 years. The relatively high populations and stable harvest of robes over a half-century are consistent with similarly stable systems of common-property rights. Numerous reporters indicate that robe harvests shipped out of the Upper Missouri region averaged between 50,000 and 100,000 robes for nearly 60 years.⁷⁹ It also seems likely that robe trade reduced subsistence use of bison because of substitution for goods from the

TABLE 3

BISON ROBE AND BISON HIDE PRICES, 1877-84

Real

Real

Annual

Annual

⁷⁴ If, however, $K = 15$ million, then $x^* = 14.8$ million.

⁷⁵ Roe, *supra* note 20, at 116.

⁷⁶ For an unusual take on this, Paul S. Martin & Christine R. Szuter, War Zones and Game Sinks in Lewis and Clark's West, 13 Conservation Biology 36 (1999), argues that such war zones were actually protected from hunters and became "game sinks" in which stocks approached carrying capacity. A war zone would be an area of prohibitively high harvest costs.

⁷⁷ Dary, *supra* note 29, at 66-67; and Allen, *supra* note 20, at 163.

⁷⁸ Flores, *supra* note 40, argues that the Comanche tried to protect their bison territories but ultimately made a peace alliance in 1840 with Cheyenne and Arapaho and Kiowa-Apaches that gave these tribes access to the bison.

⁷⁹ Hornaday, *supra* note 1; Isenberg, *supra* note 1; McHugh, *supra* note 29; Roe, *supra* note 20. During this period, there also was a limited trade in pemmican and tongues (a delicacy to whites and Indians). Barton H. Barbour, Fort Union and the Upper Missouri Fur Trade (2001), has a focus specifically on the trade out of Fort Union.

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	Hide	Robe	Hide	Robe	Change in	Change in
	Prices	Prices	Prices	Prices	Real Hide	Real Robe
	(1982 \$)	(1982 \$)			Prices	Prices
Year	(\$)	(\$)			(%)	(%)
1877	1.00-1.60	3.81		46.42		
1878		3.65		47.86		3.1
1879		3.86		52.32		9.3
1880	2.88	5.05	35.27	61.84		18.2
1881	3.43	6.50	42.89	81.27	21.6	31.4
1882	3.18	7.92	38.47	95.80	-10.3	17.9
1883	3.33	7.00	40.90	85.98	6.3	-10.3
1884	3.25	25-200	42.04	323-2,587	2.8	275-2,909

NOTE.--Prices are from William T. Hornaday, *The Extermination of the American Bison* 439-40 (1889). Hornaday collected prices from markets in Chicago, New York, and St. Paul. Because I have no information on the quantities at various prices, I calculate a simple average for hide prices. For 1883, I round the averages to \$ 3.33 for hides and \$ 7.00 for robes because one source (Hornaday, *supra*, at 440) simply notes prices are "at a slight advance" of the previous year. The robe market is quite small after 1880, and by 1884 reported prices are rare. I use a low of \$ 25 from Martin S. Garretson, *The American Bison*, 157 (1938), and a high of \$ 200 from Hornaday, *supra*, at 444 & 502. For hide prices in 1877, I use Garretson, *supra*, at 125. Real prices are in 1982 dollars using the implicit gross national product price deflator from Christina Romer, *The Prewar Business Cycle Reconsidered: New Estimates of Gross National Product, 1869-1908*, 97 J. Pol. Econ. 1, 22 (1989).

white market, so these numbers should not simply be added to the estimated 400,000 annual amount killed before the market. Prices too remained relatively stable in nominal (and real) terms, showing an increase only in the late 1880s, as shown in Table 3. There were no close substitutes for bison robes, and as the hide trade made inroads, fewer bison were killed for their robes, so the supply rapidly declined. Data on robe trade shipped out of the Hudson Bay Company's Red River region are less clear, although it is well known that the Red River "half-breeds" made annual hunts for nearly a half-century.

There were two important features of the robe trade that distinguish it from the hide trade that followed. First, the robe trade occurred mostly during a period (pre-1880s) when the land had no valuable alternative uses, so the carrying capacity of the habitat was not being reduced. Second, the optimal time to hunt bison for robes was in the late fall and early winter when the robes were prime.⁸⁰ This meant that the great summer herds had disbanded and the smaller herds were scattered. Compared to summer hide hunting, this made the hunting more costly for robes. These forces limit the exploitation of the bison, even under open access, and help explain why the robe trade persisted without severely damaging the herds. In the late years of the robe trade, however, the bison had been depleted in the Red River region and on the Canadian prairie. What is unclear is whether the robe country was

⁸⁰ Allen, *supra* note 20, at 59, reports that November through January are the prime months for obtaining robes. Robes were also more costly to prepare than hides.

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reduced to open access directly or whether conversion of land into agriculture had indirectly reduced the productivity of the bison habitat.

Only on the northern plains did a well-organized market develop for bison robes. Two reasons seem likely. First, the colder northern winters caused the bison to develop a thicker, and hence more valuable, robe. Second, prior to the railroad, the northern plains had lower transportation costs (via the Missouri River and the Hudson's Bay) to eastern markets than the southern plains. Both forces meant that the net value of robes was higher on the northern plains and imply that property rights should have been stronger there because the gains were greater.

The Hide Market: 1871-84. As implied by virtually all historical accounts, the hide market was open access from beginning to end. Several specific features of this period contributed to the rapid depletion of the bison under open access and contributed to the persistence of open access. First, the market emerged suddenly in 1871 after railroads had penetrated Kansas and new tanning techniques were developed for bison hides.⁸¹ In 1870, tanning firms experimented with bison hides, and in 1871, they sent out word to the plains that they would buy them by the thousands. This rapid and largely unanticipated emergence of a large market meant that little time was available for rights to emerge. Second, because cattle hides were a close substitute, the hide price did not rise as the bison stocks dwindled, and the eastern tanneries continued leather production even as bison were being exterminated.⁸² This meant that the value of the bison herds did not increase as the bison stocks were depleted, thus further limiting the incentive to establish ownership of the dwindling herds. Price data are not available for the early period, but prices hovered around \$ 3.00-\$ 3.50 per hide from 1880 to 1884 (see Table 3). Third, the period of the hide market was characterized by rapidly falling costs of providing hides to the market. Under open access, this can lead to severely low population levels, which makes extinction more likely. Fourth, as discussed below, almost simultaneous with open-access hunting was a rapid decline in the bison's habitat.

Although direct measures of the extent of rent dissipation are not available, Isenberg's discussion of the hide hunters' fate is consistent with open access and rent dissipation: "Euroamericans waged a scorched-earth campaign against the Indians who impeded the expansion of industry. Yet the hide hunters's victory was hollow; when the campaign was over, most of the hunters found themselves no wealthier than before."⁸³ This description of the hunter is consistent with open-access exploitation by a group of homogeneous hunters with low opportunity costs.

Hunting and shipping costs fell dramatically during the short-lived hide market. The hide market was dependent on the existence of the railroad.⁸⁴ Before the railroad reached Kansas in 1870 and Montana a decade later, the costs of transportation for hunters and hides were prohibitively high. Still, it took marketing and new tanning methods to establish the hide trade, which seemingly could have occurred earlier in Nebraska and Wyoming as the Union

⁸¹ Dary, *supra* note 29, at 94-95, Allen, *supra* note 20, at 197, and others describe how a young buffalo hunter named Joasiah Wright Mooar searched until he found a firm that could tan bison hides into useful leather, though it was still considered a soft, spongy leather somewhat inferior to cowhide. Hanner, *supra* note 43, at 243, argues that it was the railroad, not the tanning technique, that was crucial, but this does not explain why a hide market did not develop several years earlier when the railroad reached Nebraska and Wyoming.

⁸² Hanner, *supra* note 43, at 243 & 253, calls bison hides "fungible" with cowhide and notes that bison hides never comprised more than 5 percent of the hide market.

⁸³ Isenberg, *supra* note 2, at 163. There was also a small market for meat for railroad workers and settlers (for example, William "Buffalo Bill" Cody became famous as a hunter hired by Kansas Pacific in 1867 and killed 4,280 bison; see Hornaday, *supra* note 1, at 478), but this had little effect beyond the travel corridors. For example, Hornaday, *supra* note 1, at 500, notes that Colonel Dodge accounts settlers for killing just 150,000 for meat compared with 3.7 million killed in 1870-74 for hides. During the hide trade, there was a limited amount of meat shipped east, but it was generally too costly to transport from a kill site to the railroad. After 1872, small amounts were shipped in refrigerated cars.

⁸⁴ Hanner, *supra* note 43.

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Pacific was built. The railroad development, of course, was not directly derived from the demand for bison hides but rather from the demand to travel west to settle both the plains and the western regions beyond. Because this demand was strongest in the southern plains, the railroad and the hide trade began there and moved north a decade later. It was also the case that the Indians on the northern plains (Sioux, Crow, and Blackfoot) were more hostile and organized than those on the southern plains, perhaps because of the valuable robe trade.⁸⁵

Because the hide market allowed summer hunting when the herds were huge and relatively easy to hunt, the costs of killing were much lower than for robe hunting. Over time, the hunters developed tremendously effective tactics to exploit the bison's behavior in large herds. The development of large-caliber breech-loading rifles further lowered harvest costs and further reduced stocks as the open-access model implies. The chase hunt was soon abandoned, and the "still hunt" came to be the culmination of bison-hunting technique.⁸⁶ By this method, a single hunter would stalk a large herd (perhaps several thousand animals) and set up to shoot from a concealed location downwind and within a few hundred yards. Because the bison were not especially wary of humans, a single shooter might be able to kill more than 100 bison in a few hours without moving. One trick was to shoot the "lead" cows before they became nervous and moved the herd.⁸⁷ The hunter's partners would come in later to skin the animals and prepare the hides. by this method, a single hunter often killed more than 1,500 bison in a season.

On the southern plains, the evidence for open access is overwhelming.⁸⁸ The center for the southern hunt from 1870 to 1873 was Dodge City, where as many as 5,000 hunters are said to have operated at the peak of the hide trade.⁸⁹ Dodge City quickly became the center of the bison trade, and from 1871 to 1875, perhaps as many as 1.4 million hides were shipped. Waste seems to have been rampant, with three or four bison killed for every hide brought to market.⁹⁰ Thus nearly 4 million bison were killed--by way of poor shooting and hasty skinning induced by the rule of capture's incentives--in order to recover fewer than 1.5 million hides.⁹¹ Such waste is consistent with open access. Also consistent is the high number of young cows and calves also killed, even though only mature bulls with larger and thicker hides were the most valuable. Under open access, there is no incentive to wait to kill a more valuable bison. Other behavior is consistent with open access, such as the hunters lining the rivers for hundreds of miles hoping to ambush bison coming for water and hunters lining up along the border of Indian County (Oklahoma). Hunters sometimes burned fires at night to keep bison away from water. The extremely low opportunity cost for the hunters also made open access hard on the bison. Hornaday notes: "Even when the buffaloes were nearly gone, the country was overrun with men who had absolutely nothing else to look to as a means of livelihood."⁹² In just 4 years, a population of at least 4 million bison was reduced to roughly several

⁸⁵ In Canada, the Hudson's Bay Company successfully lobbied to keep settlers and railroads out of their bison-trading regions. Still, the bison were wiped out before the Canadian Railroad crossed the prairie. The earlier extermination in Canada remains a puzzle. William A. Dobek, *Killing the Canadian Buffalo, 1821-1881*, 27 *West. Hist. Q.* 33 (1996), suggests that the bison were gone from the Canadian plains by 1860 simply by being pushed out by hunters. Dary, *supra* note 29, says they actually survived into the 1870s.

⁸⁶ Hornaday, *supra* note 1, at 467.

⁸⁷ It is well known that a mature cow nearly always leads herds of ungulates (hoofed mammals). Many hide hunters actually shot the lead cow in the gut, causing it to stand still and die slowly, thus holding the herd in place. For such accounts see Victor Grant Smith, *The Champion Buffalo Hunter: The Frontier Memoirs of Yellowstone Vic Smith* (Jeanette Prodggers ed. 1997).

⁸⁸ In passing, Hornaday, *supra* note 1, at 495-96, indicates some claiming of hunting sites, but more often he notes that hunters are densely packed and in competition.

⁸⁹ Dary, *supra* note 29, at 97.

⁹⁰ Hornaday, *supra* note 1, at 494.

⁹¹ Allen, *supra* note 20, at 196; Hornaday, *supra* note 1; and Isenberg, *supra* note 2. Indians did not participate in hide trade much since the tribes had nearly all been defeated in the Indian Wars prior to the hide trade.

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hundred thousand left in the Panhandle of Texas and the western reaches of Kansas and Oklahoma. After the Comanche were defeated at the Battle of Adobe Walls (Texas), this area was open to hide hunters. In pursuit of these bison, a smaller industry survived for a few more years.⁹³

If anything, the open-access conditions for the hide market and the northern herd were even more extreme than for the southern herd. By the time railroads and hide hunters reached the bison in the north, the Plains Indians tribes were completely subdued and living on reservations. Just three seasons (1880-81 through 1882-83) were needed to reduce the bison on the northern plains to less than 100 animals, not counting the 200 in Yellowstone Park. Miles City (Montana) became the equivalent of Dodge City but had an even shorter life as a hide town. In 1882, there were 5,000 hunters and skinners working out of Miles City, which suggests about 1,000 hunters. When hunters arrived in early fall 1883 to hunt again, they simply could not find bison. Thousands of hunters went bankrupt. In Hornaday's words: "In the autumn of 1883 they [the hunters] nearly all outfitted as usual, often at the expense of many hundreds of dollars, and blithely sought 'the range' that had up to that time been so prolific in robes. The end was in nearly every case the same--total failure and bankruptcy. It was indeed hard to believe that not only the millions, but also the thousands, had actually gone, and forever."⁹⁴

The historical evidence of bankruptcy among the hide hunters implies not only a lack of ownership but also a tremendous ignorance about the bison population itself. This is somewhat surprising since many hunters were veterans of the southern trade and knew how the hide hunt had proceeded there, and they could watch the progress of the railroad moving west out of Dakota Territory. Many historians also noted the development of the myth that the bison went north to Canada during the winter of 1882-83. In fact, the information surprise about the size of the remaining bison stocks is consistent with the nomadic behavior of the bison and the general lack of communication among the hunters operating in a vast territory. No one really knew how many bison were present until long after the hunting was over. The presence of such an information surprise implies that prices of bison products should have jumped dramatically once information became clear about the increasing scarcity.

Table 3 presents the limited data on hide and robes prices from the historical record and can be used as a partial test for the presence of such an information surprise. Two findings are notable. First, hide prices show no evidence of a surprise, remaining relatively constant until the end of the hide trade in 1884. Because bison hides were (and are) close substitutes for cattle hides, this is expected, although the available data make it hard to sort out general market trends in the national rawhide market. Data on cowhide prices during this period are difficult to find, but limited evidence suggests prices in the same range as those for bison.⁹⁵ Second, robe prices show some increase in the early 1880s as the hide hunters dominated the bison and robe supplies dwindled. After the organized markets disappeared with the large herds in 1884, price data are available only through scattered anecdotes. What data exist tend to support the presence of an information surprise. For example, Martin Garretson noted a big jump in robe prices in the winter of 1884 from "\$ 5 a pelt to \$ 25 or \$ 30 and even higher," and Hornaday found that robe prices in Montana rose at the end of the 1883-84 hunt to as high as \$ 200 and that a Texas hunt in 1887 yielded 50 bison with skins (most likely robes) selling for \$ 50-\$ 150.⁹⁶ Bison heads, too, became highly prized and highly priced trophies at the end, fetching as much as \$ 500 in the mid-1890s in the area near Yellowstone Park.⁹⁷ The finding of a price surprise differs from Libecap and Ronald Johnson's study of

⁹² Hornaday, *supra* note 1, at 498.

⁹³ McHugh, *supra* note 29.

⁹⁴ Hornaday, *supra* note 1, at 512. Here Hornaday refers to hides (no hair) and not robes.

⁹⁵ For example, Walter Prescott Webb, *The Great Plains* (1931), reported cattle prices of \$ 30-\$ 40 a head in the 1870s (at 216). Walter Harvest Peters, *Livestock Production* (1942), notes that the hide represents about "10 percent of the total value" of the animal (at 86). This implies that hide prices ranged from \$ 3 to \$ 4, which is comparable to the bison hide prices shown in Table 3.

⁹⁶ Garretson, *supra* note 29, at 157; and Hornaday, *supra* note 1, at 444 & 502.

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nineteenth-century timber, which found that prices rose smoothly over time as old-growth timber stocks were depleted.⁹⁸ For timber, property rights were well defined, perhaps because of good information about the stocks, and market prices did not show unexpected scarcity.

The fact that the hide trade almost immediately ended the robe trade is further evidence in support of open access.⁹⁹ Had property rights been secure, hunters would have provided an optimal mix of hides and the more valuable robes. But since the robes were more costly to acquire and prepare and required late fall or winter hunting, there was insufficient incentive to hunt for robes. The hides were also good substitutes for cattle hides, and the price did not rise as populations dwindled, so there was little incentive to capture bison herds and husband them since cattle were just as valuable and easier to manage.¹⁰⁰

On the northern plains, hunters perfected the still hunt that had been developed during the 1870s hide market on the southern plains. Even before the northern hide trade started in 1880, the central plains were severely depleted by Indian hunters, who no longer had stable claims to territorial hunting grounds. Hunters became more efficient and wasted fewer bison in the field. Hides per kill fell to one for every 1.25 killed, from one per three to four killed a decade earlier. Still, there was much waste in the aggregate.¹⁰¹ Together, these factors indicate a low marginal cost of harvest under open access.

Even after the hide market was finished in 1884, hunters continued to pursue the remaining small herds, which survived simply because of the high costs of hunting small, isolated herds in rugged terrain.¹⁰² The most substantial of these were the 500 wood bison remaining in the Canadian north between Peace and Athabasca Rivers. A military presence in Yellowstone Park preserved about 200 bison in 1889, but there had been hunting along the border, and poaching ultimately drove the Yellowstone herd to just 23 bison by 1902. For example, during the winter of 1893-94, poachers killed about 100 bison in and around the park.¹⁰³

Outside of Yellowstone, the fate of the last wild bison was sealed in 1897 in Park County, Colorado. A small herd of 20-30 bison, which escaped the southern hide market, actually had been protected by local ranchers for nearly 2 decades. But protection was difficult, and poachers slowly diminished the herds until the last four were found killed in February 1897. After the hide hunt was finished, it is clear that the trophy value of the remaining bison rose dramatically, causing limited but intense hunting by trophy seekers. In Livingston, Montana, just north of Yellowstone Park, local taxidermists did a nice business mounting bison trophies during the 1880s and 1890s.¹⁰⁴ The fate of the few remaining small herds of bison in Colorado, Texas, and Wyoming indicate that even this increase in value was not great enough to overwhelm the costs of claiming and protection.

⁹⁷ Coder, *supra* note 29, at 81.

⁹⁸ Gary D. Libecap & Ronald N. Johnson, Efficient Markets and Great Lakes Timber: A Conservation Issue Reexamined, 17 *Explorations Econ. Hist.* 372 (1980).

⁹⁹ Hornaday, *supra* note 1, at 507, discussed how the robe trade disappeared after the hide market began in 1880.

¹⁰⁰ There was also a short-lived bone market after the bison kill. Millions of tons of bones were collected and shipped east for fertilizer and carbon processing.

¹⁰¹ Hornaday, *supra* note 1, reports that many bison he killed on the Smithsonian expedition in 1886 showed old hunting wounds.

¹⁰² At the very end, bison hunting became extremely costly with scattered small herds. It took Hornaday two trips from Washington, D.C., and 4 months in the field to kill 25 for his Smithsonian expedition (Hornaday, *supra* note 1, at 529-46).

¹⁰³ Garretson, *supra* note 29. Meagher, *Bison of Yellowstone*, *supra* note 13, argues that Garretson's claim of 116 killed by poachers is not documented and so should not be taken literally.

¹⁰⁴ Garretson, *supra* note 29; and McHugh, *supra* note 29.

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The Market for Land and Cattle. The demand for land on the Great Plains for farming and grazing also dramatically affected the bison by reducing the carrying capacity (K) of the habitat and reducing the biological growth rate (γ) of the herds. This reduction in the ability of the plains to support bison took place almost simultaneously and coincidentally with the hide market. Cattlemen were driving range cattle through the heart of bison country, and western settlers were moving across the plains since the late 1860s. Not only did cattle directly compete for grass, their presence limited bison movement and their ability to exploit variations in the habitat (for example, water sources and grass at different locations) and thus reduced the carrying capacity of the land.

Table 4 shows how land use changed on the Great Plains (excluding Canada) during the nineteenth century and how cattle essentially replaced bison, almost one for one, during this period. The table uses census data on land use for those counties that comprise the Great Plains in order to calculate the amount of bison habitat available from 1860 to 1920 and then shows the calculated carrying capacity for bison over time, allowing one to distinguish habitat loss from overharvest. In 1850, there were roughly 60,000 nomadic

TABLE 4
BISON, CATTLE, AND PEOPLE ON THE GREAT PLAINS, 1860-1920

Date	Bison	Bison	Cattle	American
	Habitat	Carrying		
	(Million	Capacity		
	Acres) a	(Millions) b	(Millions) c	Population d
1860	413.35	13.78-20.67	.18	164,474
1870	407.50	13.58-20.38	.63	591,125
1880	376.71	12.56-18.84	4.61	1,835,519
1890	208.36	6.95-10.42	6.65	3,650,342
1900	119.86	4.00-6.00	15.98	4,486,417
1910	83.81	2.79-4.19	12.71	6,457,017
1920	60.10	2.00-3.01	10.66	7,303,456

NOTE. -- The area defined to be the Great Plains comes from the Center for the Great Plains at the University of Nebraska, using their map found at <http://www.unl.edu/plains/map.html>. It includes all of the states of North Dakota, South Dakota, Nebraska, and Kansas, all but the southeast corner of Oklahoma, north central Texas, and the eastern reaches of New Mexico, Colorado, Wyoming, and Montana. This area comprises 416,162,250 acres. The counties used to compile the census data vary from decade to decade and are not reported here. No data were available for the Canadian portions of the Great Plains. Data come from using the approximate land area (acres) by state and county in U.S. Bureau of the Census, Thirteenth Census of the United States, 1910, Volume VI, Agriculture Reports by States Alabama-Montana, Table 1 (Farms and Farm Property, by County), and Volume VII, Reports by States Nebraska-Wyoming, Table 1 (Farms and Farm Property, by County).

TABLE 4**BISON, CATTLE, AND PEOPLE ON THE GREAT PLAINS, 1860-1920**

Date	Bison	Bison	Cattle	American
	Habitat	Carrying		
	(Million	Capacity		
	Acres) a	(Millions) b	(Millions) c	Population d

a Bison habitat is the acres available for bison and calculated as total acreage less land in farms and the public range in Montana, South Dakota, and Wyoming.

b Bison carrying capacity is calculated from bison habitat using a range of 20-30 acres per bison (James H. Shaw, How Many Bison Originally Populated Western Rangelands? 17 Rangelands 148 (1995)) and ranges from 13.9 to 20.8 million for the entire Great Plains.

c Cattle numbers were compiled using data from the Census of the United States, for the decennial years 1860-1920.

d Populations for Kansas, Nebraska, North Dakota, and South Dakota are out of U.S. Bureau of the Census, Fourteenth Census of the United States, 1920, Volume 1, Population, Table 8 (Population of the United States, by Divisions and States with Rank According to Populations: 1790-1920). The other states use county data in U.S. Bureau of the Census, Fourteenth Census of the United States, 1920, Volume 1, Population, Table 49 (Area and Population of Counties or Equivalent Divisions: 1850-1920).

TABLE 4**BISON, CATTLE, AND PEOPLE ON THE GREAT PLAINS, 1860-1920**

Date	Farms	Land in	Total
			Farmland
	(Thousands) e	Farms (%) e	(Million
			Acres) e
1860	13	.68	2.81
1870	52	2.08	8.67
1880	236	9.48	39.45
1890	406	21.75	90.53
1900	525	47.13	196.12
1910	733	58.41	243.07

TABLE 4

BISON, CATTLE, AND PEOPLE ON THE GREAT PLAINS, 1860-1920

Date	Farms (Thousands) e	Land in Farms (%) e	Total
			Farmland (Million Acres) e
1920	734	72.45	301.49

NOTE. -- The area defined to be the Great Plains comes from the Center for the Great Plains at the University of Nebraska, using their map found at <http://www.unl.edu/plains/map.html>. It includes all of the states of North Dakota, South Dakota, Nebraska, and Kansas, all but the southeast corner of Oklahoma, north central Texas, and the eastern reaches of New Mexico, Colorado, Wyoming, and Montana. This area comprises 416,162,250 acres. The counties used to compile the census data vary from decade to decade and are not reported here. No data were available for the Canadian portions of the Great Plains. Data come from using the approximate land area (acres) by state and county in U.S. Bureau of the Census, Thirteenth Census of the United States, 1910, Volume VI, Agriculture Reports by States Alabama-Montana, Table 1 (Farms and Farm Property, by County), and Volume VII, Reports by States Nebraska-Wyoming, Table 1 (Farms and Farm Property, by County).

e Farms and land in farms are compiled using data from the Census of the United States, for the decennial years 1860-1920. Details of these calculations are available from the author on request.

Indians on the Great Plains. On the basis of the potential carrying capacity of the 416 million acres comprising the Great Plains, the estimated number of bison ranges from 14 to 21 million. By 1900, when the bison were effectively extinct as a wild metapopulation, the Great Plains had, at most, only 120 million acres of bison habitat, 4.5 million people, 525,000 farms covering half of the land, and nearly 16 million cattle. By 1900, the carrying capacity of the Great Plains was reduced to a range of 4-6 million bison, and by 1920, this was further reduced to 2-3 million bison.¹⁰⁵ In the United States, total nondairy cattle numbers were 15.3 million in 1870 but jumped to 36.8 million by 1890. Almost all of this increase can be attributed to the rapid stocking of the Great Plains as the bison were being depleted.

Consider Kansas and Montana, two of the most important states in bison history. In 1860, Kansas had just 107,000 people, 10,400 farms comprising just 3.4 percent of the state's land, and just 43,000 cattle. By 1890, Kansas had 1.4 million people, 57 percent of the land was in farms, and there were over 3.8 million cattle. In 1870, Montana's Great Plains region had just 6,000 people, farms comprised a mere .002 percent of the state's land on the plains, and there were only 5,500 cattle. By 1900, the plains of Montana had 70,000 people, 8.6 percent of the plains land was in farms, and there were over 500,000 cattle that included extensive grazing on unclaimed public land. Similar patterns are seen in the rest of plains. Even if the bison could have escaped the hunters, they would have had no viable habitat given the competition from farmers and ranchers.¹⁰⁶ As Table 4 shows, the carrying capacity of the

¹⁰⁵ Even these estimates of carrying capacity are likely to be high because of the difficulty of getting land use data on public lands in the Great Plains. Thus the carrying capacity calculated in Table 4 represents an upper bound for years starting in 1890.

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plains for bison was dramatically reduced by the introduction of agriculture, though the introduction of agriculture was likely aided, in turn, by the depletion of the bison.

The question remains why no one simply claimed and husbanded the bison instead of bringing in the seemingly ill-suited domestic cattle from Europe. Such a possibility is not far-fetched. The aboriginal peoples of northern Europe and Asia have, for centuries, husbanded the reindeer, herding them over the vast tundra in a manner that seems to mimic their natural migration. Unlike the bison, however, the reindeer's habitat was (and is) of little value for other uses, as was also true for the Montagne's beaver habitat.¹⁰⁷ Hornaday, in fact, believed cattlemen made a huge mistake by not domesticating (even cross-breeding) bison and using them instead of range cattle. He noted the 50 percent losses of cattle on the northern plains during the 1886-87 winter and wrote: "It has for years been a surprise to me that Western stockmen have not seized upon the opportunity presented by the presence of the buffalo to improve the character of their cattle."¹⁰⁸ The evidence, however, suggests that bison herds were extremely costly to own, especially compared to domestic cattle.

Two kinds of ownership costs are relevant, those for the bison themselves and those for their habitat. Ownership of bison herds would have required ownership or contractual control of large contiguous tracts of land--perhaps a 10,000 acre minimum if herds need to have 400 head to be viable and 25 acres per head is needed--because of the bison's innate nomadic desires and tendency to aggregate. Several forces worked against the assembly of large tracts. First, direct transactions with Indians for land ownership were extremely costly because of the vagueness of the tribal claims, because of competing claims among tribes, and because of collective decision making by the tribes. Indeed, these land transaction costs are likely to have been important in causing violent conflict between whites and Indians.¹⁰⁹

Second, the U.S. system of establishing ownership to land was biased toward claims much smaller than those required for bison. Homesteading allowed just 160- and 320-acre claims. These claims were trivial in comparison to what would be needed for bison, but they could be consolidated via the land market into larger holdings. Still, a legitimate claim required a 5-year probationary period of use and settlement, so consolidation could not occur quickly. As the hide market shows, rapid consolidation would have been necessary to get a large-scale holding before the effect of open-access hunting had extinguished the herds. Third, even if large tracts could have been assembled, some method of confinement was needed. Fencing was extremely costly on the plains before barbed wire, which did not arrive in large measure until the 1880s, after the bison were gone.¹¹⁰ Larger tracts can substitute for fencing by limiting the bison's interest in wandering, but this has its own costs.¹¹¹ Even in the domestic cattle industry on the open range before the barbed wire, it took costly large-scale collective institutions (for example, cattlemen's associations, brand registries, and stock detectives) to secure property rights to the range.

¹⁰⁶ Flores, *supra* note 40, argues that there were 2 million horses in Comanche country by 1850 and this alone must have reduced bison numbers even before the hide trade. But Shaw, *supra* note 13, and Meagher, *Bison bison*, *supra* note 13, show that this is incorrect since bison and horses do not compete for the same forage. For this reason, I do not include horses in the analysis above.

¹⁰⁷ Reindeer are also migratory (not nomadic), allowing a well-defined habitat, and have a disposition that allows milking and riding, as well as herding. See Tim Ingold, *Hunters, Pastoralists, and Ranchers* (1980).

¹⁰⁸ Hornaday, *supra* note 1, at 453.

¹⁰⁹ Terry L. Anderson & Fred McChesney, *Raid or Trade: An Economic Model of Indian-White Relations*, 37 *J. Law & Econ.* 39 (1994).

¹¹⁰ Webb, *supra* note 95, at 309, found barbed wire to be first available commercially in 1874, but it was not in widespread use until the 1880s.

¹¹¹ Even today, bison fencing is perhaps twice as expensive as that for cattle, requiring at least a 6-foot fence (National Bison Association Web page). They state: "The key to remember is that well-fed, content bison will not roam."

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A comparison of bison and cattle suggests that Hornaday was overly optimistic about the possible domestication or, in economic terms, the ownership of bison. ¹¹² Roe, perhaps the most important bison historian, is deeply suspicious of Hornaday's bison domestication idea. Roe notes that many experiments, including cross-breeding, had been tried since the early 1700s and with little success. Roe simply calls bison "intractable." ¹¹³ The most fundamental feature is that domestic cattle have been raised and bred in captivity for thousands of years and thus have been selected for their relative ease of maintenance. Bison were nature's raw material.

It is not a coincidence that the English word for personal property is "chattel," derived from "catel," the old English (and old French) word for cattle. "Bison," however, derives from "bisontes," an Early Modern English term for wild ox. The roots of the names for cattle and bison are more than suggestive of the important differences between two seemingly similar animals. Compared to domestic cattle, for example, bison are nasty and strong, have a great tendency to aggregate (and are nervous when separated), and like to move constantly. Bison, in great contrast to cattle, are faster than many horses, great leapers, and very agile, able to navigate steep and rugged terrain. ¹¹⁴ These features of bison and cattle explain several advantages cattle have over bison.

First, cattle are easier to handle in order to move them and to treat them. Even today's most enthusiastic bison supporter, the National Bison Association states that "bison are not a domestic animal and require different handling than cattle. . . . Bison are much more nervous and excitable in close quarters." ¹¹⁵ Second, cattle are cheaper to fence and herd. Well into the 1930s, cattlemen had to move cattle to the market, and this required herding with horses. Herding bison would have been virtually impossible, but it was routine if not simple for cattle. The bison's disposition and their speed made them impossible to trail like domestic cattle. Indeed, Texas longhorn cattle were the wild escapees of Spanish herds dating back to the 1500s. Texas cattlemen easily rounded them up and drove them to new pastures, ranches, and ultimately to market. ¹¹⁶ That this domestication took place in the same region that held the bison is strong evidence that bison were costly to own. It took 6 years (1907-12) of annual roundups to move a herd of 600 bison on a private ranch in western Montana. ¹¹⁷ Cowboys found they could handle only a few animals at a time and could not herd them in large groups like cattle.

Third, the reproductive capacity of bison is lower than that of domestic cattle. This is true because of generations of selective cattle breeding and because cattle can be more easily handled and fed in confinement during the winter. Wild bison have a natural rate of increase of perhaps 20-25 percent, while cattle can approach 100 percent annually. Fourth, the value for meat and hides seems similar between the two animals, so bison have no real advantage here. The current demand for lean meat favors bison slightly, but bison also have a larger fraction of lower quality meat because of their relatively larger front quarters compared to cattle.

Cattlemen and hunters had plenty of time to observe bison and invest in their capture had they thought it worthwhile. Garretson described the frequent contact cattle drovers had with bison, often having to avoid large bison herds, lest they lose cattle in their midst. ¹¹⁸ They clearly had the chance to see the possibilities of

¹¹² For example, Hornaday's 1886 party did catch one bison calf, but it died soon.

¹¹³ Roe, *supra* note 20, at 706-14.

¹¹⁴ Allen, *supra* note 20, at 163. Diamond, *supra* note 60, lists several characteristics not conducive to domestication, noting "nasty disposition." Diamond also notes that had bison been susceptible to domestication, it would have occurred long before Europeans arrived in the Americas. Nearly every year seemingly docile bison kill inquisitive tourists in Yellowstone Park.

¹¹⁵ See the Bisoncentral Web site, <http://www.bisoncentral.com> (visited on August 1, 2001).

¹¹⁶ Webb, *supra* note 95, at 210-11, noted widespread claiming of wild longhorns in Texas from the 1840s to the 1860s.

¹¹⁷ This sale is described in many places, including Roe, *supra* note 20, and Dary, *supra* note 29, but the details are found in Coder, *supra* note 29, at 171-251.

¹¹⁸ Garretson, *supra* note 29, at 145-50.

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domestication. The unsuccessful case of the privately protected herd in Colorado illustrates the costs of protecting bison.¹¹⁹ Information costs also seem likely to have limited the potential to claim a herd. As the widespread ignorance of the bison hunters arriving in Miles City in the fall of 1883 attests, no one seems to have known what the state of the bison population was until Hornaday's study, after all but a thousand were gone.¹²⁰ Given the costs of establishing ownership of bison and their habitat, it seems that it was simply far cheaper to remove the bison--marketing the most valuable parts--and replace them with domestic cattle.

B. Bison Conservation

The demand for the conservation of the bison in the late nineteenth century was a major development in wildlife conservation. For wildlife, conservation means preservation of relatively large populations of more-or-less free-roaming animals on native habitat. The models developed earlier contained no explicit demand for live bison. While such formal modification of the models is straightforward, I briefly consider only two likely reasons for the emergence of this conservation demand. First, a demand for a new product such as conservation might emerge as information or incomes change. Second, the dramatic reduction in bison stocks from millions to just a few hundred might simply mean that the marginal value of any live bison could be very high, without any change in preferences. Regardless of the cause(s) of the rise of a demand for bison conservation, it is nonetheless clear that such a demand existed by the late nineteenth century and that it influenced bison exploitation and land management.

The first recorded call for bison conservation actually came in 1820 from Major Stephen Long's Colorado expedition, where they saw many bison killed. In 1832, the artist George Catlin proclaimed, "The buffalo's doom is sealed." Catlin had been spending summers at Fort Union producing landscapes and portraits of the plains Indians and, even then, noticed a decline in bison numbers. Within a decade, John James Audubon, another famous artist and visitor to Fort Union, also commented on the population declines and suggested conservation measures. Some scientists were aware of the near extinction of the European bison and had warned of a similar fate for the American version.¹²¹ Still, no meaningful protective legislation was enacted until 1894, when the Lacy Yellowstone Protection Act offered federal protection of bison in Yellowstone. Ultimately, two sets of actions led to the dramatic recovery of the bison: live capture and captive rearing of bison by private parties and, later, government establishment of refuges, stocked with the descendants of the wild bison captured in the nineteenth century.

Since the costs of claiming herds and assembling large tracts tended to be prohibitive, first possession led to open access. But first possession also meant that individual bison could be live captured, as well as killed. Live capture was cheapest when the bison were young calves, and nearly all captured bison were calves. Although a few bison had been captured as early as the 1700s, it was not until the late nineteenth century that a substantial number of bison were live captured in the United States and Canada and then captive reared. In fact, there is documentation of 84 successfully captured bison (see Appendix Table A1). By 1889, Hornaday counted 256 bison in captivity as a result. By 1901, the numbers of private bison totaled more than 600, in herds ranging in size from one to several hundred (see Appendix Table A2).

There were five "foundation herds" that ultimately supplied most of the bison in North America today. I discuss three of these cases to show how live capture and private ownership worked.¹²² In 1866, Texas rancher Charles

¹¹⁹ It seems likely that hunting costs were great for small stocks (that is, $c(x)$, $c' > 0$), which might explain how the small Colorado herd survived for 2 decades after the hide hunters left Colorado.

¹²⁰ In great contrast, Schorger, *supra* note 11, described how passenger pigeon hunters communicated by telegraph on nesting locations in the eastern woodlands.

¹²¹ Dary, *supra* note 29, at 121-25, discusses early conservation efforts. Given the nomadic nature of bison and the limited knowledge of bison population and range, one must wonder whether any of these early concerns were realistic in their anticipation of the hide hunt and plains settlement.

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Goodnight captured six calves, which he was able to cut away from their mothers and lead back to his ranch. Goodnight soon sold the calves but captured more in 1876 when the southern herd was all but gone and ultimately built a herd of 125 by 1910. In 1873, a Pend d'Oreille Indian named Samuel Walking Coyote captured seven orphan calves in 1877, after hunting along the Milk River, in north central Montana, and herded the calves back to the Flathead Reservation west of the Rocky Mountain divide. By 1888, he had 13 bison that he sold for \$ 2,000 in gold to ranchers Charles Allard and Michel Pablo. The Pablo-Allard herd thrived on the free grazing land on the Flathead Reservation and grew to over 600 by 1906.¹²³

The actions of Colonel Charles J. "Buffalo Jones" Jones, a Kansas rancher, are undoubtedly the most remarkable of all bison captors and illustrate the costs of such activity. Aware of a remnant herd around the Palo Duro Canyon in the Texas Panhandle, Jones made four trips from 1886 to 1889 to capture bison. His first trip netted 10 calves, which he led back to Kansas with the aid of domestic milk cows. His most successful trip was in May 1888, spurred by hearing that hunters had just killed 50 bison the previous winter. Hornaday wrote in awe: "His party found from first to last, thirty-seven buffaloes, of which they captured eighteen head, eleven adult cows and seven calves; the greatest feat ever accomplished in buffalo-hunting."¹²⁴ Overall, Jones captured 56 or 57 bison that survived the trips to his Kansas ranch.¹²⁵ Jones, like Goodnight, Pablo, Walking Coyote, and a handful of others, was crucial in restocking bison to refuges and parks in the west.

Once property rights to live bison were established, a market in bison, though limited, was not far behind. As a result of the private capture of live bison and the elimination of wild herds, the law has treated bison as domestic livestock rather than as wildlife. To this day, nearly all states govern bison under the law of livestock. Bison were bought and sold among ranchers, and they were also sold to zoos and ultimately to parks and refuges. In the first decade of the 1900s, an adult bison was worth \$ 300, or nearly \$ 4,000 in 1982 dollars, substantially more than most cattle. This does suggest that live bison values rose as the herds dwindled, but the relatively small amount of capture activity indicates how costly bison capture was.

There was little political activity until the 1870s as the southern herds were vanishing. A few states and territories enacted protective legislation (for example, closed seasons or fines) with no real teeth in the late 1870s when there were few bison left to protect. As the hide trade in Kansas progressed, members of Congress took notice of the species decline, and several bills were introduced to restrict the killing. In 1874, Congress even passed a bill that prohibited killing of bison cows on federal lands, proponents arguing that settlers needed to have bison for subsistence during travel, but President Grant did not sign it. By the time the northern hide market ended, most states and territories passed laws against bison hunting.¹²⁶ No important legislation was passed until the 1894 act protecting bison in Yellowstone. Even so, Yellowstone Park did not actively pursue bison conservation until 1902, when it increased its protective efforts and imported bison from private herds (primarily from the Goodnight and Pablo-Allard herds). Buffalo Jones was even hired as a park game warden and worked successfully to enhance bison in the park from 1902 to 1905, beginning with the addition of 21 bison purchased from private owners in 1902. These private bison supplemented the remaining 23 wild bison.¹²⁷

¹²² The five herds are McKay-Alloway (Manitoba), Goodnight (Texas), Walking Coyote (Montana), Dupree (South Dakota), and Jones (Kansas). See Coder, *supra* note 29; Dary, *supra* note 29; Garretson, *supra* note 29; and Ken Zontek, Hunt, Capture, Raise, Increase: The People Who Saved the Bison, 15 Great Plains Q. 133 (1995).

¹²³ Allard died before 1900, and Pablo carried on after selling Allard's share.

¹²⁴ Hornaday, *supra* note 1, at 532.

¹²⁵ The combination of hunting and Jones's capture ultimately decimated the bison in the Texas Panhandle.

¹²⁶ Coder, *supra* note 29; and Hanner, *supra* note 43.

¹²⁷ Meagher, Bison of Yellowstone National Park, *supra* note 13, at 17.

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There was no interest group driven by bison conservation until 1905, when the American Bison Society (ABS) was formed in New York City, with William T. Hornaday as its first president. Before this, there was simply no constituency interested in bison conservation. Hide buyers were not concerned because they could just shift to cattle hides. Most politicians were interested in developing the west and saw no gain from conservation. Like many early conservation organizations, the ABS membership was filled with wealthy easterners and included, of course, Theodore Roosevelt. The ABS was important in lobbying for creation of the first federal bison refuges in Montana and Oklahoma, and it raised private funds for the purchase of bison from private owners. The first bison refuge at Wichita Mountains Wildlife Refuge, in southwestern Oklahoma, was stocked with six bulls and nine cows donated by the ABS. Congress appropriated \$ 15,000 to fence 8,000 acres of the refuge in 1906, and the bison arrived in 1907. The Society also raised \$ 10,560 for the purchase of bison for the National Bison Range in Montana (on land formerly part of the Flathead Reservation), which resulted in the delivery of 34 bison in October 1909. Today there are around 20,000 bison in public herds in some 26 government parks and refuges and five preserves owned by the Nature Conservancy. By far the largest of these, and among the few free-ranging herds, is the Yellowstone Park herd, which has recently numbered around 3,000 bison. ¹²⁸ All of these bison, but for the 23 bison left in Yellowstone in 1902, are descendents of the live-captured bison by the likes of Walking Coyote, Goodnight, and Jones.

The Pablo-Allard herd, by far the world's largest in 1906 and thriving at 600 head, had a fate that again illustrates the high cost of bison ownership. In 1906, under its allotment policy, the federal government began to break up the Flathead Reservation by allowing homesteading by Indians and whites. Recognizing that he could not manage his huge bison herd under a subdivided land ownership system, Pablo looked to move or sell his herd. After a deal with the U.S. government collapsed, Pablo sold his entire herd to the Canadian government to establish herds in new parks, including Elk Island National Park in Alberta. Two points are important. First, that Pablo had to get rid of his herd under a homesteading-style land policy is consistent with the analysis of bison ownership costs. Second, the movement of the herd to Canada, which required roundups in six consecutive springs, demonstrated the tremendous costs of handling bison relative to cattle. The bison could not be trailed like cattle to the railroad but ultimately had to be individually captured and hauled overland in special crates one at a time. After some early, limited success at using horses and driving small groups, the "old bulls became so vicious they would charge a rider a quarter of a mile away and they would not permit the female stock to be driven." ¹²⁹ In total, 716 bison were shipped to Canada, but the last two attempts netted just seven bison each, so the effort was abandoned, and many bison remained in Montana, where they perished after the reservation was homesteaded. The ability of Pablo to own a large bison herd was an unusual case in which live capture was coupled with the existence of an Indian reservation with a large contiguous rangeland protected from outsiders.

V. SUMMARY AND DISCUSSION

In this paper, I use economic models of renewable resource exploitation, ownership claiming, and land use to explain the detailed economic history of the American bison. The nineteenth-century data I rely on are, of course, limited compared to the data typically used by modern economists. Still, my findings can be summarized as follows: prior to European settlement, bison were widespread throughout North America and were either ignored because harvesting costs were relatively high or governed by the common-property rights of tribal societies who lived on the Great Plains. In the eastern reaches of the continent, the bison survived until the early 1800s but ultimately vanished, little by little, under open-access hunting by whites and by conversion of their habitat into farms and enclosed pastures. On the northern plains of Canada, the Dakotas, and parts of Montana, the robe market emerged in the early 1800s and lasted until nearly 1880. For well over half a century, relatively constant numbers of bison were killed for robes and shipped east via the Missouri and Red Rivers. This period is best explained by a model of common-property exploitation among the tribes of the area interacting with white robe buyers.

¹²⁸ Taper, Meagher, & Jerde, *supra* note 23.

¹²⁹ Coder, *supra* note 20, at 227.

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The hide trade that developed after 1870 is best understood as open-access exploitation under conditions of rapidly declining harvest costs. Simultaneous with open-access hunting was the rapid conversion of the bison's habitat into farm and ranch land. The coincidence of these two events led to the near extinction of the Great Plains herds. Open access prevailed because white encroachment broke down tribal territories and because wild bison stocks were extremely costly to own. The conversion of the plains into private agricultural land reduced the value of the herds by significantly altering their habitat, thus lowering the net gains to ownership. Had the Great Plains been useful only for bison and had the bison been less nomadic, the hide market might have generated a "reindeer equilibrium" with private or group ownership of bison herds.

By 1890, only those few, small, and scattered bison herds that were too far removed from white settlement remained; essentially they were too costly to find and kill. On a few occasions during the hide-hunting era, wild bison calves were live-captured and reared in confinement, establishing private herds of bison.¹³⁰ Some of the progeny of these captives were later sold to public refuges established in the early twentieth century at the behest of the American Bison Society, which raised funds for their purchase. In the last 50 years, bison numbers have increased dramatically, mostly as private entrepreneurs have established and expanded herds and developed a market for bison and bison products. The costs of fencing and herd monitoring as well as assembly of large contiguous tracts of rangeland are now low enough that private ownership of bison is no longer prohibitive. In effect, the property rights to the bison evolved from common property to open access to, finally, private property.

At the outset, I noted that evidence of bison extermination in the face of rising market value appeared to refute Demsetz. How does Demsetz's famous thesis fare against a detailed history of the bison? The answer depends on the interpretation of Demsetz's theory. Using a narrow interpretation, there is only mixed support for Demsetz. The narrow view of Demsetz's thesis comes from his classic example of the emergence of property rights to beaver after the beaver trade: a rise in (market) value is expected to result in the creation of property rights. Indian tribes did claim and enforce bison hunting territories after horses and robe markets increased their net value. The rapid development of property rights to land for agriculture by whites is also consistent with Demsetz. The rapid demise of the bison, of course, clearly refutes this narrow view of Demsetz.

A broader view of Demsetz's theory, however, is consistent with bison history. Before his discussion of the beaver, Demsetz writes: "It is my thesis . . . that the emergence of new property rights takes place in response to the desires of the interacting persons for adjustment to new benefit-cost possibilities."¹³¹ Once Demsetz's argument is recast, the demise of the bison, even in the presence of a valuable hide market, is consistent with his theory of property rights because the cost of assembling and enforcing property rights to live bison herds seems to have been prohibitive. Bison required very large tracts of land to match their nomadic herding behavior and could not be contained at low cost, at least relative to their close substitute, cattle. These factors limited the private-rights alternative to only a few bison herds assembled for noncommercial reasons. Thus, even the path from common property to open access and to private property supports Demsetz's general thesis that rights respond to economic costs and benefits.

The historical interpretation of the bison not only has escaped economic analysis but has also undergone several phases since Hornaday. Hornaday blamed much of the extermination on the wasteful practices of Indians (such as killing cows for robes and meat) and lamented that cattlemen had not domesticated the bison. Twentieth-century writers such as Roe, and especially those less careful scholars, have foisted blame solely on white hide hunters and cattlemen and mostly exonerated the Plains Indians. In the last decade, though, the tide has turned again, so that the current revised history of the bison is a story of exploitative markets, tempered by ecological forces and

¹³⁰ Once these herds were thought to be pureblood bison, but recent DNA tests indicate that most of the descendents of these bison have some cattle genes since they were often raised in proximity to cattle and some interbreeding occurred (Mark Derr, Genetically, Bison Don't Measure up to Frontier Ancestors, N.Y. Times, April 23, 2002, at F2). Because private bison rearers will face different selection criterion than do park managers, it is also expected that bison genetics will change over time. These facts suggest a difficulty for private preservation of genetic diversity.

¹³¹ Demsetz, *supra* note 4, at 350.

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tainted Indians. This new history says that Indians were sometimes just as wasteful as whites and that drought, disease, and hard winters contributed to the bison's demise. There is little evidence, however, for major long-run population impacts from local ecological forces. ¹³²

Lamenting the removal of some 20 million bison from the Great Plains, as even the new historians are wont to do, severely ignores the costs of the alternatives. The bison's near demise, at its heart, is just another case of an agricultural culture defeating a hunter-gatherer culture. ¹³³ Now these modern agricultural-industrial societies are so rich that they spend substantial resources on the protection of wild species, even those as incompatible as the nomadic bison. Still, the fate of the bison is best summarized by a historian of the early twentieth century: "In mourning the loss of that which is gone, there is oftentimes, and especially in this instance, no thought of wishing those things back again, only that the manner of their going might be changed. That the twentieth century America might exist the buffalo and the Indian had to go, but there will always remain a sense of shame that the instincts of greed and wanton destruction were uppermost in their extermination." ¹³⁴

APPENDIX

TABLE A1

DOCUMENTED LIVE CAPTURE OF WILD BISON

Date	Location	Number	Captor
1873-74	Red River Valley, Dakota	3	Alloway
1873	Milk River, Montana	4	Walking Coyote
1878	Panhandle, Texas	3	Charles Goodnight
1882	Montana	6	Frederick Dupree
1882	Black Hills, Dakota	2	Sioux Indians
1885	Panhandle, Texas	6	C. J. Jones
1885	Western Nebraska	4	H. R. Jackett
1886	Western Dakota	1	B. C. Winston
1886	Panhandle, Texas	7	C. J. Jones
1887	Panhandle, Texas	30	C. J. Jones
1888	Panhandle, Texas	18	C. J. Jones

NOTE.--See Martin S. Garretson, *The American Bison* (1938); William T.

Hornaday, *The Extermination of the American Bison, with a Sketch of Its
Discovery and Life History* (1889); Andrew C. Isenberg, *The Destruction of
the Bison: An Environmental History, 1750-1920* (2000).

¹³² Diamond, *supra* note 59, is critical of this thesis generally, and Mary Meagher (interview, July 23, 2001), is critical of its application to bison. The evidence for this is not compelling because it does not tightly link a large local event to long-term population trends. There is considerable agreement, though, that the general climate warming with the end of the Little Ice Age (roughly 1450-1850) was already beginning to shrink the bison's habitat (McDonald, *supra* note 13, at 1981).

¹³³ Diamond, *supra* note 59.

¹³⁴ Merrill G. Burlingame, *The Buffalo in Trade and Commerce*, 3 North Dakota Hist. Q. 262, 290 (1929).

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TABLE A2
CAPTIVE BISON POPULATIONS, 1877-1901

Location	Date	Number	Owner
Manitoba	1877	10	S. L. Bedson a, b
Philadelphia	1877	10	Zoological Societies Gardens
Manitoba	1880	8	Colonel Samuel Bedson a
Montana	1884	39	Charles Allard a
Manitoba	1888	97	S. L. Bedson a
Flathead Indian Reservation	1888	35	Charles Allard a
Washington	1888	18	W. F. Cody (Buffalo Bill)
Clarendon, Texas	1888	13	Charles Goodnight a
Bismarck Grove, Kansas	1888	10	Santa Fe Railroad Co.
Fort Bennett, Dakota	1888	9	Frederick Dupree a
Lincoln Park, Chicago	1888	7	W. P. Walker
Cincinnati, Ohio	1888	4	Zoological Societies Gardens
Rapid City, Dakota	1888	5	V. T. McGillicuddy
New York	1888	4	W. A. Conklin
New York	1888	4	John Starin
Washington, D.C.	1888	4	U.S. National Museum
Hamlin, Minnesota	1888	2	B. C. Winston
Colorado, Texas	1888	2	I. P. Butler
Miles City, Montana	1888	1	Jesse Huston
Bellwood, Oregon	1888	1	L. F. Gardner
Mandan, Dakota	1888	2	Riverside Ranch Company
Optima, Indian Territory	1888	2	James R. Hitch
Estell, Nebraska	1888	1	Joseph Hudson
Kansas	1889	56	Buffalo Jones
St. Ignatius, Montana	1896	300	Charles Allard a
Jackson, Wyoming	1897	13	William Whitney
South Dakota	1901	57	Frederick Dupree

SOURCES.--Martin S. Garretson, *The American Bison* (1938); William T.

Hornaday, *The Extermination of the American Bison, with a Sketch of Its Discovery and Life History* (1889); Andrew C. Isenberg, *The Destruction of*

the Bison: An Environmental History, 1750-1920 (2000).

a Foundation herd.

b Bedson purchased the McKay-Alloway herd (George D. Coder, *The National Movement to Preserve the American Buffalo in the United States and Canada between 1880 and 1920*, at 5, 6 (unpublished Ph.D dissertation, Ohio State Univ. 1975)).

Graphic

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FIGURE 1, Geography of the Great Plains; FIGURE 2, Bison population dynamics: $F(x) = .2x - (.008)x^2$; FIGURE
3, Steady-state harvest and stock

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