Contributed Paper

The Late Prehistoric–Early Historic Game Sink in the Northwestern United States

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Abstract: *Historical data provide valuable information on ecosystem structure, function, and processes. The number of big game killed by the Corps of Discovery in 1805–1806 and recorded by Lewis and Clark suggests that ungulates were abundant in central and eastern Montana and rare in western Montana, central Idaho, and southeastern Washington during the early nineteenth century. Paleoecologists Paul Martin and Chris Szuter conclude that this difference was a function of human predation. They support their conclusion that ungulates would have been abundant in southeastern Washington had humans not hunted them by arguing that the nineteenth-century livestock industry was successful without supplemental feeding. The livestock industry was, however, not consistently successful until artificial feeding was initiated. Archaeological data from eastern Washington indicate that ungulates have been taken by human hunters more frequently than small-mammal prey throughout the last 10,000 years and that ungulates decreased relative to small mammals coincident with changes in climate. Bison (*Bison bison*) and elk (*Cervus canadensis*) were present in eastern Washington throughout the Holocene, but bison were abundant there only during a cooler and moister period; elk have been abundant only in the twentieth century, subsequent to transplants and the extermination of predators. Geographic variation in the abundance of bison across Montana, Idaho, and eastern Washington has been influenced by human predation but has also been influenced by biogeographic history, habitat differences, and climatic change.*

El Sumidero de Especies de Caza del Prehistórico Tardío/Histórico Temprano del Noroeste de los Estados Unidos

Resumen: *Los datos históricos proveen información valiosa sobre las estructuras de los ecosistemas, sus funciones y procesos. El número de animales de caza grandes que fueron sacrificados por las tropas de descubrimiento en 1805-1806 y registradas por Lewis y Clark sugieren que los ungulados eran abundantes en Montana central y oriental y raros en Montana occidental, Idaho central y el sudeste de Washington durante los inicios del siglo diecinueve. Los paleontólogos Paul Martin y Chris Szuter concluyen que esta diferencia fue causada por la depredación humana. Ellos apoyan su conclusión de que los ungulados podrían haber sido abundantes en el sudeste de Washington si los humanos no los hubieran cazado argumentando que la industria de la ganadería del siglo diecinueve exitosa sin alimento suplementario. Sin embargo, la industria de la ganadería no fue consistentemente exitosa hasta que se inició la alimentación artificial. Los datos arqueológicos de Washington oriental indican que los ungulados fueron eliminados por los cazadores humanos mas frecuentemente que las presas pequeñas de mamíferos a lo largo de los últimos 10,000 años y que la disminución de ungulados, relativa a la de mamíferos pequeños coincidió con cambios en el clima. El bisonte (*Bison bison*) y el alce (*Cervus canadiensis*) estuvieron presentes en Washington oriental a lo largo del Holoceno, pero los bisontes fueron abundantes solo durante un periodo mas frío y húmedo; los alces habían sido abundantes solo en el siglo veinte subsecuente a los transplantes y a la exterminación de los depredadores. La variación en la abundancia de alces a lo largo de Montana, Idaho y el oriente de Washington estuvo influenciada por la depredación humana, pero también por la historia biogeográfica, las diferencias en hábitat y el cambio climático.*

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Paper submitted February 18, 2000; revised manuscript accepted March 28, 2001.

Introduction

Ecologists and conservation biologists recognize the value of historic data for understanding the structure, function, and processes of ecosystems (Meine 1999). Early historic documents describing the flora and fauna of an area help explain the appearance of modern ecosystems and why these biotas are not often good reflections of their pre-Euroamerican settlement condition. Efforts to reconstruct early historic ecosystems on the basis of historical data are valuable, but are fraught with difficulty. We evaluated a recent example of such an effort to underscore some of the difficulties.

In an attempt to characterize early historic ecosystems, paleoecologists Paul Martin and Christine Szuter (1999*a*, 1999*b*) refer to ethnohistorian Harold Hickerson's (1965:43) concept of an intertribal "buffer zone," an area he characterizes as "contested territory on the frontiers between tribes which, except for communal [game] drives, was normally unoccupied." Martin and Szuter argue that records of big game killed by the Corps of Discovery led by Meriwether Lewis and William Clark (1804–1806) indicate that a kind of buffer zone (a "war zone") where large game was abundant existed between approximately the Montana–North Dakota border on the east and west-central Montana on the west. They further suggest that a "game sink" where big game was scarce existed between west-central Montana and central Washington (Fig. 1). Martin and Szuter conclude that big game was abundant in the war zone because it was largely free from year-round hunting by Native Americans, whereas big game was scarce in the game sink because of continuous human predation. They offer this interpretation as an alternative to the more typical ones that local game abundances "reflect the changing productivity of the habitat" (Martin & Szuter 1999*b*:38) and that humans who occupied North America prior to its colonization by Europeans conserved, either intentionally or incidentally, local game populations (Todd & Elmore 1997).

Martin and Szuter conclude that, were it not for human hunting in southeastern Washington and central Idaho (the game sink), ungulates would have been abundant—perhaps as abundant as they were in the war zone of Montana—in 1805–1806 when the Corps of Discovery passed through the area. This conclusion assumes much about the prehistoric abundances of ungulates. If Martin and Szuter are correct, then within the game sink ungulates were abundant some time after the initial arrival of humans about 11,000 B.P. (Ames et al. 1998), and at some time subsequent to that arrival ungulates became less abundant as a result of human predation rather than, say, environmental change. Similarly, within the war zone ungulates should have been abundant when humans first arrived, should subsequently have been depressed as a result of human predation, and finally should have increased coincident with the formation of the war zone. As part of the basis for drawing the conclusion they do, Martin and Szuter refer to the history of the livestock industry in eastern Washington and argue that, because domestic ungulates survived there in abundance during the late nineteenth century, wild ungulates would have survived there in abundance were it not for hunting.

We evaluate Martin and Szuter's "war zone and game sink" hypothesis in three ways. First, we reexamine Lewis and Clark's data and suggest that abundances of ungulates were varied within Martin and Szuter's war zone and game sink and that the border between these areas is neither abrupt nor obvious. Second, we suggest that the livestock industry was not completely successful until supplemental winter feeding was initiated. Third, we present archaeological evidence suggesting that ungulate abundances in the game sink did not change in the manner or at the time presumed by Martin and Szuter's model. Finally, we briefly review traditional ex-

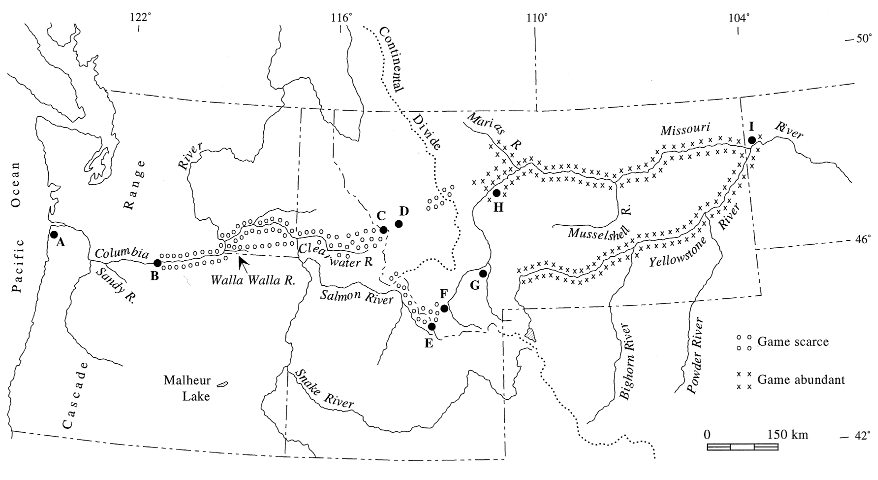

*Figure 1. Martin and Szuter's (1999*b*) model of a war zone where game was abundant in Montana and a game sink where game was scarce in western Montana, central Idaho, and southeastern Washington; A, Fort Clatsop; B, Celilo Falls; C, Lolo Pass; D, Traveler's Rest; E, Lemhi Pass; F, Camp Fortunate; G, Three Forks; H, Great Falls; I, Williston.*

planations for the rarity of certain big-game taxa in the game sink and conclude with a description of an alternative model that accounts for several diverse sets of data.

Historical Data

Historical documents such as the journals kept by Lewis and Clark are sources of data that must be evaluated for their accuracy and thoroughness (Wood 1990), particularly the ecological data they contain (Forman & Russell 1983). For example, Lewis's daily journal and Clark's daily journal often echo each other with respect to the number of deer (*Odocoileus* sp.) and bison (*Bison bison*) killed on a given day (Moulton 1983–1997), but the two authors do not comprise independent checks of each other. Martin and Szuter present a tabulation of Lewis and Clark's records, an abbreviated version of which is given in Table 1. One way to check the validity of that tabulation as a reflection of big-game abundance is to consult other historical documents to determine whether contemporary observers reported similar abundances and scarcities of game in the same areas.

Martin and Szuter reviewed a large number of early-nineteenth-century journals kept by various explorers. All of those documents "postdate the onset of significant biocultural change triggered by Eurasian diseases, guns, horses, and so forth, the legacy of Columbian contact" (Martin & Szuter 1999*a*:190). Horses first appeared in the area in the late 1600s or early 1700s (Haines 1938). Eurasian diseases began to rapidly decimate resident human populations at about the same time (Hunn 1991). Firearms reached the area less than a century later (Walker & Sprague 1998). The appearance of horses and firearms may have contributed to the early-nineteenth-century scarcity of large game in the game sink, because these items made native people more efficient hunters (Turney-High 1937; Christman 1971; Schalk & Cleveland 1983). The precise timing of such appearances is critical to testing these hypotheses, but requisite data are not available. For example, remains of both horses and firearms in late prehistoric–early historic archaeological contexts in eastern Washington and central Idaho are extremely rare.

Martin and Szuter are not explicit about the timing of the formation of the game sink or of the war zone, although it seems reasonable to assume that the acquisition of the horse and/or of firearms, if not the primary catalyst, would have exacerbated the formation of the war zone and the game sink. Given the age of the historic documents Martin and Szuter used and the nature of their arguments, we assumed that both the war zone and the game sink took their early-nineteenth-century forms (as indicated by Lewis and Clark's journals) early in the eighteenth century.

Lewis and Clark's journals indicate that horses and firearms were present among native peoples in the northwest in 1805–1806 and that diseases had reduced the human population throughout the area. Martin and Szuter (1999*a*) imply that because disease had already decimated the human population of the lower Columbia River, elk (*Cervus canadensis*) were more abundant there than in the game sink of eastern Washington. For example, they state that near Fort Clatsop, where Lewis and Clark spent the winter of 1805–1806, the captains "found elk numerous, at least until spring when the animals retreated inland. Sergeant Gass [a member of the Corps] calculated that between December 1, 1805, and March 20, 1806, the party's hunters bagged 131 elk and 20 deer" (Martin & Szuter 1999*a*:195). Lewis and Clark's journals indicate, however, that 124 elk and 14 deer were taken during this period, a perhaps insignificant difference until one compares Gass's numbers with the numbers of game animals killed in other areas.

Because the data in Table 1 (Martin & Szuter's [1999*a*] Table 2) do not seem to coincide with the map in Fig. 1,

Table 1. Game killed by the Corps of Discovery, as summarized by Martin and Szuter (1999*b*, Table 2).

	Upper Missouri River 25 Apr–13 Jul[a]	*Columbia River 18 Sep–6 Nov*[b]	*Columbia River 23 Mar–11 May*[b]	*Yellowstone River and Upper Missouri River 30 Jun–18 Aug*[a]
Deer	79	28	38	191
Elk	50	0	22	51
Bison	44[c]	0	0	55
Pronghorn	8	0	0	9
Bear	12	0	1	12
No. of individuals	193	28	61	318
No. of days	80	50	50	50
Individuals/day	2.4	0.56	1.2	6.4
Season	spring-summer	fall	spring	summer

[a] *Game abundant according to Martin and Sxuter.*
[b] *Game scarce according to Martin and Szuter.*
[c] *Seven calves not included by Martin and Szuter.*

we examined Lewis and Clark's journals (Moulton 1983–1997) and tallied the number of days spent in particular areas and the number of individuals in each taxon of big game killed in each area. We did this for the entire route on both the westbound leg and the eastbound leg, between Williston, North Dakota, and Fort Clatsop, Oregon. Occasionally Lewis or Clark reports that "4 deer were killed" on a particular day, whereas the other reports "3 deer" for that day; in all cases we used the smaller number. The few times they report that "several" animals were killed, we used one as a conservative estimate (using two did not change our results).

Reanalysis of Game Killed by the Corps of Discovery

For four reasons, we believe the data in Table 1 are invalid for identifying the borders of the game sink and war zone (Fig. 1). First, the tallies include days spent and animals killed west of Celilo Falls for both the westbound leg (29 October–6 November 1805) and eastbound leg (23 March–14 April 1806) of the journey along the Columbia River. Second, the tallies exclude days spent and game killed in eastern Idaho on both legs of the journey (14–17 September 1805 and 12 May–29 June 1806). Third, the tallies do not include all days spent or game killed in west-central Montana during the westbound leg (14 July–13 September 1805). Finally, the tallies include game taken during 10 days when the corps was east of the "war zone"; that date should be no later than 8 August 1806. The data in Table 1 have little direct relation to Fig. 1; the ground covered during the dates listed in the table is not the same as the ground depicted in the war zone or in the game sink on the figure.

Our summary of Lewis and Clark's data (Table 2) permit (1) calculation of game animals killed per day with fine-scale spatial resolution; (2) examination of variation in game abundance within (as opposed to only between) the war zone and the game sink (Table 1; Fig. 1); (3) examination of game abundances within the border area between the war zone and the game sink; and (4) comparison of game abundances in an area of western Washington not included in the game sink or a war zone. We were interested in the abruptness of the border between the war zone and game sink during the historical period, in the variation in abundances of ungulate taxa within each area, and in how many ungulates differentiate a game sink from a war zone. To make these determinations, we calculated game-killed-per-day ratios from Table 2, first following Martin and Szuter's procedure of excluding bighorn (*Ovis canadensis*) and then including them (Table 3). We then classified the journey segments in increments of 1 game animal per day (classes were 0–1.0 per day; 1.1–2.0 per day; 2.1–3.0 per day; 3.1–4.0 per day; 4.1–5.0 per day; and >5.1 per day).

Our data indicate that the vicinity of the central Idaho-Montana border was a transition zone between a game-rich area to the east and a relatively game-poor area to the west (Fig. 2). Second, the game-killed-per-day ratios were, with one exception (Table 3), higher for the eastbound segments than for the same westbound segments of the Corps of Discovery's journey; the exception is in the transition zone between Montana and Idaho (Camp Fortunate to Lemhi Pass to Lolo Pass versus Traveler's Rest to Camp Fortunate). Third, the ratios varied from a low of zero in eastern Washington to over 12 along the Upper Missouri River. Our data suggest a great deal of variation in game abundance within the war zone, which coincides with observations of Lewis and Clark. During the westbound leg of their journey, when the Corps was between the mouths of the Musselshell and Marias rivers (the heart of the war zone), Lewis noted on 24 May 1805 that "game is becoming more scerce," and the following day he wrote that "buffalow are now scarce."

The variation evident in the abundances of game animals killed across the area mapped (Fig. 2) begs the question of whether those abundances reflect the abundance of game animals on the landscape. Martin and Szuter assume they do, but we believe that in at least some cases they do not. One example is the high number of game animals killed per day in the vicinity of Traveler's Rest east of Lolo Pass. On the east-bound leg of their journey, the corps devoted three days to intensive hunting to procure meat for their forthcoming trip (south to Camp Fortunate) through an area where they had found little game the previous fall. Another example is that in western Oregon adjacent to the Sandy River the corps hunted for 7 days (31 March–6 April 1806), again attempting to procure a surplus of meat for their journey eastward. Generally, search time is inversely related to prey abundance, but the relationship is not perfect (Pianka 1978). Further, Lewis and Clark's journals are typically ambiguous with respect to amount of search time. Therefore, in our view the ratios mapped in Fig. 2 are not fine-scale measures of the abundance of big game on the landscape. The general difference between ungulate abundances east and west of the Continental Divide is, however, of sufficiently coarse scale to warrant consideration.

The number of big-game animals killed per day in southwestern Washington and northwestern Oregon suggests that the game sink was not restricted to eastern Washington and central Idaho (Fig. 1). After leaving Celilo Falls and heading west, members of the Corps subsisted on waterfowl, fresh fish, and dried fish obtained at the falls. On 10 November 1805 Clark wrote that the men had "nothing to eate but dried fish pounded which we brought from the falls." On 28 November he added

Table 2. Game killed by the Corps of Discovery, as reported by Lewis and Clark.[a]

Location, dates	*Bison*	*Elk*	*Deer*	*Bighorn*	*Pronghorn*	*Bear*
Westbound						
Williston, North Dakota to Musselshell River, 25 April–20 May 1805	19	15	35		4	6
Musselshell River to Marias River, 21 May–12 June 1805	17	32	43	9	3	8
at Great Falls, Montana, 13 June–13 July 1805	56	15	32		11	7
Great Falls to Three Forks, Montana, 14–25 July 1805	1	9	15		4	
Three Forks to Camp Fortunate, 26 July–24 August 1805		8	78	1	9	2
Camp Fortunate to Lolo Pass, 25 August–13 September 1805		1	29			2
Lolo Pass to Clearwater River mouth, 14 September–10 October 1805			6			
Clearwater River mouth to Snake River mouth, 11–17 October 1805			no game killed			
Snake River mouth to Celilo Falls, 18–23 October 1805			no game killed			
Celilo Falls to Beacon Rock, 24 October–2 November 1805			12			
Beacon Rock to Grays River, 3–8 November 1805			1			
Columbia River mouth, 9 November–7 December 1805		13	26			
Fort Clatsop, 8 December 1805–23 March 1806		114	9			
Eastbound						
Fort Clatsop to Vancouver, 24–30 March 1806			10			
at Sandy River, 31 March–6 April 1806		14	12			1
Sandy River to Celilo Falls, 6–19 April 1806			13			
Celilo Falls to Walla Walla River mouth, 20–30 April 1806			no game killed			
Walla Walla River mouth to Clearwater River mouth, 1–4 May 1806			2			
Clearwater River mouth to Lolo Pass, 5 May–29 June 1806			75			13
at Traveler's Rest, 30 June–2 July 1806			30			
Clark[b] (to, then down, Yellowstone River)						
Traveler's Rest to Camp Fortunate, 3–10 July 1806			9		1	
Camp Fortunate to Three Forks, 11–13 July 1806			12			1
Three Forks to mouth of Bighorn River, 14–25 July 1806	10	10	15		1	2
Bighorn River mouth to Williston, 26 July–4 August 1806	14	5	10	3	3	1
Lewis[c] (to, then down, upper Missouri River)						
Traveler's Rest to Great Falls, 3–17 July 1806	14	3	22		2	1
on Marias River, 18–28 July 1806	3		10		2	
mouth of Marias River to mouth of Musselshell River, 29 July–1 August 1806	2	17	18	20		3
mouth of Musselshell River to Williston, 2–8 August 1806	8	5	39			3

[a]*Bison (*Bison bison*); elk (*Cervus canadensis*); deer (*Odocoileus hemionus and O. virginianus*); bighorn (*Ovis canadensis*); pronghorn (*Antilocapra americana*); bear (*Ursus americanus and U. arctos*).*
[b]*Recorded by Clark; to, then down, Yellowstone River.*
[c]*Recorded by Lewis; to, then down, Upper Missouri River.*

Table 3. Ratio of game killed per day by the Corps of Discovery (based on Table 2).

Location	*No. of animals killed per day*[a]
Westbound	
Williston to Musselshell River	3.0
Musselshell River to Marias River	4.5 (4.9)
at Great Falls	3.9
Great Falls to Three Forks	2.4
Three Forks to Camp Fortunate	3.1 (3.2)
Camp Fortunate to Lolo Pass	1.6
Lolo Pass to Clearwater River mouth	0.2
Clearwater River mouth to Snake River mouth	0
Snake River mouth to Celilo Falls	0
Celilo Falls to Beacon Rock	1.2
Beacon Rock to Grays River	0.1
at Columbia River mouth	1.3
at Fort Clatsop	1.2
Eastbound	
Fort Clatsop to Vancouver	1.4
at Sandy River	3.9
Sandy River to Celilo Falls	0.9
Celilo Falls to Walla Walla River mouth	0
Walla Walla River mouth to Clearwater River mouth	0.5
Clearwater River mouth to Lolo Pass	1.6
at Traveler's Rest	10.0
Traveler's Rest to Camp Fortunate[b]	1.2
Camp Fortunate to Three Forks[b]	4.3
Three Forks to Bighorn River mouth[b]	3.2
Bighorn River mouth to Williston[b]	3.0 (3.3)
Traveler's Rest to Great Falls[c]	2.8
on Marias River[c]	1.4
Marias River mouth to Musselshell River mouth[c]	13.3 (20.0)
Musselshell River mouth to Williston[c]	7.9

[a]*Ratios based on number of bison, elk, deer, pronghorn, and bear; ratios in parentheses include bighorn.*
[b]*Recorded by Clark; to, then down, Yellowstone River.*
[c]*Recorded by Lewis; to, then down, Upper Missouri River.*

that because they could find no deer their situation was "truly disagreeable." On 8 January 1806 Lewis stated that "Our meat is beginning to become scarse." Just prior to leaving Fort Clatsop, Clark remarked that "we have not fared Sumptuously this winter & Spring" (20 March 1806) but that "we were never one day without 3 meals of Some kind a day either pore elk meat or roots" (23 March 1806). Buechner (1953:161) states that the Corps "began the return trip rather than risk starvation while waiting for the appearance of a ship in April." We find this curious in light of Lewis and Clark's knowledge that they were headed into the game sink, save for one telling point.

Martin and Szuter suggest that big game was abundant around Fort Clatsop, in part because the population of resident Native Americans had been decimated by European diseases to a greater degree than human populations in the game sink. The numbers of big game killed per day in southwestern Washington and northwestern Oregon were, however, no greater than those numbers in the game sink of southeastern Washington and central Idaho (Fig. 2). Similarly, the number of big game killed per day by Lewis and a portion of the corps when eastbound between Camp Fortunate and Three Forks (part of the game sink) was no different than the number killed by Clark and the other portion of the corps when eastbound along the Yellowstone River (part of the war zone). These observations beg the question of how rare big game must be to characterize a piece of the landscape as a game sink or as a war zone. Without an explicit answer, any boundaries drawn around such areas are debatable.

The Game Sink

Martin and Szuter (1999*b*:40) suggest that members of the Corps of Discovery were "unable to find enough game in the vast game sink of the Columbia Basin" of southeastern Washington to feed themselves. They find this curious in light of (1) the abundance of horses held by Native Americans west of the Rockies (p. 41), (2) "the astonishing growth of the cattle industry in the Northwest from 1855 to 1885 under year-round [open-range] grazing without supplementation" (p. 42), and (3) ethnohistoric data indicating bison could survive "west of the Rockies" in habitats characterized as "sage-brush grass steppe" (p. 42). They use each point to help justify their conclusion that human predation caused the game sink, but each is debatable.

First, data collected in 1874 on the numbers of horses held by Native American ethnic groups (Ewers 1955) indicate that horses were much more abundant in the game sink than in the war zone. The reasons for this are two. Some human groups castrated males and selectively bred horses (Osborne 1955), thereby producing a locally hardy breed. Second, even in areas of harsh winters such as in west-central Idaho, the topography was so marked that snowfall was not a limiting factor in deep valleys into which horses were driven by local peoples during winter months. In such locations snow depth was not great and feed was easily accessible to horses (Slickpoo & Walker 1973). Artificial feeding was unnecessary here (Gulick 1981), whereas it was necessary in Montana (Osborn 1983). Horses are therefore not a good proxy indicator of the potential existence or abundance of bison in either the game sink or the war zone.

Second, Van Vuren (1987:66) argues that the "assumption that bison and livestock are ecologically similar is probably invalid." Research on the diet of modern range cattle, feral horses, domestic sheep, deer, bison, and pronghorn (*Antilocapra americana*) suggests that the assumption is not warranted (e.g., Hanley & Hanley 1982; Van Vuren & Bray 1983). Martin and Szuter were arguing that if cattle could find sufficient feed to survive in the Northwest, then so could bison. Oliphant (1947: 236) noted that in Oregon and Washington "winter was the enemy that gave the cattleman no quarter; it was the only foeman that periodically brought him to his knees." Furthermore, "the history of the range-cattle industry in the Pacific Northwest reveals the fact of heavy, almost continuous, winter losses extending over a long period" (Oliphant 1932:5). Between 1860 and 1890, "in one area or another of the Pacific Northwest severe weather. . . frequently inflicted considerable damage upon the herds of some cattlemen, but within these thirty years only three winters—those of 1861–1862, 1880–1881, and 1889–1890—were generally severe and in their effect utterly devastating" (Oliphant 1947:236). The number of cattle that died is not recorded, but estimates provided for the winter of 1880–1881 were published at the time: "the losses of cattle during the winter were 83 percent in Yakima Valley [northwest of the mouth of the Snake River], 78 in Klickitat County [adjacent to and west of the mouth of the Snake River]. . .and 55 in Walla Walla County [adjacent to and east of the mouth of the Snake River]" (Oliphant 1946:30). Each winter catastrophe prompted people to argue that supplemental feeding in winter should become a regular part of the local livestock industry. Part of the catalyst for the prompting resided in the stench: "The decaying bodies of cattle polluted the air of the Walla Walla Valley" during the spring of 1862 after cattle had "literally died by the thousands" (Oliphant 1932:8–9).

This situation suggests why the fact that bison can survive in shrub-steppe habitats is no indication that they should be consistently found in abundance there. Occasional severe winters producing snowfall too deep to be displaced by foraging bison may result in local extirpation (Daubenmire 1985). Furthermore, herbaceous biomass production in the steppe habitats of the game sink is today half as much as that in the war zone (Van Vuren 1987). Finally, suitable bison habitat was discontinuously distributed in the game sink but was continuously distributed in the war zone (Van Vuren 1987), making recruitment via immigration more probable in the latter area than in the former.

That elk have historically reoccupied the shrub-steppe of south-central Washington is called on by Martin and Szuter (1999*b*:42) to support their contention that this species would have been abundant along the lower Snake and Columbia rivers in 1805–1806 had they not been hunted by indigenous peoples. The modern abundance of elk is not, however, only the result of the absence of human predators. The transplanting of elk in the 1910s and 1920s to the adjacent mountains to the west (Couch 1935; Buechner 1953), the decimation of resident populations of carnivorous mammals such as wolves (*Canis*

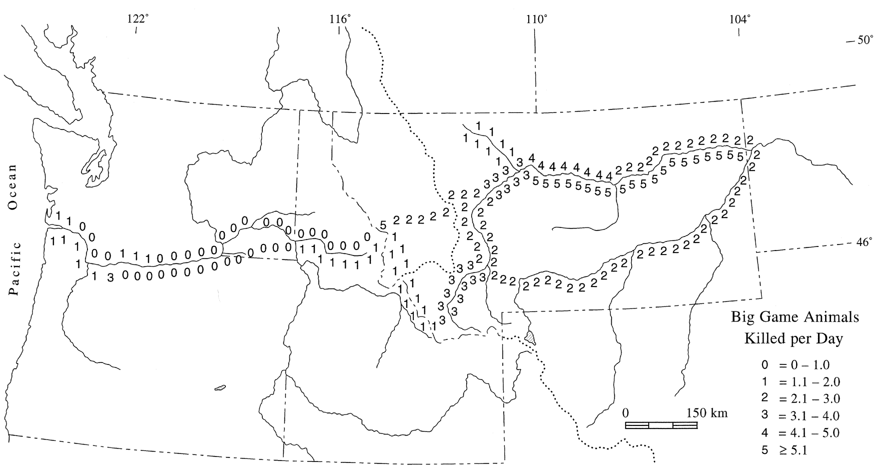

Figure 2. Number of game animals killed per day by the Corps of Discovery (from Table 3). Numbers on north side of river refer to the westbound leg of the journey; numbers on the south side refer to the eastbound leg.

lupus) and cougars (*Felis concolor*) early in the twentieth century (Booth 1947; Dalquest 1948), and the isolation of the area colonized by elk relative to areas of human settlement (Rickard et al. 1977) also seem to have contributed to the growth of the local elk population. Artificially induced changes in wildfire regimes in the twentieth century also may have influenced the movement of elk out of the progressively more closed forests of the southern Cascades and into more open-steppe habitats (Harpole & Lyman 1999 and references therein). We have no doubt that prehistoric human predation contributed to the depression of the elk and bison populations within the game sink. What we doubt is that those and other ungulate taxa would have been as abundant in the game sink as they apparently were in the war zone had human predation not taken place in the game sink.

There are difficulties with interpreting the historical data mustered by Martin and Szuter in support of what they take to be the cause of the game sink and the war zone. Our reanalysis of some of these data suggests that ungulates were less abundant in eastern Washington, Idaho, and western Montana than they were in central and eastern Montana, but the transition in abundance across space was not abrupt, and game abundance in either the game sink or the war zone was not homogeneous. We have not invalidated Martin and Szuter's conclusion with respect to game abundances. We turn next to archaeological evidence to evaluate their suggestion that the cause of those abundances in the game sink was solely human predation.

Archaeological Data

Because humans first occupied the game sink about 11,000 B.P., Martin and Szuter's suggested cause of game scarcity requires that the abundance of ungulates there decreased sometime after this date, perhaps in the eighteenth century. Archaeological data allowed us to test this suggestion. It is important to note that the local human population (the number of predators) seems to have been stable after 9000 B.P., and the only significant reduction took place in the eighteenth century when Eurasian diseases decimated the human population (Chatters 1995; Ames et al. 1998).

We tallied the number of identified specimens of bones and teeth (NISP, hereafter) per taxon recovered from archaeological sites within the game sink along or closely adjacent to the routes taken by the Corps of Discovery. To control for the fact that some faunal specimens deposited in those sites may not represent remains of human meals (Lyman 1994), we did two things. In some cases we used the distinctions of humanly deposited and naturally deposited faunal remains made by the original analysts. In cases where such distinctions were not made by the original analyst, we assigned remains of taxa often thought to be naturally deposited to that category; remains of taxa typically thought to be humanly deposited were so designated. Remains of lagomorphs, beaver, muskrat, porcupine, marmots, mustelids, felids, canids, ursids, and artiodactyls were considered humanly deposited; remains of all small rodents such as mice, chipmunks, gophers, moles, and squirrels were considered naturally deposited. We excluded from analysis remains of naturally deposited taxa. We grouped humanly deposited taxa into three categories: ungulates, carnivores, and small mammals. Carnivores were often exploited as a source of fur, but were occasionally part of the human diet. We included them in our analysis to avoid the problem of closed arrays. We examined temporal changes in the abundance of ungulates in a portion of the game sink before turning to a comparison of the game sink and the war zone.

Temporal Dimension of the Game Sink

Along the Lower Snake River between its mouth and the Washington-Idaho border, ungulate remains outnumbered those of small mammals during each 2,000-year period between 10,000 and 100 B.P. (Fig. 3). The sample dating between 10,000 and 8000 B.P. was too small to be trustworthy (NISP = 103), so we did not consider it further. The NISP was >250 for all other temporal periods. Changes in the relative abundance of ungulates at 6000, 4000, and 2000 B.P. were each statistically significant (arcsin transformation test [Sokal & Rohlf 1969], $p < 0.05$). We suspect that the decrease in ungulates at 6000 B.P. reflects the aridity that existed between 8000 and 4500 B.P. (Chatters 1998). The increase in ungulate abundance after 4000 B.P. reflects cooler temperatures and increased moisture between 4500 and 2000 B.P. After that, climate was a bit drier and warmer, approximating modern conditions (Chatters 1995, 1998). The decrease in ungulate remains after 2000 B.P. may confirm Martin and Szuter's conclusion, given that it is a time-averaged sample. If the creation of the game sink coincides with the introduction of horses and firearms in the early eighteenth century, then such a time-averaged sample may falsely suggest that ungulates decreased 2000 years earlier. It is therefore important to note that <5% of the remains comprising the 2000–100 B.P. sample were younger than 200 years. It therefore seems likely that local climate, which became modern about 2000 B.P., and coincident changes in local productivity caused that shift in the abundance of prey species.

Similarly, increased pronghorn remains relative to the remains of other ungulate taxa between 6000 and 4000 B.P. in archaeological sites in southeastern Washington (Table 4) reflect the influence of the period of relatively greater warmth and aridity between about 8000 and

4500 B.P. Furthermore, bison remains were most abundant between 4000 and 2000 B.P., coincident with a climate cooler and moister than present conditions (Chatters 1995). After 2000 B.P., bison remains decreased in abundance coincident with the onset of modern climatic conditions. The correlation of shifting pronghorn and bison abundance with fluctuations in climate suggests that the decrease in ungulate abundance relative to that of small mammals after 2000 B.P. (Fig. 3) reflects climatically depressed ungulate populations.

No sites containing abundant bison remains (representing fewer than two individuals) and older than about 2000 years or younger than about 1500 years are known in eastern Washington, although their remains have been found in nearly all stratigraphic contexts spanning the last 10,000 years. Bison seem to have been most abundant in southeastern Washington at a time when climate and vegetation were more conducive to bison productivity than they are today. The drop in bison abundance after 2000 B.P. does not seem to be a function of human exploitation; the only robust test of prehistoric hunting intensity demands mortality data (Lyman 1987) that are not available. During the last 10,000 years, bison were never as abundant in southeastern Washington as they were in Montana in 1805. The same holds true for elk (Dixon & Lyman 1996). Elk remains do not outnumber remains of all other ungulate taxa at any time during the last 10,000 years (Table 4). These observations suggest that the local elk and bison populations (and other ungulate taxa) were not large enough to be depressed by human predation to the magnitude implied by Martin and Szuter. In short, human hunting was not the only or even the major cause of the game sink. We have not compiled similar data on ungulate abundances during the last 10,000 years within the war zone because, as with that in eastern Washington, much of it is unpublished. Published data from westernmost North Dakota, however, suggest similar responses of mammals to climatic changes (Semken & Falk 1987).

The Geographic Dimension

Martin and Szuter's argument implies that ungulates should consistently outnumber small-mammal prey in the war zone and that small-mammal prey should consistently outnumber ungulates in the game sink. A comparison of archaeological data from Montana with that from Washington and Idaho is misleading because the former derive mostly from kill sites, in each of which a single instance of resource acquisition is represented. With few exceptions, the bison was the only prey species represented in each of these collections (Davis 1978; Frison et al. 1996; Roll & Hackenberger 1998). Washington and Idaho data came almost exclusively from habitation sites where a diverse suite of mammalian resources were represented, because multiple instances of resource acquisition were represented in each.

To evaluate the geographic dimension, we mapped bison-kill sites spanning the last 10,000 years in Montana, Idaho, Oregon, and Washington (Fig. 4); kill sites in Wyoming were not mapped because relevant data were not readily accessible. Our reasoning was that kill sites would indicate abundant bison, whereas habitation sites containing only a few bison remains could represent a few wandering or immigrating individuals. Some points plotted in Montana represent multiple sites (Fig. 4). Six sites are known in the game sink of eastern Washington; one of these dates to about 8700 B.P. (Daugherty 1956) and the other five date between 2400 and 1400 B.P. (Schroedl 1973; Lyman 1976; Harkins 1980; Morgan 1993; Chatters et al. 1995). Both sites in eastern Oregon date to some unknown time during the last 12,000 years; the site adjacent to Malheur Lake is a paleontological site that has produced remains of numerous bison (Van Vuren & Bray 1985). The 13 sites in Idaho span the last 10,000 years (Butler 1978; Plew & Sundell 2000). Well over 50 bison-kill sites are known in Montana (Davis 1978); their ages also span the last 10,000 years.

Several things are striking about Fig. 4. One is that a single bison-kill site (dating to the last 1500 years) is known west of the continental divide in central and northern Montana (Roll & Hackenberger 1998). A second is that the last 10,000 years are represented. If Martin and Szuter are correct that human predation depressed bison populations in the game sink, we would expect many more bison-kill sites greater than 200 years old to have been found in eastern Washington, eastern Oregon, and southern Idaho. Third, the frequency of bison-kill sites drops precipitously once an imaginary line extending northwest from the northwestern corner of Wyoming to the Continental Divide is crossed. Although

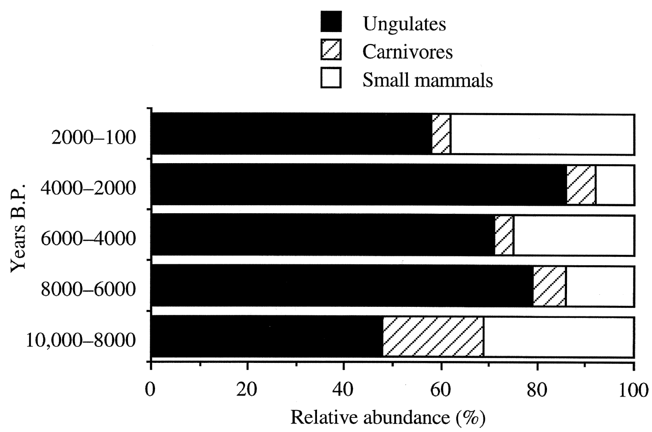

Figure 3. Temporal changes in relative abundances of ungulate, small-mammal, and carnivore remains in archaeological collections from the lower Snake River of southeastern Washington.

Table 4. Archaeological data for ungulates between the Idaho-Washington border and the mouth of the Snake River (Lyman 1976, 1992; Funk 1998).

	Years B.P.				
Taxon	*10,000–8000*	*8000–6000*	*6000–4000*	*4000–2000*	*2000–100*
Absolute abundance (number of identified bones and teeth)					
bison	0	0	2	367	134
elk	6	99	18	58	502
deer	29	227	73	303	1220
bighorn	0	4	5	22	60
pronghorn	16	84	75	129	1282
total	51	414	173	879	3198
Proportional abundance					
bison	0	0	2	42	4
elk	12	24	10	7	16
deer	57	55	42	34	38
bighorn	0	1	3	2	2
pronghorn	31	20	43	15	40

bison may have occasionally immigrated to northeastern Washington via northwestern Montana and northern Idaho (Roll & Hackenberger 1998), the kill-site data suggest that a more frequently utilized route was from southwestern Montana (or western Wyoming) through southern Idaho and eastern Oregon into southeastern Washington.

This suggestion is particularly important because Martin and Szuter (1999*a*:193) state that 20 years after Lewis and Clark failed to find any bison west of Lemhi Pass, bison "overran this country." Local populations as large as an "estimated 10,000 bison in one valley west of Lemhi Pass. . .induced both trappers and Indians to winter in southeastern Idaho" (Martin & Szuter 1999*b*:42). They believe that this "refutes the view that low overall forage production accounts for prior scarcity or absence of bison west of the Rockies" (Martin & Szuter 1999*b*:42). They explain this abrupt temporal change in bison abundance as the result of an expansion of the war zone "west across Lemhi and adjacent passes into eastern Idaho as far as Twin Falls" (Martin & Szuter 1999*b*:42). Perhaps they are correct, but this does not account for the paucity of bison-kill sites in the whole of southern Idaho or the presence of such sites there that date prior to about 1810, as do all kill sites in Idaho plotted in Fig. 4. The traditional explanation that the Continental Divide served as a filter—not an impermeable barrier—to bison immigrants better accounts for the paucity of bison in southern Idaho (and areas west and north) throughout the last 10,000 years. But there is more than that to the explanation.

The Environmental Alternative

Van Vuren (1987) reviewed explanations that had been offered to account for the historically documented paucity of bison west of the Rockies and in eastern Washington and eastern Oregon. These explanations tend to rest on single causes such as restricted immigration across the Continental Divide (Kingston 1932; Haines 1967; Butler 1971), human predation on the few immigrants

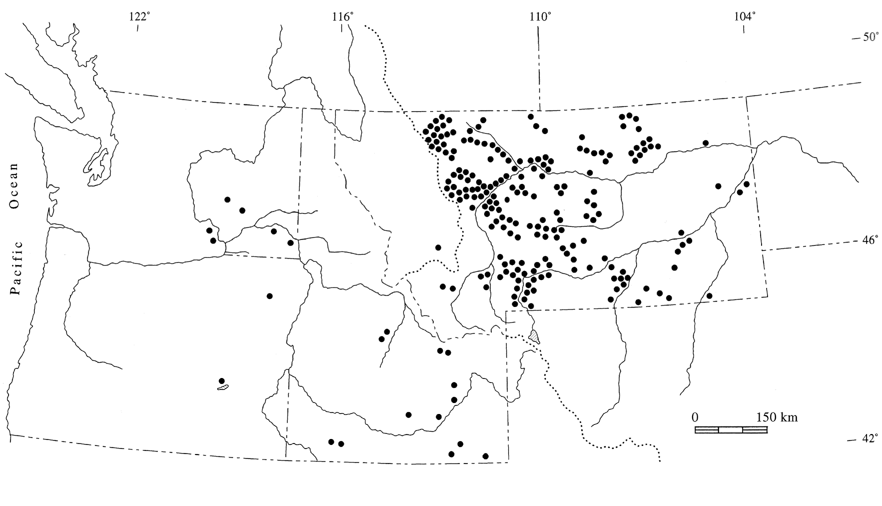

Figure 4. Distribution of prehistoric bison-kill sites dating to the last 10,000 years. Some dots in Montana represent multiple sites.

(Haines 1967; Christman 1971), low forage quality (Johnson 1951; Daubenmire 1985), seasonal variation in forage availability (Mack & Thompson 1982), and severe winters (Daubenmire 1985). Van Vuren (1987:67) finds no single cause sufficient and proposes that low bison abundances "resulted from low carrying capacity and from periodic local extinctions followed by slow rates of recolonization." He notes that (1) the production of herbaceous vegetation is lower in the steppe communities of the game sink than in the war zone; (2) recolonization of the area west of the Continental Divide would be difficult, particularly as the distance west of the divide increases; (3) human hunters, particularly after acquisition of the horse, could have made short work of any small bison populations that entered eastern Washington; and (4) occasional severe winters may have extirpated local small bison herds that survived human predation.

For several reasons, we find Van Vuren's explanation more compelling than that of Martin and Szuter. In conjunction with local climatic history, it accounts first for temporal fluctuations in the relative abundance of bison in eastern Washington (Table 4) and second for variation in bison abundance across space (Fig. 4). Third, it accounts for the fact that Lewis and Clark killed no bison between Lemhi Pass and Lolo Pass although other explorers did 25 years later; this area, particularly the southern portion, comprised part of a sporadically used immigration route to southern Idaho and regions to the west. Finally, Van Vuren's (1987) explanation is multicausal, and as such denies neither the role of traditional productivity-based mechanisms nor that of human predation.

Conclusion

That prehistoric and early historic humans occupying Montana, Idaho, Washington, and Oregon influenced the abundance of game animals by their hunting practices is indisputable. Martin and Szuter (1999*a*, 1999*b*) expand Hickerson's (1965) notion of buffer zones to include war zones, where big game was abundant, and game sinks, where populations of big game were depressed by human predation. They warrant depression by human predation in part by the history of the nineteenth-century livestock industry, a history that in fact suggests that artificial feeding is necessary to attain success. Archaeological evidence lends no support to the implication that ungulate populations in the game sink were depressed solely by human predation. Elk and bison were never abundant in southeastern Washington, and fluctuations in the relative abundance of bison and pronghorn across time are correlated with climatic changes.

Reconsideration of the number of big-game animals killed by the Corps of Discovery in 1805–1806 indicates much variation in ungulate abundances across space within the war zone and the game sink. Archaeological and historical data suggest variation in the relative abundances of big-game species throughout the Pacific Northwest. This does not mean that the apparent pattern of game abundance in Fig. 1 does not exist. Rather, that pattern holds, although we find the differences in details between it and Fig. 2 significant and in need of explanation. Ecological variation in habitats, temporal changes in local climates, and the historical contingencies of mammalian biogeography together comprise a more satisfying but also more complex model that explains why big game, particularly bison and elk, were more abundant in Montana than in southeastern Washington 200 years ago when Lewis and Clark led the Corps of Discovery through the area.

The value of historical data, either written or archaeological, to modern wildlife management and conservation biology is clear (Lyman 1996). These data help us determine such things as which taxa were present in particular areas prior to Euroamerican settlement, thereby guiding the selection of taxa for transplanting and reintroduction. Those data also may help explain why some transplant efforts fail. But, as with any other kind of data, care must be exercised during analysis and interpretation. The journals kept by Lewis and Clark during the Corps of Discovery's journey will continue to provide important ecological data for the pre-Euroamerican settlement period, but they cannot be used uncritically. They must be evaluated in light of other, independent data.

Acknowledgments

We thank W. R. Wood for access to his collection of Plains literature, and D. Glover for advice on figure preparation. Helpful comments on early drafts were provided by R. W. Graham, D. K. Grayson, R. Knight, and M. J. O'Brien. P. S. Martin provided a copy of an unpublished manuscript, a letter, and a phone call, all of which helped clarify our understanding of his and Szuter's reasoning.

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