Aboriginal Overkill and Native Burning: Implications for Modern Ecosystem Management

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Environmental Myths

Western environmental philosophy, which influences how our national parks and natural areas are managed, rests on four assumptions. First, that there is a "balance of nature," where ecosystems achieve a constancy or equilibrium that persists through time. Implicit in this assumption is the belief that climax vegetation was widespread in pre-Columbian times. Second, conservationists invariably assume that, prior to the arrival of Europeans, America was a "wilderness" untouched by the hand of man, and third, that this "wilderness" teemed with wildlife, especially ungulates like elk *(Cervus elaphus)*, moose *(Alces alces)*, and bison *(Bison bison)*. Fourth, and finally, is the assumption that Native Americans were either poor, primitive, starving savages whose numbers were too low to have any impact on the "pristine" landscape (Jobes 1991:388) or that native peoples were children of nature and original conservationists who were too wise to overuse their environment (Alvard 1993).

According to this view, pre-Columbia America was a "Garden of Eden" filled with uncountable numbers of ungulates, wolves *(Canis lupus)*, and other wildlife, and Europeans were the evil ones that destroyed this idyllic state of nature (McName 1986, Rolston 1990, Noss 1991). So under this paradigm, all that is needed to restore our ecosystems to their original condition is to eliminate European influences. This is known as "letting-nature-take-its-course" and is often referred to as "hands-off" or "natural regulation" management. These beliefs are so strongly held by many ecologists that they seldom bother to consider whether they are, in fact, valid. If they are not true, then adhering to this philosophy will not lead to the protection of biological diversity or ecological integrity. That is to say, if these underlying assumptions about nature are false, then management based on those beliefs will not produce the desired result, i.e., the original ecosystems will neither be restored nor protected.

Note: Adapted from a paper presented at the 8th George Wright Society Conference on Research and Resource Management on Public Lands, Portland, OR, April 17–21, 1995.

Although these "Garden of Eden" assumptions are romantically and bureaucratically appealing, unfortunately, they are also false gods. As Botkin (1990), Pielou (1991), and others (e.g., Johnson and Mayeux 1992, Pickett et al. 1992, DeGraaf and Healy 1993, Tausch et al. 1993) have recently done an excellent job debunking the balance-of-nature myth, I will not explore that subject further except to note that disturbance and change are the only ecosystem constants—there certainly was no forest primeval; in fact, old-growth forests, as we know them today, were very rare in pre-Columbian times (Stout 1981, Zybach 1993, Covington and Moore 1994). Instead, I will discuss the remaining myths, namely that the Intermountain West once teemed with game, that America was a "wilderness" ca. 1492, and that Native Americans had little impact on pre-Columbian ecosystems.

Lack of Game

Historical records do not support the view that the Intermountain West once teemed with wildlife. Jacobs (1991:118) and Rasker et al. (1991:63), for instance, claimed that moose were abundant throughout the northern Rocky Mountains, numbering in the tens of thousands, before those animals were slaughtered by unregulated hunting, but early fur trappers seldom reported seeing or killing even a single moose. When Peter Skene Ogden's (1950:73) fur brigade killed three moose near present-day Philipsburg, Montana in 1825, he noted that it was the first time any of his men had seen a moose despite having spent a total of nearly 300 man-years in the West during the early 1800s.

Although not as rare as moose, elk were also historically uncommon in the Rocky Mountains. Between 1835 and 1872, for example, 20 different parties spent a total of 765 days traveling through Yellowstone on foot or horseback, yet reported seeing elk only once every 18 days—today there are nearly 100,000 elk in that ecosystem [Kay 1990, in press (a)]. The same was true in the Canadian Rockies where early explorers reported seeing elk only once every 31 days (Kay et al. 1994, Kay and White in press). During the 1800s, elk were also rare or absent from Utah, Arizona, and New Mexico, as well as other regions of the Intermountain West

(Koch 1941, Rawley 1985, Davis 1986). Based on historical and archaeological data (Kay 1990, 1992, 1994a, Kay et al. 1994), there are now more elk in the West than at any time in the last 10,000 yr.

Moreover, deer (*Odocoileus hemionus* and *O. virginianus*), antelope (*Antilocapra americana*), and bighorn sheep (*Ovis canadensis*) were also rare or absent when the Rocky Mountains were first visited by Europeans. Accounts of starvation and killing horses for food are common in early journals [Kay in press (a)]. Except for the Snake River Plains and surrounding areas, few bison were ever seen west of the mountains. Today in Yellowstone National Park there are an estimated 4,200 bison, but between 1835 and 1872, early explorers encountered bison only three times despite spending 765 days in the ecosystem (Kay 1990). The Columbia Plateau and the Great Basin were particularly devoid of game at historical contact (Daubenmire 1985, Grayson 1993).

Berry production data also suggest that historical ungulate populations were low. Ethnographic accounts and archaeological studies reveal that Native Americans routinely consumed large quantities of berries such as serviceberries (*Amelanchier alnifolia*) and chokecherries (*Prunus virginiana*) (e.g., Lowie 1909, Chamberlin 1911). In September 1869, for instance, the Cook-Folsom-Peterson Expedition met Native Americans who were gathering and drying large quantities of chokecherries at the mouth of Tom Miner Creek just north of Yellowstone Park. "Here we found a wickiup inhabited by two old squaws who were engaged in gathering and drying choke-cherries. . .they had two or three bushels drying in the sun" (Haines 1965:16). The Washburn Expedition of 1870 reported that near Yellowstone Park "we crossed a small stream bordered with black cherry trees [chokecherries], many of the smaller ones broken down by bears, of which animal we found many signs" (Langford 1972:13). Since shrubs have to be at least 2 m tall before branches are commonly broken down by feeding bears, Yellowstone's chokecherry plants in 1870 not only produced abundant berries, but were also larger than those found there today.

Conditions today are vastly different. Serviceberry and chokecherry plants in Yellowstone are now less than 50 cm tall and they produce virtually no berries because they are repeatedly browsed by elk and other ungulates [Kay in press (b)] (see Table 1). Resource-limited ungulate populations and large quantities of berries are mutually exclusive on western ranges. Even moderate numbers of ungulates curtail berry production because those shrubs provide highly preferred forage, especially in winter.

The fact that historic and prehistoric peoples in the West consumed large quantities of berries suggests that ungulate numbers were low and that those animals were not limited by food. The unbrowsed condition of vegetation seen in early historical photographs also indicates that few ungulates inhabited our western ranges during the 1700s and 1800s (Chadde and Kay 1991, Kay and Wagner in press). Moreover, archaeological data reveal that ungulate populations were low in pre-Columbian times as well (Kay 1990, 1992, 1994a, Kay et al. 1994).

Table 1. The effect of ungulate browsing on berry production in the Yellowstone Ecosystem. The number of berries produced by plants protected from browsing inside ungulate-proof exclosures compared with the number of berries produced by the same species outside the exclosures. The Lamar-West and Mammoth exclosures are in Yellowstone Park while the Uhl Hill and Camp Creek exclosures are in Jackson Hole. This also explains why Yellowstone's grizzlies (*Ursus arctos*) do not consume large quantities of berries, unlike bears in other ecosystems. From 1977 to 1992, over 10,000 grizzly bear scats were collected and analyzed in Yellowstone, yet chokecherries were only reported in one scat, serviceberries in two, and buffaloberries (*Shepherdia canadensis*) in 51. Adapted from Kay [in press (b)].

	Number of berries per 100 plants		
Exclosure-species	Inside	Outside	*P*
Camp Creek			
Serviceberry	133,307	7	<0.001
Lamar-West			
Serviceberry	111,047	0	<0.001
Chokecherry	212,178	0	<0.001
Uhl Hill			
Serviceberry	10,468	0	<0.001
Chokecherry	6,508	0	<0.001
Mammoth			
Buffaloberry	119,146	250	<0.001
Total	592,654	257	<0.001

Aboriginal Overkill

Carnivore predation and native hunting are two factors that could once have limited ungulate numbers. The age of their respective kills, however, indicates that Native Americans were more efficient predators than wolves (Temple 1987). The more difficult it is for a predator to capture a particular prey, the more that predator will take substandard individuals and young. So, if two or more predators are preying upon the same species, the least efficient predator will tend to kill fewer prime-age animals (Okarma 1984). While wolves and other carnivores kill primarily young-of-the-year and old animals, Native Americans killed mostly prime-age ungulates (Figure 1).

Since ungulates recovered from Intermountain archaeological sites invariably exhibit mortality profiles dominated by prime-age animals, this suggests that Native Americans were more efficient predators than wolves or other carnivores. Killing mostly prime age animals, though, runs contrary to any maximum sustained yield strategy (Hastings 1983, 1984) and suggests that Native Americans had a major impact on pre-Columbian ungulate populations. This is even more true when one considers that Native Americans killed primarily females (Kay 1994a).

As I have presented my *Aboriginal Overkill* hypothesis elsewhere (Kay 1994a), I will not elaborate on its details here except to note that Native American preferences for prime age females runs counter to any conservation strategy. It is often claimed, however, that Native Americans' religious belief systems prevented those peoples from overutilizing their resources (e.g., Speck 1939, Nelson 1983). Native

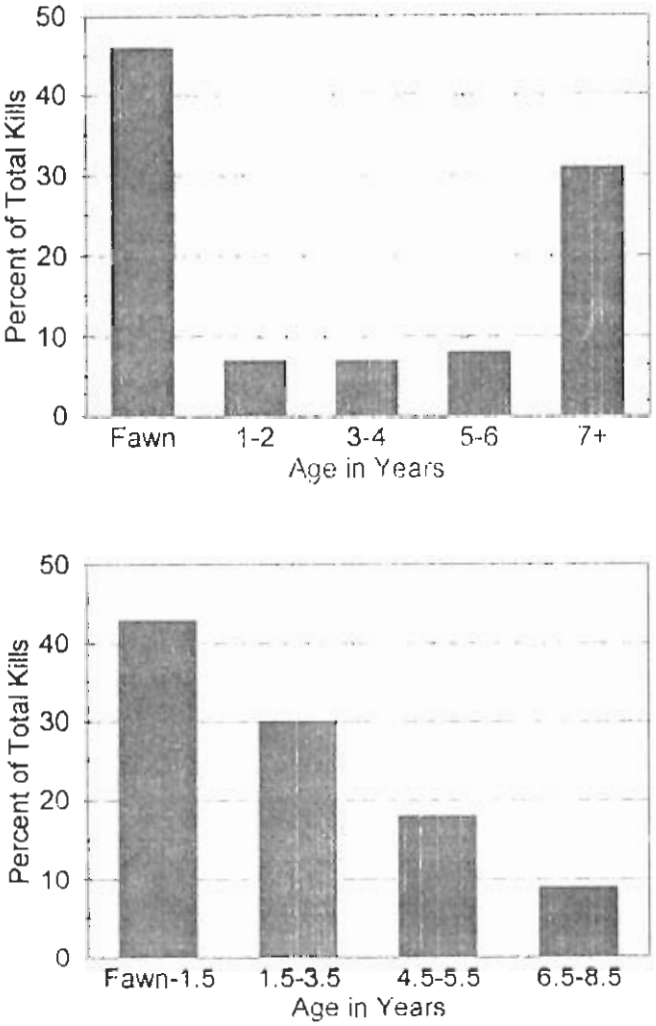

Figure 1. Age structure of ungulates killed by wolves and Native Americans. (a) Age of white-tailed deer *(O. virginianus)* killed by wolves in Minnesota (Fritts and Mech 1981). Wolves and other North American carnivores generally take a disproportionate number of very young and very old animals. (b) Age of mule deer *(O. hemious)* unearthed from the 4200 yr old Dead Indian Creek archaeological site in northwest Wyoming just east of Yellowstone Park (Simpson 1984). Unlike carnivores, Native Americans killed a predominance of prime-age ungulates—an indication that Native Americans were more efficient predators. This also suggests that aboriginal peoples had a greater impact on prey populations than carnivores, especially given the fact that natives killed mostly females. Moreover, these deer were killed with spears or atlatls which are less efficient than the bow and arrow that came into use around 1,500 yr ago (Blitz 1988). Clearly, native hunters have been able to kill all sex and age classes of North American ungulates at will for the last 10,000 or so years. Birkedal (1993) even reported that Native Americans armed with no more than spears and hunting dogs once kept grizzly bear populations at very low levels.

Americans tended to view wildlife as their spiritual kin where success in the hunt was obtained by following prescribed rituals and atonement after the kill (Feit 1987). A scarcity of animals or failure in the hunt were not viewed as biological or ecological phenomena, but rather as a spiritual consequence of social events or circumstances. If a Native American could not find any game, it was not because his people had overharvested the resource, but because he had done something to displease his gods. Since Native Americans saw no connection between their hunting and game numbers, their system of religious beliefs actually fostered the overexploitation of ungulate populations. Religious respect for animals does not equal conservation.

Instead, all native hunters are essentially opportunistic and tend to take high-ranking ungulates regardless of the size of the prey populations or the likelihood of those animals becoming extinct. Native Americans had no concept of maximum sustained yield and did not manage ungulate populations to produce the greatest offtake. In addition, human predation and predation by carnivores are additive and work in concert to reduce ungulate numbers (Walters et al. 1981). Moreover, competition from carnivores tended to negate any possible conservation practices (Kay 1994a). Because Native Americans could prey-switch to small animals, vegetal foods, and fish, they could take their preferred ungulate prey to low levels or extinction without having any adverse effect on human populations. In fact, once Native Americans killed off all the ungulates, human populations actually rose (Hawkes 1991, 1992, 1993).

There are, however, exceptions to aboriginal overkill. According to predator-prey theory, prey populations will increase if they have a refugium where they are safe from predation (Taylor 1984). So, ungulates that could escape aboriginal hunters in time or in space should have been more abundant. Moreover, refugia do not have to be complete to be effective. Partial refugia will also enable prey populations to survive. This explains why there were larger numbers of ungulates on the Great Plains and in the Arctic. By undertaking long-distance migrations, bison and caribou *(Rangifer tarandus)* were able to outdistance most of their human and carnivorous predators (Kay 1994a). Ungulates were also able to survive in buffer zones between tribes that were locked in mortal combat (Hickerson 1965). Lewis and Clark (1893:1197), for instance, noted that, "With regard to game in general, we observe that the greatest quantities of wild animals are usually found in the country lying between nations at war."

Native Burning

Besides keeping ungulate numbers low, Native Americans also had a major impact on ecosystems by repeatedly firing the vegetation. They did this to modify plant and animal communities for human benefit. In California, for instance, native peoples had at least 70 different reasons for firing the vegetation (Lewis 1973, Timbrook et al. 1982), and even in northern Canada, where the vegetation is less diverse, Native Americans still set fires for at least 17 different reasons (Lewis 1977, 1980a, 1982b, 1985, 1990a, Ferguson 1979, Reid 1987, Lewis and Ferguson 1988). While aboriginal burning has been widely reported in the anthropological literature (e.g., Lewis 1980b, 1982a, 1990b; Boyd 1986, Turner 1991, Anderson 1993, Pyne 1993, Gottesfeld 1994), these data have largely been ignored by land managers, especially in our national parks and wilderness areas (Lewis 1992, Martinez 1993). In Yellowstone, for example, the Park Service contends that aboriginal fires were unimportant, and

that most fires were historically started by lightning (Loope and Gruell 1973:434, Romme and Despain 1989). This position, though, is not supported by available ecological evidence. Instead, most fires were started by Native Americans, especially in montane habitats.

Prior to park establishment, Yellowstone's northern range had a fire-return interval of once every 25 yr (Houston 1973, 1982). Yellowstone has had a "let burn" policy for nearly 25 yr, yet during that period, lightning-caused fires have burned practically none of the northern range. In 1988, fire did burn approximately one-third of the area, but according to agency definitions, that was "unnatural" because the fire was started by man, not lightning. Besides, the 1988 fires are thought to be a 100-300 yr event (Schullery 1989a, 1989b), so similar fires could not have caused the original 25 yr fire frequency.

Despite a series of droughts, why has Yellowstone's northern range remained virtually unburned? Park biologists contend that this is because "lightning has chosen not to strike very often on the northern range" (Despain et al. 1986:109). That assertion, though, is not supported by data from the Bureau of Land Management's Automatic Lightning Strike Detection System which shows that, on average, lightning strikes the northern range 4 times per km^2/yr (Kay 1990:136–137). So lightning strikes, but why doesn't the range burn? The answer is that when most lightning strikes occur, the herbaceous vegetation is too green to carry a fire.

Repeat photographs and fire history studies indicate that western aspen *(Populus tremuloides)* communities burned frequently in the past, yet experience has proven that aspen is extremely difficult to burn (Brown and Simmerman 1986). Terms such as "asbestos type" and "firebreak" are often used to describe aspen (DeByle 1987:75). Even raging crown fires in coniferous forests seldom burn adjacent aspen communities (Fechner and Barrows 1976). At current rates of burning, "it would require about 12,000 years to burn the entire aspen type in the West" (DeByle et al. 1987:73). Something is clearly different today than it was in the past.

Research has shown that aspen communities will readily burn only when aspen is leafless and when understory plants are dry, conditions that occur only in early spring and late in the fall (Brown and Simmerman 1986). Prior to May 15th and after September 15th, however, there are few lightning strikes and virtually no lightning fires in the West (Figure 2). So, if aspen stands burned at frequent intervals in the past as data indicate they did, including those on Yellowstone's northern range, then the majority of those fires were most likely set by Native Americans.

Determining how fires started is critical because, "fires set by hunter-gatherers differ from [lightning] fires in terms of seasonality, frequency, intensity, and ignition patterns" (Lewis 1985:75). Most aboriginal fires were set in the spring, between snowmelt and vegetation greenup, or late in the fall when burning conditions were not severe. Unlike lightning fires, which tend to be infrequent high intensity infernos, native burning produced a higher frequency of lower intensity fires. So, aboriginal burning and lightning fires create different vegetation mosaics, and in many instances, entirely different plant communities (Anderson 1993, Blackburn and

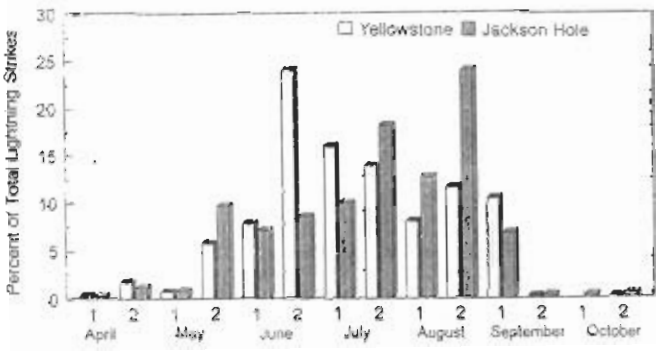

Figure 2. Temporal distribution of lightning strikes on Yellowstone's northern range and in Wyoming's Jackson Hole (Kay 1990:138). When aspen communities are normally dry enough to burn in early spring, prior to green-up, or late autumn, after aspen leaf-fall, there are few lightning strikes and virtually no lightning fires. So if aspen burned frequently in the past as data indicate they did, then the vast majority of those fires were most likely started by Native Americans.

Anderson 1993). Moreover, aboriginal burning reduces or eliminates the number of high intensity, lightning-generated fires (Pyne 1982, 1989, 1991, 1993, Reid 1987:34). Once aboriginal fires opened up the vegetation, then subsequent lightning fires behaved like those set by Native Americans.

Conclusions

Most national parks, wilderness areas, and nature reserves are supposedly managed to represent the conditions that existed in pre-Columbian times; i.e., so-called natural or pristine conditions. But what is natural? If Native Americans determined the structure of entire plant and animal communities by firing the vegetation and by limiting ungulate numbers, then that is a completely different situation than what we have today (Martinez 1993, Wagner and Kay 1993). A hands-off or natural regulation approach by modern land managers will not duplicate the ecological conditions under which those communities developed (Wagner et al. in press). Since aboriginal predation and burning created those communities, then the only way to maintain what we call natural areas today is to duplicate aboriginal influences and processes (Martinez 1993, Wagner et al. in press).

Prior to the early 1800s, for example, millions of beaver *(Castor canadensis)* occupied lush riparian zones throughout the West. Beaver were so abundant that in 1825, Peter Skene Ogden's party was able to trap 511 beaver in only 5 days on Utah's Ogden River, while in 1829, Ogden reported that his fur brigade took 1,800 beaver in a month on Nevada's Humboldt River (Kay 1994b). Yellowstone too once contained large numbers of beaver, but that species is now ecologically extinct on the park's northern range (Chadde and Kay 1991). Without native hunters, the park's burgeoning elk population has destroyed the willow (*Salix* sp.) and aspen communities beaver need for food and dam building materials (Chadde and Kay 1991, Kay and Chadde 1992). So, natural regulation management has not maintained Yellowstone's ecological integrity nor reestablished the ecosystem's original conditions.

Moreover, the idea that North America was a "wilderness" untouched by the hand of man prior to 1492 is a myth, a myth created, in part, to justify appropriation of aboriginal lands and the genocide that befell native peoples (Denevan 1992, Gomez-Pompa and Kaus 1992, Simms 1992, Martinez 1993). North America was not a wilderness waiting to be discovered, but instead was home to more than 100 million Native Americans before European-introduced diseases decimated their numbers (Dobyns 1983, Ramenofsky 1987).

Native Americans were the ultimate keystone species, and their removal has completely altered ecosystems, not only in the Intermountain West but throughout North America (e.g., Neumann 1984, 1985, 1989, Birkedal 1993). Setting aside an area as wilderness or a national park today, and then managing it by letting nature take its course will not preserve some remnant of the past but instead create conditions that have not existed for the last 10,000 yr. That is to say, the Americas as first seen by Europeans were not as they had been crafted by God, but as they had been created by native peoples (Hallam 1975, Schule 1990, Martinez 1993). Unless the importance of aboriginal land management is recognized and modern management practices changed accordingly, our ecosystems will continue to lose the biological diversity and ecological integrity they once had.

Literature Cited

Alvard, M.S. 1993. Testing the "ecologically noble savage" hypothesis: Interspecific prey choice by Piro hunters of Amazonian Peru. Hum. Ecol. 21:355–387.

Anderson, K. 1993. Indian fire-based management in the sequoia-mixed conifer forests of the central and southern Sierra Nevada. Final contract report submitted to Yosemite Research Center, Yosemite National Park, CA. Coop. Agree. Order No. 8027-2-002. 426 p.

Birkedal, T. 1993. Ancient hunters in the Alaskan wilderness: Human predators and their role and effect on wildlife populations and the implications for resource management. P. 228–234 *in* Partners in stewardship: Proc. 7th Conf. on Research and Resource Management in Parks and on Public Lands, Brown, W.E., and S.D. Veirs, Jr. (eds.). The George Wright Society, Hancock, MI. 479 p.

Blackburn, T.C., and K. Anderson, eds. 1993. Before the wilderness: Environmental management by native Californians. Ballena Press, Menlo Park, CA. 476 p.

Blitz, J.H. 1988. Adoption of the bow in prehistoric North America. N. Am. Archaeol. 9:123–145.

Botkin, D.B. 1990. Discordant harmonies: A new ecology for the twenty-first century. Oxford University Press, New York. 241 p.

Boyd, T. 1986. Strategies of Indian burning in the Wilamette Valley. Can. J. Anthropol. 5:65–86.

Brown, J.K., and D.G. Simmerman. 1986. Appraisal of fuels and flammability in western aspen: A prescribed fire guide. U.S. For. Serv. Gen. Tech. Rep. INT-205. 48 p.

Chadde, S.W., and C.E. Kay. 1991. Tall-willow communities on Yellowstone's northern range: A test of the "natural regulation" paradigm. P. 231–264 *in* The Greater Yellowstone Ecosystem: Redefining America's wilderness heritage, Keiter, R.R., and M.S. Boyce (eds.). Yale University Press, New Haven, CT. 428 p.

Chamberlin, R.V. 1911. The ethno-botany of the Gosiute Indians of Utah. Memoirs Am. Anthropol. Assoc. 2(5):331–405.

Covington, W.W., and M.M. Moore. 1994. Southwestern ponderosa forest structure: Changes since Euro-American settlement. J. For. 92:39–47.

Daubenmire, R. 1985. The western limits of the range of the American bison. Ecology 66:622–624.

Davis, G.P. 1986. Man and wildlife in Arizona: The American exploration period 1824–1865. Arizona Game and Fish Dept., Phoenix, AZ. 231 p.

DeByle, N.V., C.D. Bevins, and W.C. Fisher. 1987. Wildfire occurrence in aspen in the interior western United States. West. J. App. For. 2:73–76.

DeGraaf, R.M., and W.H. Healy. 1993. The myth of nature's constancy—preservation, protection and ecosystem management. Trans. N. Am. Wildl. & Natur. Resour. Conf. 58:17–28.

Denevan, W. 1992. The pristine myth: The landscape of the Americas in 1492. Assoc. Am. Geog. Annals 82:369–385.

Despain, D., D. Houston, M. Meagher, and P. Schullery. 1986. Wildlife in transition: Man and nature on Yellowstone's northern range. Roberts Rinehart Inc., Boulder, CO. 142 p.

Dobyns, H.F. 1983. Their numbers become thinned: Native American population dynamics in eastern North America. University of Tennessee Press, Knoxville, TN. 378 p.

Fechner, G.H., and J.S. Barrows. 1976. Aspen stands as wildfire fuel breaks. Eisenhower Consort. Bull. 4:1–26. U.S. For. Serv. Rocky Mtn. For. and Range Exp. Sta., Ft. Collins, CO.

Feit, H.A. 1987. North American native hunting and management of moose populations. Swedish Wildl. Res. (Supplement 1):25–42.

Ferguson, T.A. 1979. Productivity and predictability of resource yield: Aboriginal controlled burning in the boreal forest. M.A. thesis, University of Alberta, Edmonton, AB. 145 p.

Fritts, S.H., and L.D. Mech. 1981. Dynamics, movements, and feeding ecology of a newly protected wolf population in northwestern Minnesota. Wildl. Monogr. 80. 79 p.

Gomez-Pompa, A., and A. Kaus. 1992. Taming the wilderness myth. Bioscience 42:271–279.

Gottesfeld, L.M.J. 1994. Aboriginal burning for vegetative management in northwest British Columbia. Hum. Ecol. 22:171–188.

Grayson, D.K. 1993. The deserts' past: A natural prehistory of the Great Basin. Smithsonian Institution Press, Washington, DC. 356 p.

Haines, A.L. 1965. Valley of the upper Yellowstone. University of Oklahoma Press, Norman, OK. 79 p.

Hallam, S.J. 1975. Fire and hearth. Australian Institute of Aboriginal Studies, Canberra, Australia. 158 p.

Hastings, A. 1983. Age-dependent predation is not a simple process. I. Continuous time models. Theor. Pop. Biol. 23:347362.

Hastings, A. 1984. Age-dependent predation is not a simple process. II. Wolves, ungulates, and a discrete time model for predation on juveniles with a stabilizing tail. Theor. Pop. Biol. 26:271282.

Hawkes, K. 1991. Showing off: Tests of a hypothesis about men's foraging goals. Ethol. Sociobiol. 12:29–54.

Hawkes, K. 1992. On sharing and work. Curr. Anthropol. 33:404–407.

Hawkes, K. 1993. Why hunter-gatherers work. Curr. Anthropol. 34:341–361.

Hickerson, H. 1965. The Virginia deer and intertribal buffer zones in the upper Mississippi Valley. P. 43–65 *in* Man, culture and animals: The role of animals in human ecological adjustments, Leeds, A., and A.P. Vayda (eds.). Am. Assoc. for the Adv. of Sci. Publ. 78.

Houston, D.B. 1973. Wild fires in northern Yellowstone National Park. Ecology 54:1111–1117.

Houston, D.B. 1982. The northern Yellowstone elk: Ecology and management. MacMillan, New York. 474 p.

Jacobs, L. 1991. Waste of the West: Public lands ranching. Privately published by Lynn Jacobs, Tucson, AZ. 602 p.

Jobes, P.C. 1991. The greater Yellowstone social system. Conserv. Biol. 5:387394.

Johnson, H.B., and H.S. Mayeux. 1992. Viewpoint: A view on species additions and deletions and the balance of nature. J. Range Manage. 45:322333.

Kay, C.E. 1990. Yellowstone's northern elk herd: A critical evaluation of the "natural regulation" paradigm. Ph.D. Diss., Utah State University, Logan, UT. 490 p.

Kay, C.E. 1992. Book review—The Jackson Hole elk herd: Intensive wildlife management in North America. J. Range Manage. 45:315–316.

Kay, C.E. 1994a. Aboriginal Overkill: The role of Native Americans in structuring western ecosystems. Hum. Nature 5:359–398.

Kay, C.E. 1994b. The impact of native ungulates and beaver on riparian communities in the Intermountain West. Natur. Resour. Environ. Issues 1:23–44.

Kay, C.E. In press (a). An alternative interpretation of the historical evidence relating to the abundance of wolves in the Yellowstone Ecosystem. Paper presented at the Second North Am. symp. on wolves: Their status, biology, and management. University of Alberta, Edmonton. 27 p.

Kay, C.E. In press (b). Effects of browsing by native ungulates on shrub growth and seed production in the Greater Yellowstone Ecosystem: Implications for revegetation, restoration, and "natural regulation" management. Paper presented at the Symp. on Wildland Shrub and Arid Land Restoration, Las Vegas, NV. 41 p.

Kay, C.E., B. Patton, and C. White. 1994. Assessment of long-term terrestrial ecosystem states and processes in Banff National Park and the

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Cover: Blue oak woodland in the Sierra Nevada foothills, CA. Photo by Douglas D. McCreary.

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central Canadian Rockies. Resource Conservation, Parks Canada, Banff National Park, Banff, AB. 405 p.

KAY, C.E., and C.A. WHITE. In press. Long-term ecosystem states and processes in the central Canadian Rockies: A new perspective on ecological integrity and ecosystem management. 5th George Wright Society Conference on Research and Resource Management on Public Lands.

KAY, C.E., and F.H. WAGNER. In press. Historic condition of woody vegetation on Yellowstone's northern range: A critical test of the "natural regulation" paradigm. Paper presented at: Plants and their environments—First biennial scientific conference on the Greater Yellowstone Ecosystem. 40 p.

KAY, C.E., and S.W. CHADDE. 1992. Reduction of willow seed production by ungulate browsing in Yellowstone National Park. P. 92–99 in Proc. Symp. on ecology and management of riparian shrub communities, Clary, W.P., et al. (eds.). USDA For. Serv. Gen. Tech. Rep. INT-289. 232 p.

KOCH, E. 1941. Big game in Montana from early historical records. J. Wildl. Manage. 5:357–370.

LANGFORD, N.P. 1972. The discovery of Yellowstone Park. University of Nebraska Press, Lincoln, NE. 125 p.

LEWIS, H.T. 1973. Patterns of Indian burning in California: Ecology and ethno-history. Anthropol. Pap. No. 1. Ballena Press, Ramona, CA. 101 p.

LEWIS, H.T. 1977. Maskuta: The ecology of Indian fires in northern Alberta. West. Can. J. of Anthropol. 7:15–52.

LEWIS, H.T. 1980a. Indian fires of spring. Natur. Hist. 89(1):76–83.

LEWIS, H.T. 1980b. Hunter-gatherers and problems for fire history. P. 115–119 *in* Proc. fire history workshop, Stokes, M.A., and J.H. Dieterich, (eds.). USDA For. Serv. Gen. Tech. Rep. RM-81. 142 p.

LEWIS, H.T. 1982a. Fire technology and resource management in aboriginal North America and Australia. P. 46–67 *in* Resource managers: North American and Australian hunter-gatherers, Williams, N.M., and E.S. Hunn (eds.). AAAS Selected Symp. No. 67. 267 p.

LEWIS, H.T. 1982b. A time for burning. University of Alberta Boreal Inst. for Northern Studies Occas. Publ. 17. 23 p.

LEWIS, H.T. 1985. Why Indians burned: Specific versus general reasons. P. 75–80 *in* Proc. symp. and workshop on wilderness fire, Lotan, J.E., et al. (eds.). USDA For. Serv. Gen. Tech. Rep. INT-182. 434 p.

LEWIS, H.T. 1990a. Traditional ecological knowledge of fire in northern Alberta: Something old, something new, something different. P. 222-227 in Proc. of the Fort Chipewyan and Fort Vermilion Bicentennial Conf., McCormack, P.A., and R.G. Ironside (eds.). 319 p.

LEWIS, H.T. 1990b. Reconstructing patterns of Indian burning in southwestern Oregon. P. 80–84 *in* Living with the land: The Indians of southwestern Oregon, Hannon, N., and R. Olmo (eds.). Southern Oregon Historical Society, Medford, OR. 153 p.

LEWIS, H.T. 1992. The technology and ecology of nature's custodians: Anthropological perspectives on aborigines and national parks. P. 15–28 *in* Aboriginal involvement in parks and protected areas, Birckhead, J., T. Delacy, and L. Smith (eds.). Aboriginal Studies Press, Canberra, Australia. 390 p.

LEWIS, H.T., and T.A. FERGUSON. 1988. Yards, corridors and mosaics: How to burn a boreal forest. Hum. Ecol. 16:57–77.

LEWIS, M., and W. CLARK. 1893. The history of the Lewis and Clark expedition. Ed. by E. Coues, originally published by Harper, New York. Republished by Dover Publications, New York. Vol. I:1–352, Vol. II:353–820, Vol. III:821–1364.

LOOPE, L.L., and G.E. GRUELL. 1973. The ecological role of fire in the Jackson Hole area, Northwestern Wyoming. Quart. Res. 3:425–443.

LOWIE, R.H. 1909. The northern Shoshoni. Am. Museum of Natur. Hist. Anthropol. Pap. 2(3):165–306.

Martinez, D. 1993. Managing a precarious balance: Wilderness versus sustainable forestry. Winds of Change 8(3):23–28.

MCNAME, T. 1986. Putting nature first: A proposal for whole ecosystem management. Orion Nature Quart. 5(4):3–15.

NELSON, R.K. 1983. Make prayers to the raven. University of Chicago Press, Chicago, IL. 292 p.

NEUMANN, T.W. 1984. The opossum problem: Implications for human-wildlife competition over plant food. N. Am. Archaeol. 5:287–313.

NEUMANN, T.W. 1985. Human-wildlife competition and the passenger pigeon: Population growth from system destabilization. Hum. Ecol. 4:389–410.

NEUMANN, T.W. 1989. Human-wildlife competition and prehistoric subsistence: The case of the eastern United States. J. Middle Atlantic Archaeol. 5:29–57.

NOSS, R.F. 1991. Wilderness recovery: Thinking big in restoration ecology. Environ. Prof. 13:225–234.

OGDEN, P.S. 1950. Peter Skene Ogden's snake country journals, 1824–25 and 1825–26. Rich, E.E., and A.M. Johnson (eds.). Hudson's Bay Record Soc. Publ. 8. 283 p.

OSARMA, H. 1984. The physical condition of red deer falling prey to the wolf and lynx and harvested in the Carpathian Mountains. ACTA Therlogica 29:283–290.

PICKETT, S.T.A., V.T. PARKER, and P.L. FIEDLER. 1992. The new paradigm in ecology: Implications for conservation biology above the species level. P. 65–88 *in* Conservation Biology, Fiedler, P.L., and S.K. Jain (eds.). Chapman and Hall, New York. 507 p.

PIELOU, E.C. 1991. After the Ice Age: The return of life to glaciated North America. University of Chicago Press, Chicago, IL. 366 p.

PYNE, S.J. 1982. Fire in America: A cultural history of wildland and rural fire. Princeton University Press, Princeton, NJ. 654 p.

PYNE, S.J. 1989. The summer we let wild fires loose. Natur. Hist. 98(8):45–49.

PYNE, S.J. 1991. Burning bush: A fire history of Australia. Henry Holt, New York. 520 p.

PYNE, S.J. 1993. Keeper of the flame. A survey of anthropogenic fire. P. 245–266 *in* Fire in the environment: Its ecological, climatic, and atmospheric chemical importance, Crutzen, P.J., and J.G. Goldammer (eds.). Wiley, New York.

RAMENOFSKY, A.F. 1987. Vectors of death: The archaeology of European contact. University of New Mexico Press, Albuquerque. 300 p.

RASKER, R., N. TIRRELL, and D. KLOEPFER. 1991. The wealth of nature: New economic realities in the Yellowstone region. The Wilderness Society, Bozeman, MT. 64 p.

RAWLEY, E.V. 1985. Early records of wildlife in Utah. Utah Division of Wildl. Resour. Publ. 86-2. 102 p.

READ, D.K. 1987. Fire and habitat modification: An anthropological inquiry into the use of fire by indigenous peoples. M.A. Thesis, University of Alberta, Edmonton, AB. 169 p.

ROLSTON, H. 1990. Biology and philosophy in Yellowstone. Biol. Phil. 5:241–258.

ROMME, W.H., and D.G. DesPAIN. 1989. Historical perspective on the Yellowstone fires of 1988. Bioscience 39:695699.

SCHULE, W. 1990. Landscapes and climate in prehistory: Interaction of wildlife, man and fire. P. 273–319 *in* Fire in the tropical biota, Goldammer, J. (ed.). Springer-Verlag, New York. 497 p.

SCHULLERY, P. 1989a. Yellowstone fires: A preliminary report. NW. Sci. 63:44–54.

SCHULLERY, P. 1989b. The fires and fire policy. Bioscience 39:686–694.

SIMMS, S.R. 1992. Wilderness as a human landscape. P. 183–201 *in* Wilderness tapestry. Zeveloff, S.I., L.M. Vanse, and W.H. McVaugh (eds.). University of Nevada Press, Reno, NV. 306 p.

SIMPSON, T. 1984. Population dynamics of mule deer. Wyoming Archaeol. 27(1-2):53–96.

SPECK, F.G. 1939. Aboriginal conservators. Bird Lore 40:258–261.

STOUT, B.B., ed. 1981. Forests in the here and now: A collection of writings by Hugh Miller Raup. Ballard Professor of Forestry, Emeritus, Harvard University. Montana For. and Conserv. Exp. Sta., University of Montana, Missoula. 131 p.

TAUSCH, R.J., P.E. WIGAND, and J.W. BURKHARDT. 1993. Viewpoint: Plant community thresholds, multiple steady states, and multiple successional pathways: Legacy of the Quaternary? J. Range Manage. 46:439–447.

TAYLOR, R.F. 1984. Predation. Chapman and Hall, New York. 166 p.

TEMPLE, S.A. 1987. Do predators always capture substandard individuals disproportionately from prey populations? Ecology 68:699–674.

TIMBROOK, J., J.R. JOHNSON, and D.D. EARLE. 1982. Vegetation burning by the Chumash. J. Calif. Great Basin Anthropol. 4:163–186.

TURNER, N.J. 1991. Burning mountain sides for better crops: Aboriginal landscape burning in British Columbia. Archaeol. Montana 32:57–73.

WAGNER, F.H., and C.E. KAY. 1993. "Natural" or "healthy" ecosystems: Are U.S. national parks providing them? P. 257–270 in Humans as components of ecosystems, McDonnell, M.J., and S.T. Picken (eds.). Springer-Verlag, New York. 364 p.

WAGNER, F.H., et al. In press. Wildlife policies in the U.S. national parks—[An independent review originally commissioned by The Wildlife Society]. Island Press, Washington, DC.

WALTERS, C.J., M. STOCKER, and G.C. HABER. 1984. Simulation and optimization models for a wolf-ungulate system. P. 317–337 *in* Dynamics of large mammal populations, Fowler, C.W., and T.D. Smith (eds.). Wiley, New York.

ZYBACH, B. 1993. Native forests of the northwest, 1788-1856: American Indians, cultural fire, and wildlife habitat. Northwest Woodl. 9(2):14–15, 38.