ECOSYSTEMS THEN AND NOW: A HISTORICAL-ECOLOGICAL APPROACH TO ECOSYSTEM MANAGEMENT

Charles E. Kay

Department of Political Science, Utah State University, Logan, UT 84322-0705.

INTRODUCTION

Before ecosystem management can be implemented or ecological integrity preserved, long-term ecosystem states and processes must first be quantified. For as Aldo Leopold noted over 40 years ago, "if we are serious about restoring (or maintaining) ecosystem health and ecological integrity, then we must first know what the land was like to begin with" (Covington and Moore 1994). Unless we know what factors structured ecosystems in historic and pre-Columbian times, we can not predict how those systems will respond to modern management. Moreover, we also have to answer the age-old question of whether food (resources) or predation structured pre-Columbian ecosystems. Without a window to the past as a guide to where we might be going, it is impossible to institute meaningful ecosystem management. Historical journal observations, archaeological evidence, repeat photographs, and data on current ecosystem states and processes can be used to determine what factors structured ecosystems in earlier times.

HISTORICAL OBSERVATIONS

Some researchers have used selected quotes from historical journals as evidence that certain species, primarily ungulates and large predators, were or were not abundant during the late 1700's and early 1800's (e.g. Nelson 1967, 1969a, 1969b, 1970, 1972, 1973; Byrne 1968; Spalding 1990, 1992). With selective quotations, however, there is always a question of whether or not the author included only those passages that supported his or her preconceived hypothesis. To overcome any problems of bias, wildlife observations left by early explorers should be systematically recorded on a continuous time basis. Those data should then be tabulated in three ways; game killed, game seen, and animal sign seen or referenced (Kay 1990, Kay *et al.* 1994, Kay and White 1995).

In addition, only first-person journals penned at the time of the event or edited versions of the same written soon afterwards should be used, because later narrative accounts are less accurate (White 1991). Even "the humblest narrative is always more than a chronological series of events" (McCullagh 1987). The ideological implications of most narrative historical accounts are "no different from those of the narrative form in fiction" (Galloway 1991), because narratives are always influenced by prevailing cultural myths, such as the idea that the West was a Garden of Eden teeming with wildlife but filled with hostile savages (White 1991). Moreover, standard analytical techniques should be used to judge the accuracy of all historical source materials (Forman and Russell 1983).

HISTORICAL AND REPEAT PHOTOGRAPHS

To compile repeat photosets, the scenes depicted in historical photographs are rephotographed as they appear today (Rogers *et al.* 1984). Those paired images are then compared to document long-term vegetation changes, as well as changes that may have occurred in fire frequency or other disturbance regimes. Repeat photographic studies are common in the western United States, but are rare in Canada (Kay 1990, Kay *et al.* 1994).

Historical photographs can also be used to judge the number of ungulates that occupied areas in the past. If elk (*Cervus elaphus*), for example, were as abundant in the 1800's as they are today in various national parks (Kay 1990, Hess 1993, Kay *et al.* 1994), then favored forage species, like aspen (*Populus tremuloides*) and willows (*Salix* sp.), should show the effects of elk browsing similar to plants today. In other words, historical photographs of aspen and willows should show that those communities were as heavily browsed in the 1800's as they are at present (Kay 1990, Kay *et al.* 1994, Kay and White 1995). If aspen and willows depicted in historical images do not show evidence of repeated browsing, that would not only indicate that fewer ungulates used the range in the past, but it would also indicate that factors other than food limited those ungulate populations. Thus, historical photographs are not just snapshots in time, but they also are important indicators of long-term ecosystem states and processes, especially when combined with present vegetation measurements (Kay 1990, Kay *et al.* 1994).

ARCHAEOLOGICAL EVIDENCE

Similarly, faunal remains recovered from archaeological sites can be used to determine the relative abundance of ungulate species in pre-Columbian times. If a particular ungulate species dominates the present ungulate community and if today's conditions are thought to represent the "pristine" or "natural" state of the ecosystem, then it is logical to assume that the same ungulate species should predominate archaeologically recovered faunal remains. If that is not true, then it would indicate present conditions are not representative of earlier times (Kay 1990, 1994a; Kay *et al.* 1994; Kay and White 1995).

To be used effectively, though, archaeological data for entire ecosystems must be systematically compiled and synthesized. Consideration must also be given to site formation processes, as well as to any biases that may have been caused by differential preservation or differential transportation. Archaeological faunal remains should be tabulated and reported as both MNI (minimum number of individuals) and NISP (number of identified specimens) (see Kay 1990, 1994a; Kay *et al.* 1994 for details).

EXAMPLES FROM THE YELLOWSTONE ECOSYSTEM

There are currently an estimated 100,000 elk in the Yellowstone Ecosystem and over 4,000 bison (*Bison bison*) in Yellowstone National Park itself (Harting and Glick 1994). According to the National Park Service, these large ungulate populations are assumed to be "natural" and to represent the "pristine" state of the ecosystem (Houston 1982, Despain *et al.* 1986). If that were true, then early explorers should have reported an abundance of game. Between 1835 and 1876, 20 different expeditions spent a total of 765 days in the Yellowstone Ecosystem, yet they reported seeing elk only once every 18 days and bison were seen on only three occasions, none of which were in Yellowstone Park itself (Kay 1990). In addition, no one reported seeing or killing even a single wolf (*Canis lupus*), another indication that game was scarce (Kay in press a). Moreover, while the explorers were in Yellowstone, their journals contain 45 references to a lack of game or a shortage of food (Kay 1990). Thus, historical records provide no evidence that thousands of resource-limited elk inhabited Yellowstone during the 1800's (Kay 1990, in press a).

Again according to the National Park Service (Houston 1982, Despain *et al.* 1986), thousands of elk and other ungulates have always inhabited Yellowstone and those animals have always heavily impacted the vegetation. That is to say, the agency claims that high-lining of conifers and heavily browsed aspen and willows are natural and not signs of overgrazing. If this were true, then woody vegetation depicted in historical (ca. 1870 to 1890) photographs should reflect that fact. Historical photographs, however, show no evidence of any ungulate browsing (Kay and Wagner in press). Moreover, repeat photographs of tall willows (n=44) and aspen (n=81) show that aspen and willows have declined by more than 95% since Yellowstone was established as the world's first national park in 1872 due to repeated ungulate browsing, not other factors (Kay 1990, Chadde and Kay 1991). So, ungulate high-lining of conifers and repeated browsing of other woody vegetation are not "natural," but instead represent a departure from conditions that existed prior to the establishment of Yellowstone National Park. Moreover, since conifers and other woody species depicted in early images were approximately 70 to 100 years old or older when they were photographed and since they show no evidence of ungulate use, this would indicate that few, if any, elk wintered in Yellowstone from the late 1700's through the 1870's (Kay and Wagner in press).

Archaeological data indicate that elk and other ungulates were also rare in pre-Columbian times. Elk now comprise over 80% of total ungulate numbers in Yellowstone but elk bones are rarely unearthed from archaeological sites - averaging 3% or less of the total (Kay 1990, 1992). This is not due to the fact that Native Americans either could not, or chose not to, kill elk, nor is it due to differential preservation or differential transportation (Kay 1990, 1994a; Kay *et al.* 1994). Instead elk are rarely recovered from intermountain archaeological sites because elk and other ungulates were not abundant in western mountains during pre-Columbian times (Kay 1990, 1994a). Evidence suggests that this was also true in the Canadian Rockies.

CANADIAN ROCKIES

Elk are now the most abundant ungulate in Banff National Park's Bow Valley and other parts of the Canadian Rockies, but are those populations indicative of past conditions? In addition, is the park's present vegetation reflective of earlier times, or has it changed due to modern management that has excluded fire for over 100 years? Like Yellowstone, aspen is also declining in Banff's Bow Valley, but is this "natural" or an artifact of park management (Kay *et al.* 1994, Kay and White 1995)?

Based on repeat photographs, aspen in Banff's Bow Valley bas declined precipitously since that national park was established. Immediately outside the park where elk numbers are lower, however, aspen still continues to flourish. Aspen has also suceessfully regenerated inside Banff's exclosures while it has declined on adjacent outside plots suggesting that repeated elk browsing, not climatic change, is responsible. Aspen has also declined with advancing forest succession, but even when burned, aspen has failed to successfully regenerate due to repeated elk browsing. While aspen is often thought to be a "seral" species, successional replacement of aspen by conifers is not normal because aspen does not commonly reproduce from seed. Although aspen has maintained its presence in Banff's vegetation mosaic for thousands of years via root suckering, it is now disappearing from the park. Clearly, something is different today than in earlier times. Moreover, the very persistence of aspen in the central Canadian Rockies over the millennium, indicates that ungulate use, and especially elk browsing, was not as intense in the past as it is now (Kay *et al.* 1994, Kay and White 1995).

The ecology of aspen also suggests that aboriginal burning may have been more important than lightning fires in structuring pre-Columbian vegetation communities. Historical photographs and fire frequency studies indicate that aspen burned at frequent intervals in Banff's Bow Valley prior to park establishment. Aspen, however, will carry fire only when it is leafless and when understory fuels are dry, conditions that occur only in early spring or late fall (Fechner and Barrows 1976, DeByle *et al.* 1987). During both those periods, though, there are few lightning strikes and virtually no lightning fires in the Canadian Rockies (White 1985, Johnson and Larsen 1991), something that is true throughout the range of aspen in western North America. Thus, if aspen burned frequently in the past as historical data suggest it did, then the vast majority of those fires were likely set by native peoples (Kay 1995).

Repeat photographs, historieal observations, and fire eeology data all indieate that frequent, low-intensity, fires were onee the norm in Banff's Bow Valley and in other montane regions of the Canadian Rockies. Grasslands, open forests, aspen, and shrubfields were once common, but have now largely been replaced by conifers under 100 years of fire exelusion and suppression. Forests have both grown-up and thickened-up since Banff National Park was established setting the stage for high-intensity crown fires, something that seldom occurred in the past (Kay *et al.* 1994, Kay and White 1995).

Repeat photographs, aspen ecology, historical observations, and archaeological data, all indicate that elk are more abundant in Banff's Bow Valley today than at any point in the past. There is no evidence that current elk densities are reflective of conditions at park establishment or in pre-Columbian times. Between 1792 and 1872, for instanee, 26 different expeditions spent 369 days traveling through the Canadian Rockies on foot or horseback yet reported seeing elk on only 12 occasions or once every 31 party-days (Kay and White 1995). Similarly, few elk bones have been recovered from archaeological sites in the Canadian Rockies (Kay *et al.* 1994), a pattern that is true throughout western North America (Kay 1990, 1992). Moreover, archaeological data suggest that all ungulate species were relatively rare in the Canadian Rockies during pre-Columbian times.

CANADIAN PRAIRIES

Historical journals and archaeological faunal evidence do indicate that bison and other ungulates were more common on the Canadian prairies, but other data suggests that even those populations were being limited by factors other than food. First, ethnohistoric and archaeological studies reveal that Native Americans in the mountains and on the plains commonly consumed large quantities of berries, such as serviceberries (*Amelanchier alnifolia*) and chokecherries (*Prunus virginiana*). Palliser (1969), Thompson (Tyrrell 1916, Coues 1965), Kane (1971), Hind (1971), Henry (Coues 1965), and others, for instance, reported that berries were abundant during the early 1800's in wooded draws on the Canadian prairies. In September 1869, the Cook-Folsom-Peterson Expedition encountered Native Americans who were gathering and drying large quantities of chokecherries at the mouth of Tom Miner Creek a few kilometers 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). 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). Since shrubs have to be at least 2 m tall before branches are commonly broken down by feeding bears, chokecherry plants in 1870 not only produced abundant berries but were also very large.

Conditions today are very different. Serviceberry and chokecherry plants in Yellowstone are now less than 50 cm tall and they produce virtually no berries because the plants are repeatedly browsed by large numbers of resource-limited elk and other ungulates (Kay in press b). 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 plants provide highly preferred forage, especially in winter. The fact that Native Americans throughout the West, including the plains, consumed large quantities of berries both historically and prehistorically means that ungulate numbers were low and that those populations were not limited by food (Kay 1994a).

A second line of evidence that ungulate numbers were low is aboriginal buffer zones. Mech (1977, 1994) reported that wolf packs used the edges of their territories less frequently than the central part of their ranges in order to avoid encounters with neighboring wolves. This reduced predation pressure along the territorial edges, which permitted more white-tailed deer (*Odocoileus virginianus*) to survive in those areas. Mech (1977) could find only one other instance of this buffer zone phenomena in the literature, a paper by Hickerson (1965) entitled "The Virginia Deer and Intertribal Buffer Zones in the Upper Mississippi Valley." Hickerson (1965) noted that

> *Warfare between members of the two tribes had the effect of preventing hunters from occupying the best game region intensively enough to deplete the (deer) supply .... In the one instance in which a lengthy truce was maintained between certain Chippewas and Sioux, the buffer, in effect a protective zone for the deer, was destroyed and famine ensued.*

My research, however, has uncovered frequent references to buffer zones created by Native American hunting (Kay 1994a). Lewis and Clark (1893), 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 two nations at war." In 1859, General Raynolds, who led an expedition across the Dakota and Montana prairies, found an abundance of grass but no game east of the Powder River. Along the Powder River, though, he reported an abundance of game and little grass, whereas to the west he again encountered an abundance of grass and no game. Raynolds (1868) noted that

> *The presence of these animals (bison) in such large numbers in this barren region (Powder River) is explained by the fact that this valley is a species of neutral ground between the Sioux and the Crows and other bands nearer the mountains, or, more correctly speaking, the common war ground visited only by war parties, who never disturb the game, as they would thereby give notice to their enemies of their presence. For this reason the buffalo remain here undisturbed and indeed would seem to make the valley a place of refuge.*

Similarly, Palliser (1969) reported that game on the Canadian prairies was more abundant in aboriginal buffer zones.

> *... I must admit, we ran some risk of being surprised by an Indian war-party .... As a general rule, the more dangerous the country the greater the probability of finding (an) abundance of game, showing in more ways than one the truth of the old sportsmen's adage, "the more danger the more the sport." This part of the country is so evidently the line of direction (demarcation) between the three hostile tribes, that none of them dare venture into it for hunting, except when driven to desperation by hunger ... Much therefore as I enjoyed the (present) locality for a hunting camp, seeing buffalo on all sides, elk feeding in the distance, and fresh deer tracks in every direction ... Boucharville (my guide) did not relish it at all, and began already to calculate how soon we were to go away.*

Hind (1971) too noted that game on the Canadian prairies was "most abundant" in aboriginal buffer zones.

So, historical sources indicate that aboriginal hunting tended to extirpate or to drive out game animals, and resource depletion around camps and villages has frequently been reported in studies of modern hunter-gatherers (Kay 1994a, in prep). This pattern would be expected if people pursued an optimal-foraging strategy with no effective conservation practices (see below). Tribal territory boundary zones also explain how early explorers could encounter an abundance of game in a few locations and a lack of game elsewhere. Many aboriginal buffer zones were up to 200 km or more wide.

Third, beaver (*Castor canadensis*) also provide evidence that historical uugulate populations were not limited by resources. There is little question that millions of beaver inhabited western North America prior to the fur trade (Johnson and Chance 1974, Kay 1994b). While beaver commonly inhabited mountain streams, large numbers were also found along water courses on the Canadian and U.S. prairies, and especially in Canada's aspen parklands. The number of beaver on untrapped streams was phenomenal. One Hudson Bay Company fur brigade, for instance, caught 511 beaver from one small northern Utah drainage in just 5 days (Kay 1994b). To support these large numbers of beaver, woody vegetation that beaver need for food and dam building materials, like aspen, willows, and cottonwoods (*Populus* sp.), must have been plentiful. Moreover, those plants could not have been subjected to repeated browsing by large numbers of resource-limited ungulates, because those species are among the first to be eliminated by high levels of herbivory.

Yellowstone provides an excellent example of the impact resource-limited ungulates have on beaver populations. During the early 1800's, Osborne Russell (1965) spent weeks trapping beaver on what is now the park's northern range. Even after Yellowstone was established as the world's first national park in 1872, there were still hundreds, if not thousands, of beaver on the northern range (Kay 1990). Today, however, beaver are ecologically extinct on Yellowstone's northern range because the park's resource-limited ungulates, through repeated browsing, have eliminated the tall willows and aspen beaver need for food (Chadde and Kay 1988, 1991; Kay and Chadde 1992). Thus, if large numbers of beaver were once common, as we know they were, then that implies ungulates had to be limited by factors other than food.

Fourth, the widespread burning of the prairies in historical and pre-Columbian times provides another line of evidence that large numbers of resource-limited bison did not inhabit the plains. Early historical observations provide ample evidence that during the late 1700's and early 1800's, prairie fires often burned for days and single fires covered huge areas, often running for 100 to 200 km or more (Nelson and England 1971, Thomas 1977, Higgins 1986). Large numbers of ungulates and large prairie fires, however, are mutually exclusive, because heavy grazing reduces standing plant biomass, prevents the accumulation of plant litter, and creates discontinuous fuel patterns, all of which prevent the growth and spread of fire (Norton-Griffiths 1979). So, if there were large fires on the Canadian prairies, as we know there were (Fidler 1990), that means bison and other ungulates could not have been food limited.

Carnivore predation and native hunting are two factors that could once have limited ungulate numbers throughout western North America. Recent research in Alaska and Canada indicates that wolves and other carnivores, primarily bears - both grizzly (*Ursus arctos*) and black (*U. americanus*), more often than not, limit ungulate populations (e.g. Gasaway *et al.* 1992; Messier 1991, 1994; Seip 1991, 1992). Today, across much of Canada and Alaska, carnivore predation limits ungulate populations to only 10% or so of what the available habitat could support. In Canada's Wood Buffalo National Park, for instance, bison have declined from around 12,000 animals during the late 1970's when wolf control was terminated, to only 3,500 today, and wolf predation has been identified as the primary factor responsible for that decline (Carbyn *et al.* 1993).

As I have discussed elsewhere, however, wolves are less efficient predators than Native Americans (Kay 1994a, 1995, in prep). The presence of aboriginal buffer zones, for instance, indicates that predation by wolves and other carnivores was not the primary factor limiting pre-Columbian ungulate populations. Moreover, contrary to prevailing beliefs, Native Americans were not conservationists, but instead harvested ungulates the exact opposite of any predicted conservation strategy. By prey-switching to alternative foods like small mammals, fish, and vegetal species, which made up 80% to 90% of most aboriginal diets, Native Americans could have taken their preferred ungulate prey to low levels or extinction without adversely effecting human populations. Furthermore, carnivore predation and native hunting were synergistic and together they decimated ungulate populations that did not have refugia in time or space (Kay 1994a, in prep).

Ungulates in the Rocky Mountains had few effective refugia, so in those areas, ungulate populations were exceedingly low or nonexistent. This explains why there were few moose (*Alces alces*) in western North America at historical contact, and why bison and other ungulates failed to prosper in the grasslands of the Columbia Basin (Kay in prep.). On the plains, however, bison and other ungulates had a refugia in time; i.e., they undertook long-distance migrations (Moodie and Ray 1976, Morgan 1980). Bergerud (1990, 1992) concluded that the sole reason barren ground caribou (*Rangifer tarandus*) migrate is to avoid wolf predation, not to secure food. Even migratory populations, however, are not able to elude all their predators. Caribou populations that migrate still have densities seven times less than food-limited caribou on predator-free islands (Seip 1992). Thus, widely quoted estimates that 50 to 70 million bison inhabited western North America prior to European contact are too high. Instead, five to 10 million bison is a more realistic estimate. This, in turn, suggests that fire was much more important in structuring the Canadian prairies than was grazing.

CONCLUSIONS

Historical data, old photographs, archaeological evidence, and information on current ecosystem states and processes can be used to determine how ecosystems functioned at various points in the past (then) and now. Those data show that, contrary to prevailing beliefs, Native Americans were the ultimate keystone species that once structured ecosystems throughout the West. Moreover, the idea that North America was a "wilderness" untouched by the hand of man prior to 1492 is 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, Stannard 1992). 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 (Kay 1995). 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, even in national parks and other protected areas (Wagner and Kay 1993, Kay and White 1995).

It must be remembered, through, that Native Americans had little immunological resistance to European introduced diseases such as smallpox, and that epidemics substantially reduced native populations throughout western North America up to 200 years before actual face-to-face contact with Europeans (Dobyns 1983, Ramenofsky 1987, Campbell 1990). So even the earliest explorers, such as Peter Fidler (1990) in Canada or Lewis and Clark (1893) in the United States, did not see western North America as it was in pre-Columbian times. Instead, there were fewer native people, probably less burning, and certainly more ungulates (Kay 1994a, 1995, in prep).

ACKNOWLEDGEMENTS

I wish to thank Cliff White, Walter Willms, Randy Simmons, Fred Wagner, the Welder Wildlife Foundation, and Parks Canada for their support.

LITERATURE CITED

Bergerud, A.T. 1990. Rareness as an anti-predator strategy to reduce predation risk. Transactions of 19th International Union of Game Biologists Congress. Proceedings held September 1989, Trondheim, Norway. Vol. 1. Population dynamics: 15-25.

Bergerud, A.T. 1992. Rareness as an antipredator strategy to reduce predation risk for moose and caribou. Pp. 1008-1021 *In* Wildlife 2001: Populations (D.M. McCullough and R. Barrett, eds.). Elsevier Applied Science, New York, New York

Byrne, A.R. 1968. Man and landscape change in the Banff National Park area before 1911. *In* Studies in land use history and landscape change. National Park Series No. 1, University of Calgary, Calgary.

Campbell, S.K. 1990. Post Columbian cultural history in northern Columbia Plateau A.D. 1500-1900. Garland Publishing Inc., New York, New York.

Carbyn, L.N., S.M. Oosenbrug, and D.W. Anions. 1993. Wolves, bison, and the dynamics related to the Peace-Athabasca Delta in Canada's Wood Buffalo National Park. Circumpolar Research Series 4. University of Alberta, Edmonton, Alberta

Chadde, S., and C.E. Kay. 1988. Willows and moose: A study of grazing pressure, Slough Creek exclosure, Montana, 1961-1986. University of Montana, Montana Forest and Conservation Experiment Station Research Note 24.

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

Coues, E., ed. 1965. New light on the early history of the greater northwest: The manuscript journals of Alexander Henry and David Thompson 1799-1814. Reprinted by Ross and Haines, Minneapolis, Minnesota. Originally published by Francis P. Harper, New York, New York. 1897.

Covington, W.W., and M.M. Moore. 1994. Southwestern ponderosa forest structure: Changes since Euro-American settlement. Journal of Forestry 92: 39-47.

DeByle, N.V., C.D. Bevins, and W.C. Fisher. 1987. Wildfire occurrence in aspen in the interior western United States. Western Journal of Applied Forestry 2: 73-76.

Denevan, W. 1992. The pristine myth: The landscape of the Americas in 1492. Association of American Geographers Annals 82: 369-385.

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

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

Fechner, G.H., and J.S. Barrows. 1976. Aspen stands as wildfire fuel breaks. Eisenhower Consortium Bulletin 4: 1-26. U.S. Forest Service Rocky Mountain Forest and Range Experiment Station, Ft. Collins, Colorado.

Fidler, P. 1990. A look at Peter Fidler's journal: Journal of a journey over land from Buckingham House to the Rocky Mountains in 1792 & 3. B. Haig, ed. Historical Research Centre, Lethbridge, Alberta.

Forman, R.T., and E.W. Russell. 1983. Evaluation of historical data. Ecological Society Bulletin 64: 5-7.

Galloway, P. 1991. The archaeology of ethnohistorical narrative. Pp. 453-469 *In* Columbian Consequences (D.H. Thomas, ed.). Smithsonian Institution Press, Washington, D.C. Vol. 3.

Gasaway, W.C., R.D. Boertje, D.V. Grangaard, D.G. Kellyhouse, R.O. Stephenson, and D.G. Larsen. 1992. The role of predation in limiting moose at low densities in Alaska and Yukon and implications for conservation. Wildlife Monograph 120.

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

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

Harper, J.R., ed. 1971. Paul Kane's frontier: Including wanderings of an artist among the Indians of North America. University of Texas Press, Austin, Texas.

Harting, A., and D. Glick. 1994. Sustaining greater Yellowstone, a blueprint for the future. Greater Yellowstone Coalition, Bozeman, Montana.

Hess, K., JR. 1993. Rocky times in Rocky Mountain National Park: An unnatural history. University Press of Colorado, Niwot, Colorado.

Hickerson, H. 1965. The Virginia deer and intertribal buffer zones in the upper Mississippi Valley. Pp. 43-65 *In* Man, culture and animals: The role of animals in human ecological adjustments (A. Leeds and A.P. Vayda, eds.). American Association for the Advancement of Science Publication 78.

Higgins, K.F. 1986. Interpretation and compendium of historical fire accounts in the Northern Great Plains. U.S. Fish and Wildlife Service Resource Publication 161.

Hind, H.Y. 1971. Narrative of the Canadian Red River exploring expedition of 1857 and of the Assinniboine and Saskatchewan exploring expedition of 1858. Charles E. Tuttle Company, Rutland, Vermont.

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

Johnson, D.R., and P.H. Chance. 1974. Presettlement over harvest of upper Columbia River beaver populations. Canadian Journal of Zoology 52: 1519-1521.

Johnson, E.A., and C.P.S. Larson. 1991. Climatically induced change in fire frequency in the southern Canadian Rockies. Ecology 72: 194-201.

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

Kay, C.E. 1992. Book review — The Jackson Hole elk herd: Intensive wildlife management in North America. Journal of Range Management 45: 315-316.

Kay, C.E. 1994a. Aboriginal overkill: The role of Native Americans in structuring western ecosystems. Human Nature 5: 359-398.

Kay, C.E. 1994b. The impact of ungulates and beaver on riparian communities in the Intermountain West. Natural Resources and Environmental Issues 1: 23-44.

Kay, C.E. 1995. Aboriginal overkill and native burning: Implications for modern ecosystem management. Eighth George Wright Society Conference on Research and Resource Management on Public Lands, Portland, Oregon. April 17-21, 1995 (in press).

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 American symposium on wolves: Their status, biology, and management. University of Alberta, Edmonton, Alberta. August 25-27, 1992.

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 Symposium on Wildland Shrub and Arid Land Restoration, Las Vegas, Nevada. October 19-21, 1993.

Kay, C.E. In prep. Aboriginal Overkill: The role of native Americans in structuring western ecosystems. Oxford University Press, New York, New York.

Kay, C.E., B. Patton, and C. White. 1994. Assessment of long-term terrestrial ecosystem states and processes in Banff National Park and the central Canadian Rockies. Resource Conservation, Parks Canada, Banff National Park, Banff, Alberta.

Kay, C.E., and C.W. White. 1995. Long-term ecosystem states and processes in the central Canadian Rockies: A new perspective on ecological integrity and ecosystem management. Eighth George Wright Society Conference on Research and Resource Management on Public Lands, Portland, Oregon. April 17-21, 1995. (in press).

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. Yellowstone National Park, Mammoth, Wyoming. Sept. 16-17, 1991.

Kay, C.E., and S.W. Chadde. 1992. Reduction of willow seed production by ungulate browsing in Yellowstone National Park. Pp. 92-99 *In* Proceedings, Symposium on Ecology and Management of Riparian Shrub Communities (W.P. Clary, E.D. McArthur, D. Bedunah, and C.L. Wambolt, eds.). U.S. Forest Service General Technical Report INT-289.

Langford, N.P. 1972. The discovery of Yellowstone Park. University of Nebraska Press, Lincoln, Nebraska.

Lewis, M., and W. Clark. 1893. The history of the Lewis and Clark expedition. Edited by E. Coues, originally published by Francis P. Harper, New York. Republished in 1964 by Dover Publications, New York. Vol. I: 1-352, Vol. II: 353-820, Vol III: 821-1364.

McCullagh, C.B. 1987. The truth of historical narratives. History and Theory (Beiheft) 26: 30-45.

Mech, L.D. 1977. Wolf-pack buffer zones as prey reservoirs. Science 198: 320-321.

Mech, L.D. 1994. Buffer zones of territories of gray wolves as regions of intraspecific strife. Journal of Mammalogy 75: 199-202.

Messier, F. 1991. The significance of limiting and regulating factors on the demography of moose and white-tailed deer. Journal of Animal Ecology 60: 377-393.

Messier, F. 1994. Ungulate population models with predation: A case study with the North American moose. Ecology 75: 478-488.

Moodie, D.W., and A.J. RAY. 1976. Buffalo migrations in the Canadian plains. Plains Anthropologist 21: 45-52.

Morgan, R.G. 1980. Bison movement patterns on the Canadian plains: An ecological analysis. Plains Anthropologist 25(88 part 1): 143-160.

Nelson, J.G. 1967. Man and landscape in the western plains of Canada. Canadian Geographer 11: 251-264.

Nelson, J.G. 1969a. Some observations on animals, landscape, and man, in the Bow Valley Area: c. 1750-1885. Pp. 219-237 *In* Vegetation, soils, and wildlife (J.G. Nelson and M.J. Chambers, eds.). Methuen, Toronto, Ontario.

Nelson, J.G. 1969b. Land use history, landscape change and planning problems in Banff National Park. International Union for the Conservation of Nature Bulletin 2: 80-82.

Nelson, J.G. 1970. Man and landscape change in Banff National Park: A national park problem in perspective. Pp. 63-96 *In* The Canadian parks in perspective (J.G. Nelson, ed.). Harvest House, Montreal, Quebec.

Nelson, J.G. 1972. Some reflections on man's impact on the landscape of the Canadian prairies and nearby areas. Pp. 33-50 *In* The Canadian prairies (P.J. Smith, ed.). University of Toronto, Toronto, Ontario.

Nelson, J.G. 1973. Animals, fire and landscape in the northwestern plains of North America in pre and early European days. Pp. 63-79 *In* Prairie perspectives (A.W. Rasporich and H.C. Klassen, eds.). Holt, Rinehart, and Winston, Toronto, Ontario.

Nelson, J.G., and R.E. England. 1971. Some comments on the causes and effects of fire in the northern grasslands area of Canada and the nearby United States, 1750-1900. Canadian Geographer 15: 295-306.

Norton-Griffiths, M. 1979. The influence of grazing, browsing, and fire on the vegetation dynamics of the Serengeti. Pp. 310-352 *In* Serengeti: Dynamics of an ecosystem (A.R.E. Sinclair and M. Norton-Griffiths, eds.). University of Chicago Press, Chicago, Illinois.

Palliser, J. 1969. Solitary rambles and adventures of a hunter in the prairies. Charles E. Tuttle Company, Rutland, Vermont.

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

Raynolds, F.W. 1868. Report on the exploration of the Yellowstone River in 1859-60. U.S. Senate Executive Document 77, 40th Congress, 2nd Session.

Rogers, G.F., H.E. Malde, and R.M. Turner. 1984. Bibliography of repeat photography for evaluating landscape change. University of Utah Press, Salt Lake City, Utah.

Russell, O. 1965. Journal of a trapper, 1834-43. (A.L. Haines, ed.). University of Nebraska Press, Lincoln, Nebraska.

Seip, D.R. 1991. Predation and caribou populations. Rangifer (Special Issue) 7: 46-52.

Seip, D.R. 1992. Wolf control and the management of ungulate populations. Pp. 331-340 *In* Wildlife 2001: Populations (D.M. McCullough and R. Barrett, eds.). Elsevier Applied Science, New York, New York.

Simms, S.R. 1992. Wilderness as a human landscape. Pp. 183-201 *In* Wilderness tapestry (S.I. Zeveloff, L.M. Vause, and W.H. McVaugh, eds.). University of Nevada Press, Reno, Nevada.

Spalding, D.J. 1990. The early history of moose (*Alces alces*): Distribution and relative abundance in British Columbia. Royal British Columbia Museum Contributions to Natural Science 11: 1-12.

Spalding, D.J. 1992. The history of elk (*Cervus elaphus*) in British Columbia. Royal British Columbia Museum Contributions to Natural Science 18: 1-27.

Stannard, D.E. 1992. American holocaust. Oxford University Press, New York, New York.

Thomas, G. 1977. Fire and fur trade: The Saskatchewan District: 1790-1840. The Beaver (Autumn): 32-39.

Tyrrell, J.B., ed. 1916. David Thompson's narrative of his exploration in western America 1784-1812. The Champlain Society, Toronto, Ontario.

Wagner, F.H., and C.E. Kay. 1993. "Natural" or "healthy" ecosystems: Are U.S. National Parks providing them? Pp. 257-270 *In* Humans as components of ecosystems (M.J. McDonnell and S.T. Pickett, eds.). Springer-Verlag, New York, New York.

White, C.A. 1985. Wildland fires in Banff National Park 1880-1980. Occasional Paper 3. National Parks Branch, Parks Canada, Environment Canada, Ottawa, Ontario.

White, R. 1991. It's your misfortune and none of my own: A history of the American West. University of Oklahoma Press, Norman, Oklahoma.

Provincial Museum of Alberta
Natural History
Occasional Paper No. 23
1996

PROCEEDINGS OF THE FOURTH PRAIRIE CONSERVATION AND ENDANGERED SPECIES WORKSHOP

February 1995

At
The University of Lethbridge
and
Lethbridge Community College
Lethbridge, Alberta

Edited by:
Walter D. Willms
Johan F. Dormaar

Published by:

Curatorial Section
Provincial Museum of Alberta
12845-102 Avenue
Edmonton, Alberta
T5N OM6