Ruthann Knudson

Using the Past to Shape National Park Service Policy for Wild Life

NPS Natural Resource Management Policies and Paleoecological Research

To understand modern ecosystems and the wild life in them, and manage these and future ecosystems, one has to know about past ecologies and the complex interrelationships among their biological, geophysical, and sociocultural components. In drafting its statement of ecosystem management within the National Park System (NPS 1994), the National Park Service (NPS) recognized that "living things exist in complex, interconnected systems within a broad landscape" and that cultural systems are and have been part of ecosystems (NPS 1994, 5), though this is not clearly recognized in Halvorson and Davis's recent book *Science and Ecosystem Management in the National Parks* (1996).

I manage a park with Miocene mammalian fossil beds, and I suggest that paleontological and paleoecological information from throughout at least the past 20 million years is useful to understanding modern ecosystems (Knudson 1999). Certainly we ought to understand them throughout the 100,000 or so years of the Wisconsinan period of the Late Pleistocene, and certainly we need to understand the paleoecology of the last 15 to 25 millennia in North America, the terminal Late Pleistocene and Holocene period, when people were living in the American hemisphere.

Current NPS policies for managing wildlife are set forth in the agency-wide *Management Policies* (NPS 1988, chap. 4), which are consistent with the Leopold Report's recommendation (Leopold et al. 1963) that NPS landscapes should generally represent pre-Euroamerican panorama (cf. Huff 1993, 1997; Sellars 1997; Wagner et al. 1995). The more recent *Natural Resources Management Guidelines* (known as *NPS-77;* NPS 1991) retain this approach. Natural and social science research are an integral element in supporting NPS natural resource management program planning and implementation. However, as Porter and Underwood (1996) have pointed out, NPS reacted to the Leopold Report, and the various policies based on it, by seeking ecological constancy rather than equilibrium. As NPS has developed new understanding of the fluctuations in natural processes and worked at developing more responsive resource management programs, it has had problems communicating the value of the new concepts in contrast to the publicly understood goal of maintaining the status quo.

NPS's 1993 sustainable design guidance (NPS 1993) includes requirements for a basic understanding of natural behavior within an ecosystem, cumulative human demands, an initial definition of the acceptable limits of change, and routine monitoring and evaluation. Understanding the dynamic nature of ecosystems over the past 100,000 years and formally recognizing this in policy and guidance would add significantly to the Service's ability to plan and monitor its natural resource management activities and gain public support for those.

Academic and government scholars have been conducting paleoecological research in the national parks throughout the past century, especially during its second half. Most of these paleoecological studies (e.g., Fryxell 1930; Heusser 1972; Mehringer 1977; Waddington and Wright 1974; Wright and Frey 1965; cf. Beaudoin and Beintjes 1994) have focused on biological or geophysical contexts, but there has also been a century of archeological and historic studies that provided paleoenvironmental data. These began on what were to be NPS lands as early as Bandelier's 1880 research at Pecos (Lee 1970; cf. Rothman 1989) and continue today with projects such as those by Kuehn (1995) and Fredlund and Sundstrom (1996). Together, these constitute some of the most significant contributions to Late Quaternary studies.

Until recently (e.g., Whitlock et al. 1991) NPS has not consciously incorporated the collected data into its natural resource management programs. The terms "geomorphology," "paleoecology," "palynology," and "pedology" are not mentioned in the 1991 natural resource management guidelines, and much less is there recognition of the baseline data available in cultural resource studies. NPS now recognizes that the systematic evaluation and synthesis of the known paleoecological data from its park units and their regional contexts, and programmatic collection of new data, is a critical element in managing the dynamic ecological communities within the agency's lands and waters. There is also an opportunity for the NPS, particularly in partnership with the U.S. Geological Survey's Geological Resources, Water Resources, National Mapping (McClelland 1997), and Biological Resources (Selleck 1997) divisions, to provide leadership in building models for the practical application of these scientific data about past ecosystems. The Sierra Nevada Ecosystem Project (CWWR 1996) incorporated sociocultural, biological, and geophysical information and evaluations into its management planning. Yellowstone's northern range studies (YNP 1997) are a pivotal recognition of the interrelationships of the sociocultural, biological, and geophysical components within ecosystems and the utility of diachronic information about all these relationships in wildlife management planning.

Climatic Change Over 110,000 Years

We now have information about 110,000 years of climate and climatic changes leading up to the present time in North America, including scientifically acceptable information about the presence of people in the American ecosystem in the Late Pleistocene.

Radiocarbon (^{14}C) dating of organic materials up to about 40,000 years in age was introduced to the archaeological and geological world in January 1948 (Taylor 1987, 155), and our understanding of paleoecology has developed immensely since. There is a variety of methods for dating organic and inorganic Quaternary deposits and materials (Rutter and Catto 1995) that provides us with chronological data to build models of past climates and ecosystems.

For generations people have been trying to figure out how climates and weather come to be, probably since people relied on hunted and gathered wild foods and certainly since they began to rely on cultivated crops. In his introduction to the recent publication on the COHMAP project (Cooperative Holocene Mapping Project; Wright et al. 1993), Wright (1993) notes that it was Milankovitch's post-World War I computations of variations in the Earth's orbit around the sun that was the key to the scientific understanding of climate and climatic variability. Milankovitch had documented the Earth's "precession," or seasonal changes in the Earth–sun orbital geometry due to solar and lunar gravitational forces upon the Earth. When ocean cores and glacial features could be radiocarbon-dated, there was an apparent correlation of major climatic changes and the precession cycles.

On the basis of this information, and with increased computer capabilities, the CLIMAP (Climate Mapping, Analysis and Prediction) modeling project was initiated in the 1970s by a group of paleoceanographers. Computerized models of Milankovitch cycles were compared with ocean core data, and the CLIMAP reports proved to be strong evidence supporting Milankovitch's theories. In the late 1970s, the COHMAP project was initiated to model climates over both land masses and ocean bodies. COHMAP models include global January and July temperatures, surface wind/sea-level pressures, precipitation, annual precipitation minus evaporation, wind speed, and surface storm tracks at 3,000-year intervals over the past

18,000 years (Wright et al. 1993). Broecker (1995, 1997), who has modeled the ocean's thermohaline circulation system, notes that it is very sensitive to freshwater additions and may be a key to global climatic shifts that can jump from one mode to another in a decade. Bryson (1988, 1993) has been a leader in modeling climate change in the Northern Hemisphere, and has highlighted the influence of volcanic ash in affecting solar budgets and weather patterns. It should be noted that not all scholars (e.g., Muller and MacDonald 1997) accept the primacy of Milankovitch cycles in regulating glacial cycles, but the Milankovitch model prevails at present.

Any model is only as good as the data supporting it. A problem linking the models and real-world data was pointed out recently in an overview of general circulation models by Sellers et al. (1997), who note that the global carbon cycle is intricately linked to the physical climate system and that, therefore, radiocarbon determinations must be calibrated against some other dating system to accommodate the climatic changes being documented (cf. Eglington et al. 1997; Freeman 1997; Schindler et al. 1997).

Since the modeled COHMAP data have been developed, researchers around the world have used datable sediment core materials (e.g., pollen, dust, volcanic ash, invertebrates, soils) to test the hypothesized data triggered by precessional concepts. Past paleoecological information collection from national park lands is important to evaluations of these models, and new research designed to provide a more systematic understanding of the paleoecology of individual park units would provide comparative information for testing the modeled hypotheses, as well as support more informed natural resource management planning and public education.

In the 1990s, several deep cores were taken from the ice in Greenland (Zielinski and Mershon 1997) and Antarctica (Mayewski et al. 1996), and these give annual climatic data for the past 110,000 years. The Greenland GISP2 core and evidence from ostracod and disseminated organics and seeds in pluvial Lake Estancia, New Mexico (Allen and Anderson 1993), indicate significant climatic changes between 20,000 and 13,000 years ago at decadal intervals.

Researchers are learning a lot about global patterns, and are refining it and regionalizing it with data from specific landforms, cores, estimated ice volumes, etc. Recently, a working group of zoologists and archeozoologists has developed the FAUNMAP database, collecting information on the fossil mammal faunas from nearly 3,000 localities across the USA (Graham et al. 1996). The data document that mammalian range shifts were a complex response to climatic change, habitat reorganization, biological interactions, and stochastic events, and the researchers concluded that models for future change must rely more on individual species and their requirements than on species associations. In complement, Pitelka et al. (1997) have used a COHMAP-like approach to model the distribution of plant communities over periods of climatic change, and comparison of these and the FAUNMAP data may aid in explaining faunal distributions over time. Holman (1995) has synthesized the existing knowledge of Quaternary herpetofaunas in North America, and notes that no genera became extinct at the Pleistocene–Holocene transition. The concept that glacial cycles and related climatic changes have had a dominant role in influencing vertebrate genetic adaptations during the Quaternary is not supported by songbird genetics (Klicka and Zink), which document a five-million-year history of speciation.

While the traditional U.S. professional archeological hypothesis is that people settled the Americas from Asia, bioanthropological documentation of that is ongoing, and several scholars are questioning the hypothesis (e.g., Bonnichsen et al. 1995, 41-44; cf. Deloria 1995). The preponderance of the morphological, genetic, and mitochondrial DNA evidence collected to date from Native Americans supports an Asian-origin hypothesis. Recent geological investigations at the archaeological Diring Yuriakh site on the Lena River in northeastern Siberia support dates of from 366,000 to 240,000 years ago for humanly made choppers and scrapers (Waters et al. 1997, though see Rink 1997), which provides evidence of an adaptation to northern latitudes older than that which was previously believed. At this point, the possibilities are open as to the earliest movement of people into the Americas and what would be recognized as evidence of their presence.

There is well-accepted archaeological evidence from the Monte Verde site in Chile (Dillehay 1997) that people were established in the Americas by 12,500 years ago. Native American population estimates in 1492 vary. Dobyns (1983) estimates that the population north of Mexico then was 18 million, and this is generally supported by Ramenofsky (1987); in contrast Verano and Ubelaker (1992) estimate under 2 million people. I am more comfortable with Dobyns' and Ramenofsky's research.

Many of the local geophysical, biological, and cultural data continue to come from NPS lands and waters (e.g., Kuehn 1995; Romme and Turner 1991), and the relatively unmodified properties could be an even greater source of paleoecological information to use in managing resources and providing public education.

Paleoecological Data Collection and Analysis

We know North American ecosystems of the past were dynamic, and that people were part of them from at least 12,500 years ago, and perhaps as much as 30,000 years. What are the methods of collecting information about what the past ecosystems were like and how people, fauna, flora, weather, and Earth resources interacted?

Information can come from archaeological sites with associated paleoecological data, or from sites with no cultural evidence. In additional to the paleoecological information, archaeological sites often provide direct evidence of human use of natural resources or the landscape. Physical remains that provide paleoecological information include the following: geomorphology and stratigraphy; soils, with humic acids for dating; pollen; malacology; plant macrofossils, including peat; vertebrate remains; core materials, including oxygen isotope data, dust, volcanic ash, and diatoms.

Information is also available in historical records and archival materials, including comments from early Euro-American explorers, such as Lewis and Clark (Moulton 1983, 1986-1993), Ogden (Cline 1974), and Culbertson (1952); artists and draftsmen such as Bodmer (Hunt and Gallagher 1984); and early photographers such as Curtis (Andrews 1962) and Jackson (Hale 1984). There are extensive comments about vegetation and marker trees in the records of the General Lands Office that date to 1812 (since the 1940s, the records have been held by Division of Lands of the Bureau of Land Management; see Harrison 1962). There are 6,000 volumes of cadastral survey notes (a major source of vegetation data) and 100,000 survey plats. There is also information about flora, fauna, weather, and landscapes in diaries and letters in local, state, and national archives (e.g., Bustard 1992).

There is a wealth of natural resource information in ethnographic reports and frontier autobiographies, particularly those from the late nineteenth and early twentieth centuries when Native Americans were still practicing many of their traditional subsistence patterns (e.g., Schultz (1962) about life in the Northern Plains between 1878 and 1915; see also Glenn 1992). Schlesier (1994) has linked the prehistoric archeological record of the Plains to modern Native American tribes and groups, but these associations are tenuous given the amount of time which has elapsed and the sparseness of the data.

NPS, Paleoecology, and Natural Resource Management

In the past decade, especially since the 1992 Earth Summit in Rio de Janeiro, land managers and the general public have come to better understand the linkages among the geophysical, biological, and sociocultural components of ecosystems and realize that few diachronic baseline data are available from which to monitor future changing conditions. Collection of such data, including its description as scientifically useful information, is labor-intensive; the availability of computers has assisted in cutting analysis time and supporting more sophisticated linkages; still, the data first have to be collected. There is little immediate public return for data collection, and hence funds for it do not compete well with (for example) primary and secondary education programs and policing needs. Information about the past, especially the distant past, is often difficult to find—dynamic geophysical erosion and deposition processes have not left that many readily available and well-preserved deposits. There is no law protecting peat bogs and significant Late Quaternary landforms, unless they are within managed public lands. Archeological sites with their embedded paleoecological information are more frequently seen by land managers only as a compliance issue—something that has to be inventoried and treated in compliance with legal mandates before the *real* resource management activity can be accomplished.

In 1997, the Institute for Environmental Education's Annual Environmental Forum was entitled "Reality is What Goes on Between the Disciplines," focusing on the disciplines within the life and earth sciences. I suggest that that paradigm be taken one step further, to look at what goes on among all the disciplines and constituencies that represent the major components of ecosystems as that concept is defined by NPS (NPS 1994).

Given the limited availability of funds, both within NPS and outside of it, we need to be smarter with what we have.

Within NPS, there has been a great variety of projects that have collected paleoecological data. Here is a selection of references. The Sierra Nevada Ecosystem Project (CWWR 1996) included multidisciplinary information about traditional Native American land-use practices and ecological impacts (CWWR 1996; Anderson and Nabhan 1991) and historic settlement patterns. In Olympic National Park, ethnographic, ethnohistoric, and archeological data have been used to understand the distribution of mountain goats over time (ONP 1995; Schalk 1993; Schultz 1994). The role of ancient hunters in Alaskan ecosystems has been described (Birkedal 1993). Various natural and cultural paleoecological data have been described in Yellowstone (e.g., Barnosky 1994; Cannon 1998; Cannon and Phillips 1993; Conner 1991; Greiser 1994; Janetski 1987; Johnson 1997), but until recently (YNP 1997) have not been integrated to provide a truly interdisciplinary diachronic perspective (cf. comments in Boyce 1991; Coughenour and Singer 1991; GTNPNER 1996; Singer 1996). Lynott (1993) has collected natural and cultural paleoecological data for the Ozark National Scenic Riverways, and Richner (1993) has evaluated the role of Native Americans in the Voyageurs National Park ecosystem (cf. Bonnicksen et al., forthcoming). I have described the various paleoecological data sets currently or potentially available for Agate Fossil Beds National Monument lands (Knudson 1999). There are dozens of NPS archeological reports available (e.g., Alex 1991) that include important natural paleoecological information useful to wildlife managers.

Paleoecological information has been collected from NPS lands for a century, and much of this can make a contribution to the agency's wildlife management by providing an interdisciplinary diachronic baseline. Several activities would support development and use of this baseline.

- Available specific and regional paleoecological information should be compiled and interpreted for each NPS unit by an interdisciplinary team.
- Data gaps should be identified.
- Missing information should be actively sought.
- The use of interdisciplinary paleoecological data should be supported by managers, without being bounded by traditional NPS barriers between natural and cultural programs. This should include funding and staffing decisions and revisions to *NPS-77*.
- Managers and resource specialists at all levels should be trained in the use of multidisciplinary paleoecological information in developing current policies and programs.
- As new multi-resource ecological data are collected, they should be integrated with previously collected information and the whole combined with natural resource monitoring information to understanding developing processes.

Under NPS's compliance with GPRA, the Government Performance and Results Act (Public Law 106-62, 31 U.S. Code 1101; NPS 1997a), NPS has developed a national strategic plan (NPS 1997b) and the natural resource stewardship and science program has its own strategic plan (NPS 1997c). At present, none of these is consistent with the NPS draft ecosystem management statement (NPS 1994), but each rather reflects the strong disciplinary-specific programs sustained in the agency's recent reorganization. NPS's GPRA response and current long-range planning do not provide opportunities for the kind of interdisciplinary integration of paleoecological information that has provided such a strong basis for the Sierra Nevada ecosystem management plan (CWWR 1996) and Yellowstone's northern range evaluations (YNP 1997). We need to search out those opportunities and the policy support to implement them.

References

Alex, L. M. 1991. *The Archeology of Beaver Creek Shelter (39CU779): A Preliminary Statement.* Selections from the Division of Cultural Resources, Rocky Mountain Region No. 3. Denver: National Park Service.

Allen, G. D., and R. Y. Anderson. 1993. Evidence from western North America for rapid shifts in climate during the last glacial maximum. *Science* 260, 1920-1923.

Anderson, M. K., and G. P. Nabhan. 1991. Gardeners in Eden. *Wilderness* 55(194), 27-30.

Andrews, R. W. 1962. *Curtis' Western Indians.* New York: Bonanza.

Barnosky, E. H. 1994. Ecosystem dynamics through the past 2,000 years as revealed by fossil mammals from Lamar Cave in Yellowstone National Park, USA. *Historical Biology* 8, 71-90.

Beaudoin, A. B., and F. D. Reintjes. 1994. *Late Quaternary Studies in Beringia and Beyond, 1050-1993: An Annotated Bibliography.* Archaeological Survey Occasional Paper no. 35. Edmonton: Provincial Museum of Alberta.

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. Pp. 174-177 in *Partners in Stewardship: Proceedings of the Seventh Conference on Research and Resources Management in Parks and on Public Lands.* W. E. Brown and S. D. Veirs, Jr., eds. Hancock, Mich.: The George Wright Society.

Bonnichsen, R., T. D. Dillehay, G. C. Frison, F. Ikawa-Smith, R. Knudson, D. G. Steele, A. R. Taylor, and J. Tomenchuck. 1995. Future directions in First Americans research and management. Pp. 30-71 in *The Public Trust and the First Americans.* R. Knudson and B. C. Keel, eds. Corvallis: Oregon State University Press.

Bonnicksen, T. M., M. K. Anderson, H. T. Lewis, C. E. Kay, and R. Knudson. Forthcoming. American Indian influences on the development of North America's native forest ecosystems. In *Ecological Stewardship Handbook.* W. Sexton and R. Szaro, eds. Washington, D.C.: U.S. Forest Service.

Boyce, M. S. 1991. Natural regulation or the control of nature? Pp. 183-308 in *The Greater Yellowstone Ecosystem: Redefining America's Wilderness Heritage.* R. B. Keiter and M. S. Boyce, eds. New Haven, Conn.: Yale University Press.

Broecker, W. S. 1995. *The Glacial World According to Wally.* Palisades, N.Y.: Eldigo Press, Lamont-Doherty Earth Observatory, Columbia University.

———. 1997. Will our ride into the greenhouse future be a smooth one? *GSA Today* 7(5), 1-7.

Bryson, R. 1988. Civilization and rapid climatic change. *Environmental Conservation* 15(1), 7-15.

———. 1993. Simulating past and forecasting future climates. *Environmental Conservation* 20(4), 339-346.

Bustard, B. I. 1992. *Western Ways: Images of the American West—An Exhibition at the National Archives and Records Administration, Washington, DC.* Washington, D.C.: National Archives Trust Fund Board.

Cannon, K. P. 1998. *A Review of Prehistoric Faunal Remains from Various Contexts in Yellowstone National Park, Wyoming.* Mammoth Hot Springs, Wyo.: Yellowstone National Park, National Park Service.

Cannon, K. P., and P. Phillips. 1993. *Post-Fire Inventory and Evaluation in Yellowstone National Park, Wyoming: The 1989 Field Season.* Midwest Archeological Center Technical Report No. 24. Lincoln, Neb.: Midwest Archeological Center, National Park Service.

CWWR [Centers for Water and Wildland Resources]. 1996. *Status of the Sierra Nevada, Volume 11: Assessments and Scientific Basis for Management Options.* Sierra Nevada Ecosystem Project Final Report to Congress. Wildland Resources Center Report No. 37. Davis: CWWR, University of California–Davis.

Cline, G. L. 1974. *Peter Skene Ogden.* Norman: University of Oklahoma Press.

Conner, M. A. 1991. Human ecology of the greater Yellowstone area. Pp. 331-339 in *Partners in Stewardship: Proceedings of the Seventh Conference on Research and Resources Management in Parks and on Public Lands.* W. E. Brown and S. D. Veirs, Jr., eds. Hancock, Mich.: The George Wright Society.

Coughenour, M. B., and F. J. Singer. 1991. The concept of overgrazing and its application to Yellowstone's northern range. Pp. 209-230 in *The Greater Yellowstone Ecosystem: Redefining America's Wilderness Heritage.* R. B. Keiter and M. S. Boyce, eds. New Haven, Conn.: Yale University Press.

Culbertson, T. A. (J. F. McDermott, ed.). 1952. *Journal of an Expedition to the Mauvaises Terres and the Upper Missouri in 1850.* Bureau of American Ethnology Bulletin no.147. Washington, D.C.: Smithsonian Institution.

Dillehay, T. D. 1997. *Monte Verde: A Late Pleistocene Settlement in Chile. Volume 2: The Archaeological Context and Interpretation.* Washington, D.C.: Smithsonian Institution Press.

Deloria, Vine, Jr. 1995. *Red Earth, White Lies.* New York: Scribner's.

Dobyns, H. F. 1983. *Their Number Become Thinned: Native American Population Dynamics in Eastern North America.* Knoxville: University of Tennessee Press.

Eglington, T. I., B. C. Benitez-Nelson, A. Pearson, A. P. McNichol, J. E. Bauer, and E. R. M. Druffell. 1997. Variability in radiocarbon ages of individual organic compounds from marine sediments. *Science* 277, 796-799.

Elias, S. A. 1995. *The Ice-Age History of Alaskan National Parks.* Washington, D.C.: Smithsonian Institution Press.

———. 1996. *The Ice-Age History of National Parks in the Rocky Mountains.* Washington, D.C.: Smithsonian Institution Press.

Fredlund, G. G., and L. Sundstrom. 1996. Geomorphology and geoarchaeology of Lower Highland Creek, Wind Cave National Park, South Dakota. Report on file. Denver: Rocky Mountain Region, National Park Service.

Freeman, K. H. 1997. A new look at old carbon. *Science* 277:777-778.

Fryxell, F. M. 1930. Glacial features of Jackson Hole, Wyoming. *Augustana Library Publication 13.* N.p.

Glenn, J. R. 1992. *Guide to the National Anthropological Archives, Smithsonian Institution.* Washington, D.C.: National Anthropological Archives, National Museum of Natural History, Smithsonian Institution.

Graham, R. W., E. L. Lundelius Jr., M. A. Graham, E. K. Schroeder, R. S. Toomey III, E. Anderson, A. D. Barnosky, J. A. Burns, C. S. Churcher, D. K. Grayson, R. D. Guthrie, C. R. Harington, G. T. Jefferson, L. D. Martin, H. Gregory McDonald, R. E. Morlan, H. A. Semken Jr., S. D. Webb, L. Werdelin, and M. C. Wilson. 1996. Spatial response of mammals to Late Quaternary environmental fluctuations. *Science* 272, 1801-1806.

GTNPNER [Grand Teton National Park National Elk Refuge]. 1996. *Jackson Bison Herd Long Term Management Plan and Environmental Assessment.* Moose, Wyo.: Grand Teton National Park National Elk Refuge, National Park Service, in cooperation with Wyoming Game and Fish Department and Bridger-Teton National Forest.

Greiser, S. T. 1994. Archeological implications of changing levels of Yellowstone Lake, Yellowstone National Park, Wyoming. *Current Research in the Pleistocene* 11, 106-108.

Hale, P. 1984. *William Henry Jackson.* London: Macdonald & Co., Ltd.

Halvorson, W. L., and G. E. Davis, eds. 1996. *Science and Ecosystem Management in the National Parks.* Tucson: University of Arizona Press.

Harrison, R.W. 1962. Public land records of the federal government. Pp. 487-499 in Carstensen, V., ed. *The Public Lands: Studies in the History of the Public Domain.* Madison: University of Wisconsin Press. (Reprinted from *Mississippi Valley Historical Review* 41 [1954], 277-288).

Heusser, C. J. 1972. Palynology and phytogeographical significance of a late Pleistocene refugium near Klaloch, Washington. *Quaternary Research* 2, 189-201.

Holman, J. A. 1995. *Pleistocene Amphibians and Reptiles in North America.* London: Oxford University Press.

Huff, D. E. 1993. On naturalness. Pp. 174-177 in *Partners in Stewardship: Proceedings of the Seventh Conference on Research and Resources Management in Parks and on Public Lands.* W. E. Brown and S. D. Veirs, Jr., eds. Hancock, Mich.: The George Wright Society.

Huff, D. E. 1997. Wildlife management in America's national parks: Preparing for the next century. *The George Wright Forum* 14(1), 25-33.

Hunt, D. C., and M. V. Gallagher. 1984. *Karl Bodmer's America.* Lincoln: Joslyn Art Museum and University of Nebraska Press.

Janetski, Joel C. 1987. *Indians of Yellowstone Park.* Salt Lake City: Bonneville Books, University of Utah Press.

Johnson, A. 1997. How long have bison been in the park? *The Buffalo Chip* (January-March), 5. [Resource management newsletter, Yellowstone National Park.]

Klicka, J., and R. M. Zink. 1997. The importance of recent ice ages in speciation: A failed paradigm. *Science* 277, 1666-1669.

Knudson, R. 1999. Using cultural resources to enhance ecosystem management. Pp. 129-139 in *Integrating Social Sciences and Ecosystem Management.* H. K. Cordell, and and J. D. Bergstrom, eds. Champaign, Ill.: Sagamore.

Kuehn, D. D. 1995. The geoarchaeology of the Little Missouri Badlands: The Late Quaternary stratigraphic and paleoenvironmental context of the archaeological record. N.p.

Lee, R. F. 1970. *The Antiquities Act of 1906.* Report No. FNP-HH-71-38, National Park Service. NTIS Report PB 200 042. Springfield, Va.: National Technical Information Service.

Leopold, A. S., S. A. King, C. M. Cottam, I. N. Gabrielson, and T. L. Kimball. 1963. Wildlife management in national parks. *Transactions of the North American Wildlife and Natural Resources Conference* 28, 29-45.

Lynott, M.J. 1993. Past patterns of human adaptations in the eastern Ozarks, southeast Missouri. Pp. 389-393 in *Partners in Stewardship: Proceedings of the Seventh Conference on Research and Resources Management in Parks and on Public Lands.* W. E. Brown and S. D. Veirs, Jr., eds. Hancock, Mich.: The George Wright Society.

Mayewski, P. A., M. S. Twickler, S. I. Whitlow, L. D. Meeker, Q. Yang, J. Thomas, K. Kreutz, P. M. Grootes, D. L. Morse, E. J. Steig, E. D. Waddington, E. S. Saltzman, P.-Y. Whung, and K. C. Taylor. 1996. Climate change during the last deglaciation in Antarctica. *Science* 272, 1636-1638.

McClelland, L. 1997. Working with the U.S. Geological Survey: Partnership with the USGS. P. 27 in *Natural Resource Year in Review 1996.* J. Selleck, ed. Lakewood, Colo.: Natural Resource Information Division, Natural Resource Program Center, National Park Service.

Mehringer, P. J., Jr. 1977. Great Basin late Quaternary environments and chronology. *Desert Research Institue Publications in Social Science* 12, 113-167.

Moulton, G. E. 1983. *The Atlas of the Lewis and Clark Expedition.* Lincoln: University of Nebraska Press.

Moulton, G. E., ed. 1986-1993. *The Journals of the Lewis & Clark Expedition.* 8 vols. Lincoln: University of Nebraska Press.

Muller, R. A., and G. J. MacDonald. 1997. Glacial cycles and astronomical forcing. *Science* 277, 215-218.

NPS [National Park Service]. 1988. *Management Policies.* Washington, D.C.: National Park Service.

———. 1991. *Natural Resources Management Guidelines, NPS-77.* Washington, D.C.: National Park Service.

———. 1993. *Guiding Principles of Sustainable Design.* Denver: Denver Service Center, National Park Service.

———.1994. Ecosystem management in the National Park Service (discussion draft). Vail Agenda: Resource Stewardship, Ecosystem Management Working Group. Washington, D.C.: National Park Service.

———. 1997a. *GPRA on the GO: Government Performance and Results Act (GPRA) & Performance Management.* Washington, D.C.: Office of Strategic Planning, National Park Service.

———. 1997b. *National Park Service FY99 Annual Performance Plan.* Washington, D.C.: National Park Service.

———. 1997c. *Natural Resource Stewardship and Science (NRSS) Strategic Plan.* Washington, D.C.: Office of the Associate Director, Natural Resource Stewardship and Science, National Park Service.

ONP [Olympic National Park]. 1995. *Goats in Olympic National Park: Draft Environmental Impact Statement for Mountain Goat Management.* Port Angeles, Wash.: Olympic National Park, National Park Service.

Pitelka, L. F., R. H. Gardner, J. Ash, S. Berry, H. Gitay, I. R. Noble, A. Saunders, R. H. W. Bradshaw, L. Brubaker, J. S. Clark, M. B. Davis, S. Sugita, J. M. Dyer, R. Hengeveld, G. Hope, B. Huntley, G. A. King, S. Lavorel, R. N. Mack, G. P. Malanson, M. McGlone, I. C. Prentice, and M. Rejmanek. 1997. Plant migration and climate change. *American Scientist* 85, 464 ff..

Porter, W. F., and H. B. Underwood. 1996. Of elephants and blind men: Deer management in the U.S. national parks. Paper presented at The Ecological Society annual meeting.

Ramenofsky, A. F. 1987. *Vectors of Death.* Albuquerque: University of New Mexico Press.

Richner, J. J. 1993. The Chippewa occupation of the Voyageurs National Park area. Pp.437-442 in *Partners in Stewardship: Proceedings of the Seventh Conference on Research and Resources Management in Parks and on Public Lands.* W. E. Brown and S. D. Veirs, Jr., eds. Hancock, Mich.: The George Wright Society.

Rink, W. J. 1997. Archaeological dating. *SAS Bulletin* 20(3/4), 8-9.

Romme, W. H., and M. G. Turner. 1991. Implications of global climatic change for biogeographic patterns in the greater Yellowstone ecosystem. *Conservation Biology* 5(3), 373-386.

Rothman, H. 1989. *Preserving Different Pasts: The American National Monuments.* Urbana: University of Illinois Press.

Rutter, N. W., and N. R. Catto, eds. 1995. *Dating Methods for Quaternary Deposits.* GEOtext2. St. John's: Geological Association of Canada, Memorial University of Newfoundland.

Schalk, R. 1993. A review of the ethnographic and archaeological evidence relating to mountain goats in the Olympic Mountains. Report on file. Seattle: National Park Service.

Schindler, D. E., S. R. Carpenter, J. J. Cole, J. F. Kitchell, and M. L. Pace. 1997. Influence of food web structure on carbon exchange between lakes and the atmosphere. *Science* 277, 248-251.

Schlesier, K. E., ed. 1994. *Plains Indians, A.D. 500-1500: The Archaeological Past of Historic Groups.* Norman: University of Oklahoma Press.

Schultz, J. W. (K. C. Seele, ed.). 1962. *Blackfeet and Buffalo: Memories of Life Among the Indians.* Norman: University of Oklahoma Press.

Schultz, S. 1994. Review of the historical evidence relating to mountain goats in Olympic Mountains before 1925. Pp. 256-293 in *Mountain Goats in Olympic National Park: Biology and Management of an Introduced Species.* D. B. Houston, E. G. Schreiner, and B. B. Moorehead. Scientific Monograph NPS/NROLYM/NRSM-94/25. Seattle: National Park Service.

Selleck, J. 1997. USGS plans for future. *Park Science* 17(1), 3.

Sellars, R. W. 1997. *Preserving Nature in the National Parks: A History.* New Haven, Conn.: Yale University Press.

Sellers, P. J., R. E. Dickinson, D. A. Randall, A. K. Betts, F. G. Hall, J. A. Berry, G. J. Collatz, A. S. Denning, H. A. Mooney, C. A. Nobre, N. Sato, C. B. Field, and A. Henderson-Sellers. 1997. Modeling the exchanges of energy, water, and carbon between continents and the atmosphere. *Science* 275, 502-509.

Singer, F. J., ed. 1996. *Effects of Grazing by Wild Ungulates in Yellowstone National Park.* Technical Report NPS/NRYELL/NRTR/96-01. Denver: National Park Service, Natural Resource Program Center, Natural Resource Information Division.

Taylor, R. E. 1987. *Radiocarbon Dating: An Archaeological Perspective.* Orlando: Academic Press.

Verano, J. W., and D. H. Ubelaker, eds. 1992. *Disease and Demography in the Americas.* Washington, D.C.: Smithsonian Institution Press.

Waddington, J. C. B., and H. E. Wright, Jr. 1974. Late Quaternary vegetational change on the east side of Yellowstone Park, Wyoming. *Quaternary Research* 4, 175-184.

Wagner, F. H., R. Foresta, R. B. Gill, D. R. McCullough, M. R. Pelton, W. F. Porter, and H. Salwasser. 1995. *Wildlife Policies in the U.S. National Parks.* Washington, D.C.: Island Press.

Waters, M. R., S. L. Forman, and J. M. Pierson. 1997. Diring Yuriakh: a Lower Paleolithic site in central Siberia. *Science* 275, 1281-1284.

Whitlock, C., S. Fritz, and D. R. Engstrom. 1991. A prehistoric perspective on the northern range. Pp. 289-308 in *The Greater Yellowstone Ecosystem: Redefining America's Wilderness Heritage.* R. B. Keiter and M. S. Boyce, eds. New Haven, Conn.: Yale University Press.

Wright, H. E., Jr. 1993. Introduction. Pp. 1-4 in *Global Climates Since the Last Glacial Maximum.* H. E. Wright, Jr., J. E. Kutzbach, T. Webb III, W. F. Ruddiman, F. A. Street-Perrott, and P. J. Bartlein, eds. Minneapolis: University of Minnesota Press.

Wright, H. E., Jr., and D. G. Frey, eds. 1965. *The Quaternary of the United States.* Princeton, N.J.: Princeton University Press.

Wright, H. E., Jr., J. E. Kutzbach, T. Webb III, W. F. Ruddiman, F. A. Street-Perrott, and P. J. Bartlein, eds. 1993. *Global Climates Since the Last Glacial Maximum.* Minneapolis: University of Minnesota Press.

YNP [Yellowstone National Park]. 1997. *Yellowstone's Northern Range: Complexity and Change in a Wildland Ecosystem.* Mammoth Hot Springs, Wyo.: Yellowstone National Park, National Park Service.

Zielinski, G. A., and G. R. Mershon. 1997. Paleoenvironmental implications of the insoluble microparticle record in the GISP2 (Greenland) ice core during the rapidly changing climate of the Pleistocene-Holocene transition. *GSA Bulletin* 109(5), 547-599.

Ruthann Knudson, Agate Fossil Beds National Monument, 301 River Road, Harrison, Nebraska 69346-2734; ruthann_knudson@nps.gov