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"Natural" or "Healthy" Ecosystems: Are U.S. National Parks Providing Them?

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Introduction

Ecosystem ecologists are now generally agreed on the desirability of having areas of natural biota minimally disturbed by technological societies to serve as reference points for understanding the structure and function of ecological systems. Systems, of course, exist along a continuum from little or no human disturbance to complete anthropogenic alteration (cf. McDonnell et al., Chapter 15, this volume). An in-depth understanding of how they respond to different intensities of human perturbation, what constitutes ecosystem sustainability, and how profoundly altered systems can be restored, is facilitated by a knowledge of structure and function along the entire continuum.

A number of different kinds of areas, acquired and administered under a variety of arrangements, are expected to provide relatively undisturbed reference systems. These include state natural areas, as in the Wisconsin system, privately owned areas like those of The Nature Conservancy, and wilderness areas under the aegis of several federal agencies. But most important in terms of their age, size, prohibition against consumptive use of natural resources, and public recognition, are those national parks and monuments that were established to protect exceptional biotas minimally affected by post-industrial humans. This chapter examines how effectively the U.S. national parks are serving this reference-point role, but raises ecological and policy considerations that also apply to the other types of areas.

Some Conceptual Issues

National Park Service policies generally adopt this reference-point role for those areas in the National Park System that contain significant biological

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resources. Indeed, the legislation establishing Yellowstone National Park, the world's first national park, ordered retention of the "...natural curiosities, or wonders...in their natural condition..." (16 USC 21-22). Since that time numerous documents and policy statements have reiterated this general theme:

- "As a primary goal, we would recommend that the biotic associations within each park be maintained...as nearly as possible in the conditions that prevailed when the area was first visited by the white man" (Leopold et al. 1963).

- "The use of national parks for the advancement of scientific knowledge is also explicit in basic legislation. National parks, preserved as natural, comparatively self-contained ecosystems, have immense and increasing value to civilization as laboratories for serious basic research. Few areas remain in the world today where the process of nature may be studied in a comparatively pure natural situation" (Anon. 1968:43).

- "The primary purpose of Yellowstone National Park is to provide present and future visitors with the opportunity to see and appreciate the natural scenery and native plant and animal life as it occurred in primitive America" (Anon. 1977).

Although the words "nature" and "natural" feature prominently in these and other similar statements, they provide no criteria of ecosystem structure and function by which "natural" ecosystems can be characterized, or which can be used as goals to be achieved by management programs. But they do generally state or imply, in many cases ambiguously, two characteristics:

- "A portrayal of primitive America is defined as having natural conditions where scenery and 'balance of nature' in ecosystems are not altered by man" (Anon. 1967).

- "The natural resource policies of the National Park Service are aimed at providing the American people with the opportunity to enjoy and benefit from natural environments evolving through natural processes minimally influenced by human actions" (Anon. 1988).

- "National parks were founded on the principal of...natural processes, and the importance of minimizing human interference...management's primary purpose is to maintain the area's pristine condition to the fullest extent possible...This includes the perpetuation of natural processes in the absence of human interference—processes essential to the existence of a healthy ecosystem" (Varley 1988).

The ambiguities in these statements lie in the variations between "minimal" and no human actions, and in whether they refer implicitly to the effects of post-Columbian Europeans or Native Americans or both. We are inferring that the references are to Europeans, and that any pre-Columbian human effects are implicitly assumed to be inconsequential. We base this inference on the 1967 statement above in which "...primitive America is defined as having natural conditions...not altered by man..." and the last which defines "pristine conditions" as having "...natural processes in the absence of human interference...

The second ambiguity lies in the evolutionary stipulation of the second of the three statements. The same document expands on the point further:

- "Managers...will try to maintain all the components and processes of naturally evolving park ecosystems" (Anon. 1988:4.1).

- "The National Park Service will strive to protect the full range of genetic types (genotypes) native to plant and animal populations in the parks by perpetuating natural evolutionary processes and minimizing human interference with evolving genetic diversity" (Anon. 1988:4.10).

Here again we infer that the explicit reference is to post-Columbian Europeans, and that Native American effects are implicitly assumed, consciously or subconsciously, to be unimportant (see also Egerton, Chapter 2; Williams, Chapter 3; Russell, Chapter 8; Foster, Chapter 9, this volume).

In the remainder of this chapter, we will develop the thesis that:

1) There is growing archaeological and anthropological evidence worldwide that pre-industrial humans significantly modified the structure and function of ecosystems, including those now in national parks;
2) Ecosystems of national parks in the United States are being materially altered by burgeoning, ungulate herds which may be increasing, in part, because they are no longer being constrained by aboriginal hunting; and
3) Park Service policies do not face up realistically to either the pre-industrial role of humans or the role of unconstrained animal populations. These two circumstances need to be given serious consideration in more explicitly defining the ecological purposes of national parks, and tailoring management programs to those purposes.

Ecological Effects of Pre-Industrial Humans

Until quite recently, North American ecologists have tended subconsciously to dismiss the influence of pre-Columbian humans on their continent's ecosystems, and commonly have sought to study systems supposedly free of any anthropogenic effects. But archaeologists, anthropologists, and other social scientists worldwide are forcing on ecology the realization that such effects have been dismissed too lightly (e.g., Turner and Meyer, Chapter 4; Vayda, Chapter 6; Boyden, Chapter 7; Richerson, Chapter 11, this volume). Effects on animal populations, influence of fire, and alteration of vegetation by pre-industrial cultures are being reported from every continent with increasing frequency.

Evidence from Outside the Western Hemisphere

There is now wide familiarity with the hypothesis and evidence that many Holocene faunal extinctions worldwide followed the first human contact with unadapted faunas. Best known are the North American and Australian megafaunal extinctions. Less well known are numerous insular extinctions (Martin and Klein 1984; Steadman and Olson 1985; Diamond 1988). Diamond (1988) commented that "on every oceanic island for which we have adequate knowledge, the first arrival of humans was quickly followed by the extermination of all or most large animals, the best known victims being the moas of New Zealand, the giant lemurs and elephant birds of Madagascar, and the flightless geese of Hawaii..."

Still less well known, and of greater interest here, are the effects of hunter-gatherer cultures on population densities and community structure of persisting animal species. Thorbahn (1984) investigated the archaeology and ethnohistory of the Tsavo National Park region of central Kenya in an effort to relate precolonial human activities to the character of the biota. He concluded that heavy ivory trade to India and the Middle East by indigenous people between A.D. 155 or earlier and the end of the nineteenth century significantly reduced elephant populations. Prior to this period, the vegetation was a more open grassland, and human populations were more dense. Today, following reduction of the browsing elephants, the vegetation has changed to a dense thorn-scrub called *nyika*, which means in Swahili "wilderness."

Similar vegetation changes have occurred in the southern African countries. By 1900 there were only 4,000 elephants in Zimbabwe, a legacy of the ivory trade which had been underway for several centuries (David Cummings, pers. comm.). Vegetation here, too, has grown up to a dense thorn scrub. Today, following protection, elephant numbers have increased to 50,000.

Klein (1979) traced the species composition of ungulate remains in South African archaeological sites through the Middle Stone Age (roughly 130,000 to 30,000-40,000 years B.P.) and Late Stone Age (ca. 40,000 B.P. to the colonial era). At about 10,000-12,000 B.P., there was a pronounced improvement in the weaponry and hunting techniques. Coincidentally, changes in

ungulate species composition and age ratios reflected changing exploitation rates. Some species present in the earlier strata disappeared.

Legge and Rowley-Conwy (1987) traced the species composition of ungulate remains in archaeological sites of hunter-gatherer cultures occupying an area of northern Syria between 11,000 and 8,000 B.P. From 11,000 to shortly after 8,500, goitered gazelle (*Gazella subgutturosa*) made up 80% of the large animal remains. Sheep, goats, wild asses, wild cattle, wild pigs, and deer made up the remainder. At roughly the seventh century B.P., there was an extensive proliferation of drive traps, termed "desert kites," in northern Jordan on the migration routes of the gazelles summering in northern Syria. Within a few hundred years thereafter, gazelles declined to 20% of animal remains in the sites, and sheep and goat remains rose to the gazelles' previous 80%. These authors concluded that the extensive increase in gazelle trapping reduced their populations and forced a dietary shift to domestic animals.

Koike and Ohtaishi (1985) analyzed the age composition of sika deer (*Cervus nippon*) in archaeological sites from the Jomon Period (5,500-3,000 B.P.) on the island of Hokkaido. Age composition of animals from the Early Jomon Period contained a large proportion of older animals, as would occur in a lightly exploited population. But samples from the Late and Latest Jomon Periods were mainly comprised of animals younger than 5 years of age, an age distribution similar to those of contemporary, heavily hunted populations on Hokkaido. The authors concluded that hunting pressures by Jomon peoples increased over time and reduced deer densities.

Although declines in game animals are most often cited, reduction of plant species used for food (Jochim 1981) and firewood (Baksh 1985) have been reported. Feely (1980) and Hall (1984) cite evidence indicating that pre-colonial agriculture dating back at least 1,500 years significantly shaped the character of vegetation in southern Africa through cultivation, grazing, and burning. Vestiges of these effects are still evident today. Flenly and King (1984) documented the deforestation of the Easter Islands by early Polynesian immigrants.

Assigning ecological meaning to archaeological data always depends on inferences about past events and processes that cannot be observed. Hence, they always leave an element of uncertainty. However, the hypotheses proposed by archaeologists concerning the influences of subsistence cultures on animal populations and communities are gaining support from anthropological investigations on contemporary hunter-gatherer cultures. These, too, are finding evidence of significant impacts on the fauna. Resource depression around camps and villages has frequently been reported from the historic literature and from studies of hunter-gatherer cultures. Hunting yields decline as a function of village age, and increase as a function of distance from settlement (Hames and Vichas 1982).

The ubiquity of these influences prompted Simms (1992) to generalize that "...all human societies have played a role in shaping ecosystems, [and] there are many cases of hunter-gatherer behavior that...would be classified as having negative impacts upon wilderness environments. The evidence suggests that simple societies may be as susceptible to causing significant environmental damage as more complex societies. To be sure, there is a difference of scale..." And Redford (1990), referring to what he called "the myth of the noble savage," commented that "The recently accumulated evidence...refutes this concept of ecological nobility...Paleobiologists, archaeologists, and botanists are coming to believe that most tropical forests have been severely altered by human activities before European contact...These people behaved as humans do now: they did whatever they had to to [sic] feed themselves and their families."

New World Evidence

The interactions between Western Hemisphere pre-industrial humans and other components of their ecosystems differ from those of Eurasia, Africa, and Australia in three historical ways: 1) the New World interactions have taken place over a much shorter time period; 2) humans arrived in the Western Hemisphere at a relatively late stage of neolithic evolution in the sophistication of weaponry and foraging behavior; and 3) the biota did not coevolve with humans before the latter's recent arrival. Hence, there were circumstances that predisposed the Western Hemisphere biota to especially significant human impacts, and, indeed, nowhere in the world have the megafaunal extinctions been as sweeping as those of this half of the world.

Skeptics of pre-European impacts have suggested that North American human populations were too sparse to effect any major ecological alterations. But these judgments are based on the assumption that Native American populations at the time of early European contact were similar to those of preceding centuries. Recent investigations (cf. Dobyns 1983; Ramenofsky 1987) present evidence that European diseases were introduced by the first Spaniards arriving in the West Indies. These were carried to the mainland by the natives, whereupon the epidemics swept across the continent and decimated populations up to two centuries in advance of European contact on the mainland. Pre-Columbian human populations are thus thought to have been anywhere from 4 to 10 times as dense as those encountered by the eighteenth and nineteenth century European explorers, trappers, and settlers.

In an analysis of the ecological impacts of North American pre-industrial cultures on wild ungulate populations, Kay (1990a) quantified historical and archaeological evidence on the abundance and species composition of large mammals in the pre-Columbian western United States. Kay (1990a) tabulated the number of occasions on which large mammals were recorded in the journals of 19 known expeditions conducted in the region of what is now Yellowstone National Park during the early and mid 1800s. The number of individuals in each party varied from 3 to 60, with over half of the groups containing 17 or more. The total time spent was 765 party days. Ungulates were seen on only 121 occasions, or approximately once every 6 party days. Elk (*Cervus elephas*), by far the most abundant and frequently seen ungulate in the region today, were seen only once every 18 party days. Moreover, not one single wolf or mountain lion was reported to have been seen by the 19 expeditions. This scarcity of large carnivores would be expected if prey animals were scarce.

Kay (1990a) analyzed the ungulate species composition in the remains of more than 200 archaeological sites in Washington, Oregon, Idaho, Montana, Wyoming, Utah, and Nevada. These contained over 52,000 identified ungulate bones. Yet, elk remains made up only 3% of that total. Elk were similarly rare in sites near Yellowstone National Park where today they comprise roughly 80% of all ungulates.

From these and other sources of evidence, Kay (1988, 1990a,b) concluded that the low ungulate densities and very different species composition in the pre-Columbian western United States were maintained by aboriginal hunting, possibly in synergy with carnivorous predators.

An extensive literature reports the role of fire in North American ecosystem structure and function, and implicates aboriginal burning (cf. Lewis 1982). Two studies in the western United States exemplify the significant control of vegetation structure by fire. Barrett and Arno (1982) conclude that Native American fires maintained the open, park-like structure of ponderosa pine (*Pinus ponderosa*) forests in the northern Rocky Mountains, which the first European settlers encountered. Similarly, Bonnicksen and Stone (1981, 1982a) describe the patchwork, mixed-age character of the giant sequoia-mixed conifer forests of Kings Canyon National Park, which prevailed near the end of the last century. They ascribed this character, and the shrub and hardwood understory, to periodic burning by Native Americans.

In all of these cases, the authors recognize that Indian burning and lightning fires interacted. Consequently, the effects of aboriginal burning were difficult to separate out and quantify. Greenlee and Langenheim (1990) attempted this separation by using both the empirical evidence of fire scars on coastal redwoods (*Sequoia sempervirens*), and modeling approaches. These investigators inferred five successive, historical fire frequencies in the coastal vegetation of Santa Cruz and Monterey Counties of California: 1) lightning (up to 11,000 B.P.); 2) aboriginal (11,000 B.P. to A.D. 1792); 3) Spanish (1792 to 1848); 4) Anglo (1848 to 1929); and 5) recent (1929 to present). Thus, by subtracting the lightning frequency from the aboriginal, the difference, in these authors' opinion, constituted the effects of early human-set fires in the locale. The separation was made possible by the datable arrivals of the first humans in the region, and of the Spaniards.

There is also evidence of significant modification of North American landscapes through deforestation. Betancourt and coworkers (Betancourt and Van Devender 1981; Betancourt et al. 1986) traced the vegetation changes in the Chaco Canyon region of northern New Mexico between the early tenth and twelfth centuries. The Anasazi peoples who occupied the area during this period abandoned it, apparently in part because they had exhausted woody vegetation used for building construction and firewood over a radius of 75 km.

In total, the evidence for alteration of North American ecosystems by pre-industrial Native Americans appears as extensive as that for other parts of the world. The North American landscape was already significantly shaped by human action when the first Europeans arrived.

Recent Changes in National Park Ecosystems

Given the prevalence of pre-industrial human ecological influence on the landscape, including areas now in national parks (e.g., Yellowstone and Kings Canyon), we may now return to the meaning of such terms as "natural," "healthy," and "pristine," and consider what purpose parks should serve. Although the early human influences have rarely been considered or incorporated in park objectives for managing natural resources, the Park Service has consistently held to the policy of preserving examples of "natural" or "pristine" (i.e., commonly, pre-European) biotas. This is implied in the legislation establishing the early parks, and in the 1916 Organic Act. In 1963, a National Parks Advisory Committee, appointed by the Secretary of the Interior, and generally termed "The Leopold Committee" after its chair, A. Starker Leopold, recommended that the purposes of parks should be "to preserve vignettes of primitive America" (Leopold et al. 1963).

The Service has vacillated over the years on the question of whether it should engage in active resource management to maintain ecosystems in the conditions thought to prevail in pre-Columbian times. The Leopold Committee firmly recommended such management procedures as controlling excessive ungulate numbers and use of fire to maintain seral stages. Indeed, Yellowstone Park controlled predators and fed ungulates in the first half of this century (Houston 1982). It then entered a stage of controlling elk through shooting and trapping, and controlled fires up to the early 1970s. Wind Cave National Park currently controls elk, prairie dogs, and bison, and engages in controlled burning. Current Park Service policy (cf. Anon. 1988) advocates these kinds of management where deemed necessary.

However, in 1967, Senator Gale McGee of Wyoming, then on the Appropriations Subcommittee which funded the Park Service, threatened to cut off Yellowstone funding if the Park did not discontinue shooting elk (Chase 1986). Promptly thereafter, the Park adopted the natural-regulation paradigm as a conceptual basis for a new management policy.

Without the support of empirical evidence, and based only on an evolutionary rationale, the paradigm concluded that elk and other ecosystem components had coexisted since the Pleistocene without predatory (and implicitly, human) constraint (Cole 1971). Elk numbers were considered to be "regulated" by food resources, and given more than 10 millennia, the system must have arrived at some equilibrium over this period. The Park had been established early in the European settlement of the West (1872) when there presumably had been little human ecological alteration, and by the late 1960s had been protected from significant human intrusion for the better part of a century. For these reasons, the contemporary, large elk herd and character of the remainder of the system must be presumed to typify the pre-Columbian conditions. Hence, there should be no need to intervene with advertent management.

The natural-regulation concept became a strong influence in the Park Service despite the recommendations of the Leopold Committee, the language in the policy documents approving management where desirable, the practice of advertent management in some parks, and strong criticism from a number of biologists (cf. Erickson 1981; Gale 1987; Gilpin 1987). Most parks have refrained from controlling ungulate herds. And as Bonnicksen (1989a) has pointed out, the philosophy's manifestation in park fire management is the "let burn" policy: the practice of not controlling naturally set fires.

It is now of interest to examine whether any changes have occurred in park ecosystems during the approximately 20 years of natural-regulation management. The natural-regulation concept implicitly dismisses any pre-Columbian human influences on park ecosystems. If there have been any ecological changes during the history of the parks, they have occurred in the absence of pre-European anthropogenic effects. Such changes provide a partial test of the natural-regulation paradigm which holds that the systems have arrived at some equilibrium, implicitly without human intervention. It is true that large, nonhuman predators have been removed in many cases. Hence, aboriginal influences are not the only variable removed. But as shown below, simulation modeling of wolf predation on Yellowstone elk herds does not project much effect.

Kay's (1990a) study of Yellowstone's northern range examined nearly 50,000 early photographs in ten photo archival collections to reconstruct the character of the vegetation at, or in the early decades after, Park formation in 1872. Aspen (*Populus tremuloides*) woodlands today: 1) consist only of older trees without young saplings; 2) have black, scarred bark up to about 2 m induced by elk chewing; and 3) have a lawn-like understory dominated by exotic grasses and low forbs. Early photographs show aspen stands of mixed age classes, no bark scarring, and dense understories of shrubs and tall forbs. The early stands resembled the character of contemporary aspen stands in exclosures in the Park, and outside but near Park boundaries where elk numbers are held at lower levels by public hunting. The area of aspen woodlands, as a type, has declined between 50 and 95% in the Park's north range since Park formation.

Kay (1990a) also assembled repeat photosets of riparian zones. Early photographs show dense shrub strips along streams on the northern range. Today, these are totally eliminated, the banks bare, and in many cases, sloughing into the streams. Once again, willows (*Salix* spp.) and other shrubs flourish inside Park exclosures and along streams outside the Park boundaries.

Kay (1990a) unearthed a number of historical accounts describing an abundance of berry-bearing shrubs (*Prunus virginiana, Amelanchier alnifolia, Shepherdia canadensis*) and extensive use of the fruit by the local Native Americans. Today, these species seldom exceed a height of 0.3 m and rarely produce fruit in Yellowstone except in exclosures. They reach heights up to 3 m and produce abundant fruit outside Park boundaries where ungulates are not concentrated.

The vegetation changes are accompanied by faunal changes. Kay (1990a) reviewed early accounts of abundant beaver (*Castor canadensis*) in the Park, large numbers being trapped, and one estimate placing the number at 10,000 in the early 1900s. Today, beaver are infrequently encountered and are absent from areas in which they were historically numerous. Sally Jackson (pers. comm.) has found avian densities and diversity much lower in heavily browsed riparian zones in and near the Park than in relatively unused stands outside the boundaries. White-tailed deer, once present in the Park, no longer occur there (Kay 1990a).

In sum, deciduous woody vegetation and its associated fauna in the ecosystem of the Park's north range have declined sharply during the Park's history. Understory vegetation in aspen stands inside the Park is much less diverse than that in aspen exclosures and in aspen stands outside the Park. In total, the system has experienced a marked decline in plant and animal diversity. The overwhelming evidence indicates that this decline has occurred as a result of the pressure of elk on the north range, where today they number around 20,000. The unbrowsed condition of the vegetation, shown in the early photographs, also supports the inferences drawn above from the historical and archaeological data, that elk numbers in the region (and other ungulates as well) were low at the time of European contact. And the collective evidence challenges the natural-regulation paradigm which holds that modern abundance of elk and condition of the rest of the biota are what prevailed in pre-Columbian times.

It is true that aboriginal hunting is not the only pre-Columbian population constraint on elk that is no longer present. There are, today, mountain lions but no wolves. However, recent simulation modeling of the effects of wolf reintroduction into Yellowstone National Park (cf. Boyce 1992) predicts only a minor reduction in elk numbers.

Braun et al. (1991) observed an increasing elk population in Rocky Mountain National Park, which winters in the subalpine and alpine zones, an unprecedented behavior pattern. The elk browse on, and are markedly reducing, the willows in the wintering areas. The willows are also staple food for white-tailed ptarmigan (*Lagopus leucurus*) in the Park. Ptarmigan censuses over 25 years have shown a population decline, and the authors hypothesize that this may be associated with elk-induced reduction in willow abundance.

Warren (1991) reviews the extensive literature describing the effects of white-tailed deer on eastern North American forest vegetation. Deer populations have increased to high densities throughout much of the eastern United States in the twentieth century, and negative effects on vegetation are widely observed. Warren also reviews studies in which vegetation alteration by deer has been accompanied by shifts in species composition of rodents, lower abundance of snowshoe hare (*Lepus americanus*), and lower avian species richness.

Warren cites evidence from several studies, including his own, which have measured some of these effects in Great Smoky Mountain National Park (GSMNP), several other national park areas in the eastern United States, and Catoctin Mountain Park in Maryland. Effects in GSMNP include reduction in number of plant species, loss of hardwood species, and heavy grazing on and reduction of potentially threatened plant species.

Pastor et al. (1987, 1993) have measured the effects of moose (*Alces alces*) browsing on entire nutrient cycles in Isle Royale National Park. Moose arrived in Isle Royale somewhere around the turn of the century, and, hence, are a relatively new influence in the island ecosystem. Wolves arrived on the island somewhat later, and since then have entered into what may in part be a predator-prey oscillation (Peterson 1988), although there is some evidence of a vegetation oscillation as well.

As the moose reach the peaks of their oscillation, they browse heavily on the deciduous species, particularly aspen, and convert the vegetation to a coniferous type. Nitrogen mineralization under deciduous litter proceeds at a faster rate than under coniferous litter, and primary production is higher in soils with rapid nitrogen-mineralization rates. Hence, the effects of the moose browsing in the Park are: 1) to convert the vegetation to coniferous growth, thereby reducing diversity; and 2) to slow nitrogen mineralization and thereby reduce primary production.

Clearly, there are profound and unprecedented changes taking place in national park ecosystems. There is a substantial basis for inferring that these are taking place because of the removal of pre-Columbian ecological constraints. Aboriginal hunting may well have been one of the most important of those constraints. If the purpose of national parks is to preserve "pristine" or "healthy" ecosystems, with pristine and healthy defined as the conditions prevailing at the time of European settlement, many of the parks are clearly not achieving this purpose.

What Needs to Be Done?

In one sense, this question can be construed as a query about what management protocols need to be instituted. Should there be: no management, as at present? Active, advertent management? Management to simulate early human effects?

But management programs are designed to achieve goals, and effective management protocols cannot be designed until goals are clearly defined. Numerous authors (cf. Bonnicksen and Stone 1982b,c; Agee and Johnson 1988; Johnson and Agee 1988; Bonnicksen 1989a; Gordon et al. 1989) have commented on the ambiguity of park goals, and the inconsistency with which the existing ones are carried out: ungulate control in Wind Cave, not in Rocky Mountain; prescribed burning in Kings Canyon, not in Yellowstone; and elk control in Yellowstone up to 1967, no control from 1967 to the present. National policy documents advocate ungulate control where needed, yet most parks rigidly avoid control. Hence, as the above authors concur, the most immediate need is a precise definition of the ecological purposes or goals of the national parks. Once this is achieved, the appropriate management goals can be decided upon.

Ecologists, natural-resources managers, and policy analysts are increasingly converging on the view that management policies for public resources are set to satisfy social values (cf. Hendee 1974; Giles 1978; Kennedy 1985; Bonnicksen 1989a; Kania and Conover 1991; Wagner 1993). As Bonnicksen and Stone (1985) state, "Goals are value judgments that describe the ideal or preferred condition. Therefore, goal setting is a social or political decision, not a professional decision."

Park goals were/are appropriately set by social and political action when Congress passed the Park Service Organic Act in 1916, and passed the enabling legislation establishing each park. And as discussed at the beginning of this chapter, the biological goals have generally been the provision of ecological reference areas. But legislation is characteristically abstract and vague, and that ambiguity provides the interpretative leeway within which Park Service officials can employ the diversity of management approaches described above, or simply the inaction of the natural-regulation paradigm.

What is urgently needed from the ecological community, as pointed out by other authors (cf. Bonnicksen and Stone 1982b,c, 1985; Agee and Johnson 1988; Bonnicksen 1989b), is an ecologically explicit and substantive definition of the reference-area goals. Bonnicksen (1989b) advocates setting quantitative and measurable standards of ecosystem structure and function as part of such goals. This would require the most insightful and sophisticated ecological understanding of each ecosystem, and should be carried out collaboratively by ad hoc groups of a wide variety of ecologists familiar with each area. The task is too large and complex to be carried out internally by the small cadre of Park Service biologists, as such efforts to date indicate. And care should be taken to include scientists with differing points of view. Too often, Service officials seek advice from outside scientists who are known to concur with their views and policies, and ignore scientists who draw contrary inferences from the available evidence.

In this definition process, the options of simulating and not simulating pre-industrial human influences on park ecosystems would be kept open. If such influences were not included in the goals, it would be incumbent upon the deliberation process to state what scientific purpose would be served by allowing these systems to seek some end determined by the absence of ecological factors with which they have co-evolved for ten millennia. If they were included, that too should be based on a scientific rationale and accompanied by precise definition of management protocols.

More generally, goal definition would be accompanied by prescriptions for management policies, with the overriding alternatives of managing or not managing to compensate for the changes these systems have experienced since settlement (cf. Wagner 1991). Current absence of the ecological conditions established by early human influence is only one such change. At present, the systems are all changed and are changing to varying degrees from their pre-Columbian structure, and no one knows how they will develop, or whether they will irrevocably alter themselves without judicious and ecologically enlightened management assistance. Advisory committees have repeatedly recommended such management (cf. Leopold et al. 1963; Gordon et al. 1989). To continue the no-management policy, with its risk of ecosystem self destruction, is a goal option. But that would need to be supported with a well considered and explicated ecological rationale. Self destruction would eliminate the reference-area value.

Epilogue

Historical, archaeological, and anthropological research is providing us with new perspectives on ecosystem structure and function. Ecosystems analysis and natural-resources management will be increasingly enhanced by including these disciplines in the research efforts. Humans have been components of ecosystems for millennia, and the systems that we encounter today are significantly shaped by their presence. It is the "natural" systems—i.e., those completely free of any human influence—that are the exceptions. We can see a rich future for the social-scientific disciplines working collaboratively with ecology.

Recommended Readings

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