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Legal and Biotic Boundaries of Western North American National Parks: A Problem of Congruence

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ABSTRACT

The boundaries of a national park may be defined in terms of its legal and biotic boundaries. The legal boundaries are the boundaries established by the highest legislative authority of a country. The biotic boundaries are hypothetical boundaries which would be necessary to maintain existing ecological processes and a given assemblage of species within a national park. Practically, the biotic boundaries are defined as those hypothetical boundaries encompassing the entire watershed of a park and an area of sufficient size to maintain a minimum viable population (MVP) for the terrestrial non-volant species with the largest home range found within the current legal boundaries. The legal and biotic boundaries for eight of the largest continental national parks and park assemblages in western North America were examined for congruence. The legal boundaries for seven of the eight parks/park assemblages were found to be larger than the biotic boundaries by a factor of 1·2–9·6 for a MVP = 50 and 6·0–96·0 for a MVP = 500. One to seven percent of all the mammals, excluding chiropterans, found currently in seven of the eight national parks/park assemblages have an area requirement (MVP = 50 × home range) exceeding the legal boundaries. It is urgent while an opportunity exists that an active effort be made to enhance the congruence of the legal and biotic boundaries of these parks and park assemblages through the cooperative management of adjacent public and private lands so as to minimize the potential loss of wildlife.

INTRODUCTION

The number and complexity of problems facing many western North American national parks are increasing. These problems range from the traditional concerns of poaching, visitor safety and impact, to the more recent concerns of acid rain, introduction of exotic species, commercial development along the parks boundaries, and control of concessionaires (e.g. Mantell, 1979; National Park Service, 1980; Stottlemeyer, 1981).

Yet there is one problem which may overshadow both these traditional as well as current concerns. This is whether most national parks can function as effective repositories for the maintenance of biological and genetic diversity. The maintenance of biological diversity refers to the long-term protection of existing plant and animal species; while the maintenance of genetic diversity refers to the long-term protection of existing gene pools within a species. This problem has arisen in part because the legal and biotic boundaries of many western North American national parks are incongruent, i.e., being of different size or position (Wright *et al.*, 1933; Cahalane, 1948; Houston, 1971). In this paper, the problem, the source, and the implications of incongruence between the legal and biotic boundaries for a series of western North American national parks will be discussed.

LEGAL AND BIOTIC BOUNDARIES

The legal boundaries of a national park are those boundaries established by the highest legislative authority of a country (Fig. 1). These boundaries may change as a result of legislative action. The legal boundaries of many national parks have been altered by governmental action since their initial designation. For example, the legal boundary of Banff National Park in Canada has been altered six times since 1886 (Lothian, 1977).

The biotic boundaries are the hypothetical boundaries necessary to maintain existing ecological processes and a given assemblage of species within a national park. The enormous potential size of the biotic boundaries for many national parks makes it quite improbable that the legal and biotic boundaries will be congruent. In most cases, the biotic boundaries will be larger than the latter.

Practically, the biotic boundaries are defined by the entire watershed of a park and the area necessary to maintain a minimum viable population for the terrestrial non-volant species with the largest home range found

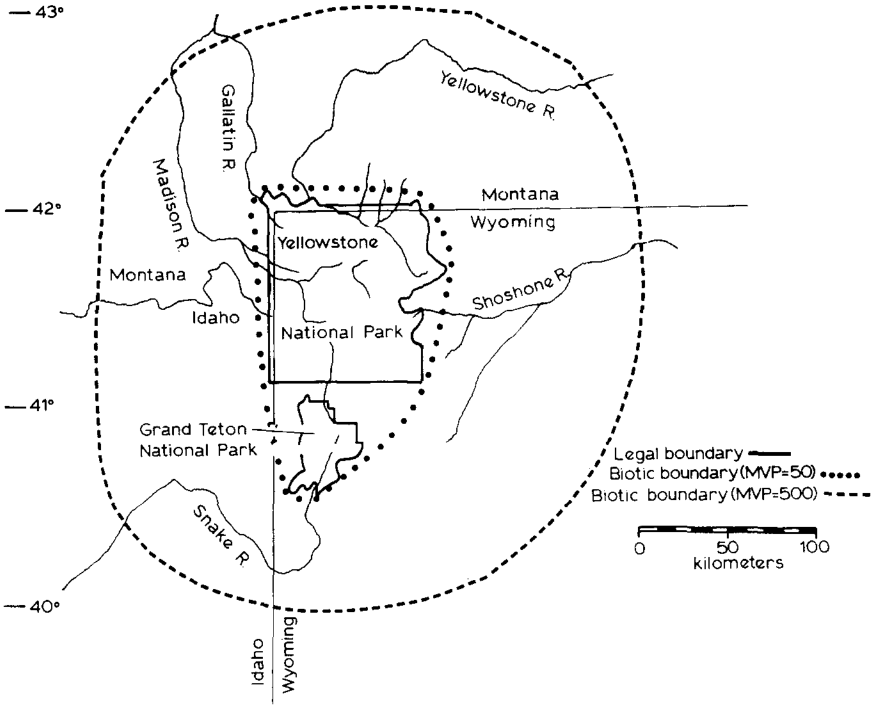

Fig. 1. The legal and biotic boundaries of the Yellowstone–Grand Teton National Park assemblage. The biotic boundaries are defined by the entire watershed for this park assemblage and the area necessary to support a minimum viable population (50 individuals for short-term survival; 500 individuals for the long-term survival) of the grizzly bear *Ursus arctos* which has the largest home range—489 km^2 (Craighead & Mitchell, 1982)—of any terrestrial non-volant species found within the legal boundaries.

within the current legal boundaries. Implicit in this definition are the following assumptions: that the biotic boundaries are dynamic; that the species with the largest home range will overlap the home ranges of all other species found within the legal boundaries; and that male and female home ranges of a species overlap. The home range is defined as the total area utilized by an individual organism throughout its lifetime.

The biotic boundaries are defined partially in terms of a complete watershed because of the necessity of water quality and quantity to the adequate protection of the aquatic flora and fauna of a park. Also, the protection of a complete watershed of a park reduces the potential for soil erosion and flooding. This was tragically demonstrated in Redwood National Park in California when shortly after the official designation of the park, a large number of old-growth redwoods were toppled because of abnormally high runoffs, which in turn were attributed to the logging of upstream portions of the park's watershed (Runte, 1979). The use of a complete watershed to define the biotic boundaries of a park is obviously possible only in mountainous regions because of the enormous size of watersheds in non-mountainous regions.

The biotic boundaries are defined additionally in terms of a minimum viable population which represents the number of individuals necessary for the long-term survival of a population (Frankel & Soulé, 1981; Shaffer, 1981; Samson, 1983). The concept of a minimum viable population is important for several reasons.

First, small populations are believed to lose genetic variation through genetic drift and inbreeding more quickly than larger populations (Franklin, 1980; Frankel & Soulé, 1981). The ability of a population to respond to environmental changes appears to be a function of its genetic diversity (Vida, 1978). In terms of maintaining genetic fitness, Franklin (1980) has recommended that the minimum population for short-term survival of a species is approximately 50 individuals, and for the long-term survival of a species he recommends 500 individuals. These recommendations are based upon the assumptions of random mating, equal numbers of breeding females and males, the absence of severe fluctuations in numbers, non-overlapping generations, and a random distribution of offspring among families (Frankel & Soulé, 1981)—which are rarely found in the real world. For most species, the minimum viable population for short-term and long-term survival is probably larger.

The second reason why the concept of a minimum viable population is important is that random extinctions due to demographic and environmental stochasticity and catastrophes tend to be more of a threat to small populations than large populations (Shaffer, 1981). Shaffer (1981) demonstrated that the probability of the grizzly bear population in Yellowstone National Park becoming extinct may be strongly dependent upon environmental and demographic stochasticity.

CONGRUENCE BETWEEN LEGAL AND BIOTIC BOUNDARIES

Eight of the largest national parks and park assemblages in the western continental United States and Canada were examined for congruence between the legal and biotic boundaries (Table 1). The biotic boundaries were defined by the entire park watershed and the area required to

TABLE 1
Comparative Sizes of the Legal and Biotic Boundaries for a Series of Western North American National Parks and Park Assemblages

National park/park assemblage	*Size of boundary (km^2)*			*Ratio*	*Species used to define biotic boundary*
	Legal	*Biotic ($MVP = 50$)*	*Biotic ($MVP = 500$)*		
Kootenay–Banff–Jasper–Yoho	20 736	12 233	122 330	1:0·6:6	Grizzly bear *Ursus arctos*
Grand Teton–Yellowstone	10 328	12 233	122 330	1:1·2:12	Grizzly bear *Ursus arctos*
Grand Canyon	4 931	8 125	81 250	1:1·6:16	Mountain lion *Felix concolor*
Glacier–Waterton Lakes	4 627	12 233	122 330	1:2·6:26	Grizzly bear *Ursus arctos*
Olympic	3 628	7 490	74 900	1:2·1:21	Mountain lion *Felis concolor*
Sequoia–Kings Canyon	3 389	10 125	101 250	1:3·0:30	Wolverine *Gulo luscus*
Yosemite	2 083	10 125	101 250	1:4·8:48	Wolverine *Gulo luscus*
Rocky Mountain	1 049	10 125	101 250	1:9·6:96	Wolverine Gulo luscus

The size of the legal boundaries are taken from IUCN (1980). The biotic boundaries are defined by the entire park watershed and the area necessary to maintain a minimum viable population (50 individuals for the short-term survival and 500 for the long-term survival) for the terrestrial non-volant species with the largest home range (Hornocker & Hash, 1981; Craighead & Mitchell, 1982; Dixon, 1982) found currently within the legal boundaries of the park.

TABLE 2

Number and Percent of Total Species of Mammal[a] found currently in a Series of Western North American National Parks and Park Assemblages with an Area Requirement[b] exceeding the Legal Boundaries of the National Park or Park Assemblage

National park/park assemblage	*Legal size of park* (km^2)	*Species of mammal with an area requirement exceeding the legal boundaries*		
		No. of spp.	*Percent of total spp.*	*Species*
Kootenay–Banff–Jasper–Yoho	20 736	0	0	—
Grand Teton–Yellowstone	10 328	1	2	Grizzly bear *Ursus arctos*
Grand Canyon	4 931	1	2	Mountain lion *Felis concolor*
Olympic	3 628	1	2	Mountain lion *Felis concolor*
Sequoia–Kings Canyon	3 389	2	3	Wolverine *Gulo luscus*, Mountain lion *Felis concolor*
Yosemite	2 083	2	4	Wolverine *Gulo luscus*, Mountain lion *Felis concolor*
Rocky Mountain	1 049	3	7	Wolverine *Gulo luscus*, Mountain lion *Felis concolor*, Black bear *Ursus americanus*
Glacier–Waterton Lakes	4 627	4	7	Wolverine *Gulo luscus*, Grizzly bear *Ursus arctos*, Mountain lion *Felis concolor*, Gray wolf *Canis lupus*

[a] Excluding chiropterans.

[b] The area requirement for each species of mammal is calculated as the product of the minimum viable population (assumed to be 50 individuals with 25 males and 25 females having overlapping home ranges) and the home range (Hornocker & Hash, 1981; Craighead & Mitchell, 1982; Dixon, 1982; Paradiso & Nowak, 1982; Pelton, 1982) of that species.

support the terrestrial non-volant species with the largest home range which is currently found within the legal boundaries of the national park. The area required to support a species was calculated as the product of the minimum viable population (assumed to be 50 individuals with 25 males and 25 females having overlapping home ranges for the short-term survival and 500 individuals with 250 males and 250 females having overlapping home ranges for the long-term survival) and the home range of the species. Seven of the eight national parks/park assemblages had biotic boundaries larger than the current legal boundaries by a factor of 1·2–9·6 when MVP = 50; while all eight national parks/park assemblages had biotic boundaries larger than the current legal boundaries by a factor of 6·0–96·0 when MVP = 500.

As these eight national parks/park assemblages become more insularized and the potential for colonization is reduced, it is possible that they may experience a faunal collapse similar to that seen on continental oceanic islands (Diamond, 1975; Wilson & Willis, 1975; Miller & Harris, 1977) though the magnitude of a potential faunal collapse is unclear. Soulé *et al.* (1979) have predicted that as East African wildlife reserves become increasingly isolated they may lose from 6–23 % of their species, depending upon the size of the protected area, in the next 50 years under a policy of benign neglect. These predictions, however, were made by extrapolating extinction rates of mammals from the Malay archipelago.

It is unclear whether the eight national parks/park assemblages examined here would experience a similar faunal collapse. Currently 1–7 % of all the mammals excluding chiropterans within seven of the eight national parks/park assemblages have an area requirement exceeding the legal size of the park (Table 2). These results should be interpreted cautiously when trying to predict the magnitude of a future faunal collapse. A variety of additional ecological and socio-economic factors would need to be considered in order to predict accurately the magnitude of a future faunal collapse. Two additional factors would be certainly the degree of habitat disturbance or change and the presence of barriers within and outside of the legal boundaries of these parks.

With an increase in human population, energy and land development in the western United States and Canada, there is a potential for considerable habitat disturbance and change on the lands surrounding the national parks. Existing national parks may become true habitat islands unless an active effort is made to manage cooperatively the public and private lands that adjoin the parks.

The magnitude of a potential faunal collapse may also be affected by the presence of barriers both within and outside the legal boundaries which may divide the national park into several ecological units. Barriers may be natural such as rivers, canyons, mountain chains, and lakes or man-made such as roads, buildings, parking lots, and cultivated lands.

The degree to which natural or man-made barriers may subdivide a park will depend upon the relative ability of a species to disperse across barriers. What may be a barrier to one organism may not be a barrier to another. For example, roads (Oxley *et al.*, 1974; Joule & Cameron, 1975; Wilkins & Schmidly, 1980) and abrupt habitat changes (Wegner & Merriam, 1979) have been shown to inhibit small mammal dispersal; clearings in tropical forest of less than a few kilometres in width (Terborgh, 1975) and narrow water gaps of an equivalent distance (Diamond, 1973; Willis, 1974) have been shown to inhibit tropical bird dispersal; and abrupt changes in habitat have been shown to inhibit butterfly dispersal (Ehrlich & Raven, 1969).

SOURCES OF INCONGRUENCE

There are a number of factors responsible for the incongruence of the legal and biotic boundaries of the western North American national parks. Several of the more important factors are that many national parks were established historically for a set of objectives other than the maintenance of biological and genetic diversity. These objectives included the protection of scenic grandeur and wilderness and the promotion of tourism and recreation. The maintenance of biological and genetic diversity was considered either a secondary objective or was not recognized in many of the first western North American national parks (Ise, 1961; Runte, 1979). The initial legal boundaries for many of the early western North American parks reflected an attempt to protect scenic vistas (Runte, 1979). Not until 1934, with the establishment of Everglades National Park in Florida, was a national park established in the United States for the primary objective of wildlife protection. Unfortunately the entire park ecosystem was not contained within the legal boundaries (Kushlan, 1979), resulting in a dramatic reduction over time in the number of birds in the park (Hendrix & Morehead, 1983).

A second factor responsible for the incongruence between the legal and biotic boundaries of these national parks was that sufficient knowledge and information was often unavailable at the time of their establishment to ensure their congruence (McNeeley & Miller, 1983). The establishment of the first national parks in North America predated the development of ecology as a formal discipline. Ecology as a distinct discipline within biology was not formally recognized until around the turn of the century (Odum, 1971). Yellowstone National Park, the first national park in the US, and Banff National Park, the first national park in Canada, were established in 1872 and 1885 respectively.

An additional factor which has led to the incongruence of the legal and biotic boundaries is political expediency. The western North American national parks were created within a political arena and as a result their legal boundaries reflect political compromise and concessions (Ise, 1961). This has tended to strengthen the parks politically; however it has created managerial problems in terms of trying to protect biotic and genetic resources.

IMPLICATIONS

There is an obvious need to promote the congruence of the legal and biotic boundaries of western North American national parks in order to minimize the loss of wildlife within parks. To improve the capacity of these existing national parks to protect biotic resources effectively will require the development of innovative management techniques to enhance the congruence of their legal and biotic boundaries. There are probably no remaining regions in western North America where there are expanses of wildlands of sufficient size in which it will be possible to design national parks so that the legal and biotic boundaries of a park are congruent. In addition, because of the enormous potential size of the biotic boundaries, it may be both politically and economically impractical to purchase the necessary lands. Cooperative forms of land management between the national parks and adjoining public and private lands will be necessary.

There are several examples of innovative approaches to the management of adjoining public and private lands outside western North America which may provide potential models. The current Amboseli National Park management plan in Kenya represents a creative approach for the protection of migratory wildlife. Financial incentives have been provided to the private owners of land adjoining the park to allow wildlife to migrate across their lands. This has not only enhanced the protection of the migratory wildlife but has also promoted local economic development (Western, 1982). Alternatively, the biosphere reserve model represents an innovative approach by which biotic protection can be promoted while at the same time incorporating local peoples into the management of the reserve and allowing the sustainable use of selected renewable resources in restricted zones (UNESCO, 1974). The Rio Platano Biosphere Reserve in Honduras provides an example of such an approach (Glick & Betancourt, 1983).

It is urgent, if these western North American national parks are to function as effective repositories for the maintenance of biological and genetic resources, that an active effort be made to develop techniques to manage cooperatively public and private lands adjoining the parks.

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