US National Park Buffer Zones: Historical, Scientific, Social, and Legal Aspects

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ABSTRACT / This review will trace the evolution of beyond boundary/buffer zone thinking and policy responses in the US National Park Service (NPS); address buffer zone science, benefits, and limitations; examine pertinent legal and social concerns; highlight some agency attempts to create buffer zone-like areas; and propose highlights of a protected area strategy, with buffer zones and corridors as one component. Some findings follow. The need to expand national parks to accommodate large ungulate movement began in the late 1800s, but the recognition that such land was also needed to thwart human impacts such as poaching surfaced in the 1930s. External park buffer zone recommendations by 1930s park scientists were not implemented, and other related adopted policy forgotten, supporting the belief that great insight can be discovered in forgotten institutional history. Buffer zones can remedy some impacts but not others, but their benefits are multiple and underappreciated. The science of buffer zones is very immature and deserves more attention. A present primary obstacle to creating park buffer zones and connecting corridors is a social climate opposing federal initiatives that may intrude on the rights of private landowners. Some proactive NPS bufferlike activity examples are reviewed, but there were none where permanent, complete, effective nonlegislated park buffer zones, derived from nonfederal property, circumscribed large natural area parks. The need for buffer zones and corridors may be a symptom of inadequate regional planning. Options to create buffer zones from private and federal land are outlined. A comprehensive, overall protected area strategy must include more than just buffer zones, with highlights provided. Because optimal regional planning for US national parks is now thwarted by land-use politics, American society must soon decide what is most crucial to future well-being.

The protected reserve idea can be traced back to the hunting reserves that were established in ancient Babylonia and Sumer from 1000–2500 BC (Brockman and Merriam 1959, p. 31), to ancient Assyria in 700 BC and Persia from 500–350 BC (Runte 1979, p. 2), and to India in 252 BC (Gadgil 1989). This practice continued in Greece and Rome and medieval Europe (Brockman and Merriam 1959, p. 31). Poaching animals from William the Conqueror's hunting preserve was punishable by death (Marsh 1874, pp. 241–242). This ancient nature preservation model influenced the creation of national parks and protected areas and resulted in an inside/outside approach to nature protection. This zoolike model, which did not take into account the spatial extent of some natural processes (Shafer, 1998d), the need to provide guardrails against expanding human populations, and other concerns, demand effective buffer zones to reduce problems this early myopic view did not foresee.

A buffer zone has been defined as "a collar of land managed to filter out inappropriate influences from surrounding activities" (Reid and Miller 1989, p. 80). Although buffer zones can safeguard a central reserve, they provide other, less-appreciated benefits. This review will: (1) look at the evolution of buffer zone thinking and policy responses in the US National Park System; (2) address buffer zone science, benefits, and limitations; (3) look at some pertinent US legal and social aspects of buffer zone establishment, (4) highlight some agency attempts to create buffer zone-like areas, (5) propose a protected area strategy, and (6) end with some speculative afterthoughts.

KEY WORDS: Buffer zone; Reserve; Boundary; Policy; Planning

History of Beyond-Boundary Awareness

Expansion for Large Mammals

Early US legislators and government officials made attempts to change national park boundaries to optimize them for large ungulates. For example, General Philip H. Sheridan's 1882 excursion through Yellowstone National Park, in Wyoming, Montana, and Idaho, prompted Senator George Graham Vest to introduce legislation to expand the park's boundaries (Haines 1977, p. 94). In the Senate debates of 1887, John Wesley Powell argued that the proposed boundary for Crater

Figure 1. A view looking north, from atop a hill just south of the US–Mexico international border. The farmland in the foreground, east of Sonoyta, Mexico, comes to a halt at the international border, visible in the background. This abrupt land-use transition is the southern boundary of Organ Pipe Cactus National Monument, Arizona (Photo courtesy US National Park Service).

Lake National Park, Oregon, be moved more than 3 km eastward to provide winter range for mule deer (*Odocoileus hemionus*) and antelope (*Antilocapra americana*) (Milestone 1993, p. 406). The Secretary of the Interior unsuccessfully made attempts from 1907 to 1912 to expand Mount Rainier, Crater Lake, and Glacier National parks to include more winter range for ungulates (Ise 1961).

There were, however, successes in the Yellowstone region. In 1898 the Senate asked the Secretary of the Interior to determine if the region south of Yellowstone should be controlled by the park superintendent in order to reduce threats to its game herds (Brownell 1931, p. 3). A National Elk Refuge was established south of Yellowstone in 1912 and was subsumed by Grand Teton National Park in 1929, with the most optimal land added in 1950. There was early recognition by scientists that the boundaries of Yellowstone were insufficient to provide a year-round refuge for elk (*Cervis elaphus*) (Nelson 1917) and grizzly bear (*Ursus arctos*) (Heller 1925) because of outside hunting.

In the early 1930s, buffer areas were recommended because natural movements or migrations had been truncated (Wright and others 1933, p. 37; Shelford 1933a,b), because of outside hunting or trapping (Wright and others 1933, p. 43; Wright and Thompson 1935, pp. 124, 130), or because of outside land conversion (Wright and others 1933, pp. 123–124). The later is the topic of the next section.

Development and Recognition of Other Threats

The threat of dams inside national parks began in 1913 when President Theodore Roosevelt approved the Yosemite Hetch Hetchy Reservoir project. Through the early 1950s, the National Park Service (NPS) fought other proposed flood control, power, or irrigation projects at Yellowstone, Grand Canyon, Sequoia, Mammoth Cave, Kings Canyon, Big Bend, Rocky Mountain and Dinosaur (Ise 1961). Mining, logging, and grazing threats surfaced during World War I and World War II (Mackintosh 1991). Shelford (1921, p. 431) voiced the concern of scientists: ‘‘Even the national parks must be watched and defended against external aggression.’’ The NPS’s second director, Horace Albright, noted the ‘‘pushing of civilization to the very lines of the Parks’’ (Albright 1929, p. 507). By the 1960s, a team of scientists warned of changes in land use or economic activity outside park boundaries (Robbins and others 1963, p. xiv) (Figure 1). A 1965 supplement to the NPS research handbook (NPS 1966, p. I-2) echoed Wright’s and others (1933) early observations:

> The National Parks are, in essence, ecological islands. Their insulation and areal limitation generate internal problems with respect to

migratory species, predator and other population controls, habitat limitations, and other space-imposed factors. Furthermore, these islands are impinged upon by forces resulting from the increasingly intensive use of bordering lands. Among them are fire, forest insect and disease infestation, exotic plant and animal invasions, stream pollution, predator control, overlapping ranges of domestic stock and wildlife, and the like.

Wright and others (1933) did not focus on habitat isolation, but they were concerned about park size, boundary configuration, and outside boundary influences (Shafer 1998b,d). To Wright and others (1933, p. 19), external influences were humans or exotic species that did not find park boundaries a barrier. The terminology buffer area later became buffer zone (Shelford 1941a).

Reserve Design History Updated

Simberloff (1988) correctly attributes multiple-species reserve design thinking to Willis in 1971 (later found in Wilson and Willis 1975). However, we might begin thinking about large mammal natural history as part of reserve design too. Wright and others (1933) believed more area could minimize poaching (p. 142) or other external influences (p. 19). They also provided ideas viewed as important to reserve design today: a notion of minimum populations (p. 147) and minimum areas (p. 142) and observations (p. 130) that decades later were expressed as park area / perimeter ratios (e.g., Diamond and May 1976).

The Ecological Society of America's sanctuary plan was adopted 28 December 1932 (Shelford 1933b). Shelford (1933a,b) proposed buffer areas around core reserves. However, the book written by Wright and others (1933) was finished in 1932. March 1932 memos by Wright and colleagues reflect their boundary views (Sellars 1993b, p. 83) and Shelford (1933a) recognized their contribution. Great insight can be found in forgotten institutional history, so future progress might hinge on a careful reading of the past.

Studies and Prescriptions

The *Administrative Policies for Natural Areas of the National Park System*, abolished in 1975, noted that ''parks are fast becoming islands of primitive America, increasingly influenced by resource use practices around their borders . . .'' (NPS 1970, p. 161). Next, Kusler (1974) discussed in depth the legal issues associated with protecting adjacent land. Soon after, two private studies revealed widespread concern about encroachment and other influences originating beyond park boundaries, such as pollution and poaching (Shands 1979, NPCA 1979).

Although NPS was already aware of some air, water, exotic species, and development threats to parks, the release of *State of the Parks-1980: Report to the Congress* (NPS 1980) was a pivotal turning point, resulting in newspaper and popular articles that increased public awareness of beyond-boundary influences. It ended what Sax (1981) called the agency's ''enclave mentality.'' Subsequently, a plan was sent to Congress recommending, among other things, zoning and regulation by state and local governments (NPS 1981). Congressional legislation, intended to provide relief, was introduced in 1982 (see Keiter 1985, Coggins 1987, Freemuth 1991) with variations into the 1990s. Keiter and Boyce (1991, p. 392) provide an apt characterization of the late 1980s: ''the threat of comprehensive federal legislation looms like the sword of Damocles over the entire Yellowstone region, along with the ever-present threat of general park protection legislation.'' External influences are defined in broad terms—development, grazing, cultivation, energy production, mining, and even recreation and exotic species (Elfring 1986). Although the most conservative journals recognize that many US national parks suffer from external pressures, such as suburban and rural housing construction, proposed highways and dams, and ongoing mining (Mitchell 1994), such legislation has not become law. The congressional opponents of the bills feared they would create, yes, buffer zones!

A reality early this century arrived at the doorstep of public awareness via ''threats to parks'' terminology. The general external impacts problem described in NPS (1980) were supported in follow-up government reports, both for outside influences (e.g., GAO 1987, 1994) and inside activities (GAO 1996a) while the NPS track record of abating external threats received criticism (GAO 1987, Bloom 1992). Although the term ''threats'' was described as ''a social metaphor applied to biological systems'' and ''hopelessly anthropogenic'' (Machlis and Tichnell 1985, pp. 10, 13), the public grasped the message. However, conservation organizations still try to educate about problem immediacy (e.g., Buccino and others 1997). Awareness by some conservation biologists of externally derived reserve problems often begins with Janzen's (1983) weedy farmland species invasions. Park officials were trying to thwart encroachment of a different sort in the 1920s (Albright and others 1987, p. 38): mining, logging, grazing, resort construction, hunting, and in particular, power and irrigation projects. The scientific community was aware of the exotic species invasion threat in 1921 (Shelford 1921). Park managers and scientists were aware of exotic burro (*Equus asinus*), goat (*Capra hircus*), and pig (*Sus scrofa*) problems in the 1950s. Valuable institutional history too infrequently assimilated and disseminated

may be the reason for some of academia's lack of familiarity (Shafer 1998b,d).

NPS Policy Responses

The 1930s

Wright and Thompson (1935, p. 14) were very concerned about ''the failure of the parks to be self-contained, self-walled biological units . . . ,'' and recommended buffer zones. The publication of *Fauna of the National Parks No. 1* (Wright and others 1933) and *Fauna of the National Parks No. 2* (Wright and Thompson 1935) represented landmark guidance for the NPS. The recommendations in Wright and others (1933, pp. 147–148) were quickly adopted as policy in 1934 (Sellars 1993a, p. 67). A few of these policy statements were:

> Each park shall contain within itself the year-round habitats of all species belonging to the native resident fauna.
>
> Each park shall include sufficient areas in all these required habitats to maintain at least the minimum population of each species necessary to insure its perpetuation.
>
> Park boundaries shall be drafted to follow natural biological barriers where possible, particularly life-zone or similar habitat boundaries.

These policy messages later disappeared and cannot be found in subsequent NPS policy handbooks (NPS 1978, 1988). No mention is made of including sufficient area for minimum viable populations or the ideal of having a species' seasonal movement circumscribed by a park boundary. Why? The policies were in Wright and others (1993) which was out of print after World War II (Sumner 1983). Diminishing regard for previous science and policy or political considerations are also possibilities. However, insisting on such goals today would surely precipitate political backlash (see Mann and Plummer 1993).

The 1960s and On

The NPS has long opted for cooperation with landowners outside park boundaries, not regulation, to influence land use (e.g., Swem 1968). Nevertheless, 1978 policy stated cooperative regional planning could include ''zoning and land use controls on lands in the park's vicinity'' and ''development of needed Federal, State, and local legislation'' (NPS 1978, p. II-6). Later, NPS (1980, p. viii) claimed park external impacts were a result of ''their surrounding buffer zones gradually disappearing,'' but these so-called buffer zones had no accompanying land-use restrictions.

The mood in the United States towards land-use planning changed around 1981, reflecting the 1980s ''Sage Brush Rebellion'' concern about government regulation. Revised official 1988 policy declared ''buffer zone'' a taboo term (NPS 1988, p. 1.4). This result was due to congressional review of the draft pre-1988 policies. The policy was, and currently remains, that buffer zones and additional veto power over activities on adjacent lands will not be sought. The endorsed strategy is ''cooperative planning'' and using existing authorities of federal, state, and local agencies to deal with water quality or use, mining activity, hazardous or toxic waste, zoning, or subdivision.

Administrative Pseudo-Buffer Zones

Greater is better: The Rocky Mountains as a park. Senator Cole of California, during the congressional debates preceding the creation of Yellowstone National Park, said ''There is an abundance of public ground in the Rocky Mountains that will never be occupied. It is all one great park, and never can be anything else'' (Buck 1946, p. 10). His prediction proved to be wrong because the Rocky Mountains has not remained one large, undisturbed park. For example, Heller (1925) noted Yellowstone needed land in adjacent national forests to accommodate the grizzly bear (*Ursus arctos*). Later, Shelford (1941b) provided a map to illustrate this need for the gray wolf (*Canis lupis*). In the 20th century, highways, mining activity, resort development, and homes cover a landscape thought to be inaccessible and incapable of such alteration in the last century. Because people thought the 19th century American West was so vast, the idea of buffer zones never occurred to them. The lesson provided is one other countries with vast tracts of natural land might note.

Greater ecosystems. ''Greater Yellowstone'' terminology can be traced back to 1917 (Haines 1977, p. 320); however, land managers did not use it much until the 1960s (NPS/USFS 1987). The ''greater ecosystem'' of Yellowstone, an administrative label, carries no accompanying land-use regulations. It is often viewed as an interagency commitment to cooperate. However, interagency cooperation on shared problems may not always be induced by labels or even formal, written agreements. Additionally, one quarter of the Greater Yellowstone area consists of private land containing key winter range, migration routes, and fertile bottomland. Its ongoing rampant subdivision is a concern of the Greater Yellowstone Coalition (Glick 1995) and other private conservation organizations. The greater ecosystem idea that developed in Yellowstone was later recommended for wider application (e.g., Grumbine 1990). In such cases, the belief seems to be that if we all work together, perhaps a buffer zone is unnecessary. The greater ecosystem concept has proved to be a poor substitute.

The MAB influence. UNESCO (1974) proposed a buffer zone for biosphere reserves, influenced perhaps more by park management experience in the Third World than the described beyond-boundary experience in the United States and other developed countries. The model core/buffer configuration would allow local people to live in the buffer zone (i.e., demonstrate compatible human use) and keep recreation/tourism away from the less-disturbed, central core. Secondary purposes were to provide space needed by wide-ranging species and allow for manipulative/experimental research. Today, the optimal biosphere reserve design, if there is one, is uncertain (e.g., Dasmann 1988).

The first 26 US biosphere reserves were designated in 1976, including 12 national parks. In the rush to designate, the United States selected a fallback ''cluster'' variation of the ideal model. The requirement that biosphere reserves have ''a suitable legal framework within which the necessary controls on land use can be implemented'' (UNESCO 1974, p. 139), reaffirmed in UNESCO (1984, 1996), has not been pursued. To really protect a biosphere reserve core, regulations, easements and voluntary cooperation must be focused on the outer zones.

The void between the biosphere reserve model and its implementation has been noted (e.g., Tangley 1988). Many US biosphere reserves have been erroneously portrayed as having officially designated buffer zones next to a core national park. However, only one US national park biosphere reserve has an officially delineated UNESCO-recognized zone external to the core park with even limited protective potential—the managed use areas next to Mammoth Cave National Park in Kentucky.

A few pre-1980 biosphere reserves, many ''multisite'' types (1980–1986), and the ''regional'' ones (primarily since 1988) have adjacent landowners who potentially can serve the buffer zone/transition zone function (MAB 1995). Even while the United States recognizes 47 biosphere reserves in 99 administrative units (consisting of 24 management categories on federal, state, local, and private land), a hard lesson has been learned—there are political obstacles to converting existing protected areas into model US biosphere reserves. Present US biosphere reserve managed use areas or areas of cooperation are not buffer zones. In this case, we encounter administrative denial because of social pressures. The allusion is that a US biosphere reserve core can get along fine without a real buffer zone.

Shelford's (1933b) recommendation that national parks consist of core ''research reserves'' surrounded by less well-guarded land is similar to the UNESCO (1974) core/buffer model, but Shelford focused primarily on roaming large mammals. However, the UNESCO (1974) buffer zone model resulted in the term ''buffer zone'' becoming common agency jargon 35 years after Shelford (1941b) used it. Regardless of not having model buffer zones, there are many US biosphere reserve success stories (see MAB 1995). Nevertheless, the original UNESCO biosphere reserve core/buffer zone model was changed in the 1980s to the core/buffer zone/transition zone model. In the 1990s, the United States adopted friendlier-sounding terminology: core became protected area, buffer zone became managed-use area, and transition zone became area of cooperation. Politics may have influenced dropping threatening terms such as ''buffer zone'' and adding positive ones such as ''cooperation.'' The biosphere reserve concept continues to evolve (Batisse 1997).

A Lost Opportunity

Introduced by Congressman John Seiberling in 1982 and 1983, HR 2379 sought the following: formal agency consultation procedures, required plans formulated by federal/state/private partners for managing land outside park boundaries, planning grants to local governments to develop land-use plans, technical assistance, individual park management plans taking into account outside boundary considerations, more inventory, more research on park threats, development of biotic condition indexes, training, and recruitment. Unfortunately, NPS and department officials testified against it. Coupled with ways to stop harmful adjacent land use on private lands, this legislation would have been a major step in the right direction.

Political Pressure

Field implementation. Hough (1988, p. 130), describing developing countries, said ''where national parks already exist, proposals to create zones of controlled exploitation outside the existing park boundaries are likely to meet with massive opposition.'' A similar outcome is frequently the result in developed countries as well, in large part due to complex regional patterns of land ownership. For example, the Alaska National Interest Lands Conservation Act of 2 December, 1980 was a landmark achievement. However, after the interagency planning team forwarded legislation that specified the proposed reserves be surrounded by legally binding ''areas of ecological concern,'' Congress deleted the language prescribing this form of buffer zone before the legislation was enacted (B. Brown personal communication)

As a second example, the 1883 Senate debates about

Yellowstone National Park extending its boundaries ''brought protests from adjoining ranchmen, miners, and others'' (Ise 1961, p. 41). The situation has not changed much in more than 100 years (see Goldstein 1992, Lichtman and Clark 1994). The fears of adjoining landowners weigh heavily on whether and how land-use planning is undertaken outside park boundaries. How essential it may be to park biota over the long term rarely overrides such opposition.

Policy and initiative. Park establishment is known to be highly political (e.g., Everhart 1972). Written policy is sometimes influenced by politics as well. For example, the NPS policy of not seeking ''buffer zones'' or veto power over adjacent land activities (NPS 1988) became official policy due to congressional insistence. ''The enterprise of extricating policy from politics assumes that analysis and politics can be, and are in essential ways, separate and distinct activities'' (Stone 1988).

George T. Frampton, during his tenure as president of the Wilderness Society, said ''if we're not able to ensure that the agencies of our own federal government can't protect park wilderness, do ecosystem planning and begin to plan for buffer zones that are necessary to protect our existing parks and wildernesses, how can we ask other countries to do it?'' (Frampton 1988, p. 228). However, in his subsequent capacity as a top government official overseeing the US national parks, the dominant political party views on land-use planning weigh heavily on any initiative considerations.

Science, Benefits, and Limitations of Buffer Zones

Providing for Reserve Biota

Population size and dispersal. Buffer zones can increase the population of rare species (e.g., UNESCO 1974) because they provide additional usable area. Both buffer zones and areas of cooperation (Salwasser and others 1987) can also increase the population of more common species. Additionally, buffer zones may make movement easier by turning a hard edge into a soft one (Stamps and others 1987).

Buffer zones can also function as corridors (Vujakovic 1987). Mwalyosi (1991) proposed 1-km-wide, 30+-km-long corridors between Lake Manyara National Park, Tanzania, and Tanangire National Park to the southeast and a 2-km-wide, 15-km-long extension buffer between Lake Manyara and Marang Forest Reserve to the southwest. The extension buffer is shaped like a corridor but hugs the park border and could function as a corridor over a short distance. Really wide corridors become harder to distinguish from general matrix dispersal (Rosenberg and others 1997).

Edge and matrix effects. Much of what is known about how far some human activities can influence biota did not stem from this growing ''beyond park boundary'' awareness. Instead, some was derived from habitat fragmentation concerns, earlier dubbed the ''edge effect.'' An edge effect is a deleterious influence resulting from abrupt human-precipitated vegetation boundaries (e.g., a woodlot/corn-field boundary). For example, avian nest predators such as cowbirds sometimes nest 1000 m in from the edge of fragmented blocks of eastern deciduous forest (Wilcove and others 1986), and increased predation has been documented for reptiles (Temple 1987) and mammals (Prins and Iason 1989) as well. Another type of edge effect concerns the depth of physical processes, for example, the physical impact of human-created forest edge (i.e., temperature and humidity) extended a remarkable 240 m into Pacific Northwest conifer forests (Chen and Franklin 1990). These two edge effects will not be eliminated by buffer zones, rather they will be moved farther away from the reserve's center. A third type, similar to some beyond-boundary concerns, involves more direct types of human impact. For example, 95% of all human trampling and firewood gathering in suburban forest fragments reached 83 and 130 m, respectively (Matlack 1993).

Matrix effects, in contrast to edge effects, are human impacts originating between primary blocks of habitat and are of the beyond-boundary category. For example, dry land pollutants such as heavy metals (Deroanne-Bauvin and others 1987) and salt (Simini and Leone 1986) can extend 120 m from roads, while acid-mine drainage and other water-borne matter, such as sediment from logging or dredging, can impact reserve biota many kilometers away. Roads cause problems for other reasons. Road noise can disturb Roosevelt elk (*Cervus elaphis roosevelti*) or Alaskan caribou (*Rangifer tarandus*) at 500–600 m (references in Schonewald-Cox and Buechner 1992), while busy highways can disturb some grassland birds at 1600–1800 m (van der Zande and others 1980). Any lack of good, scientific evidence for all categories of park threats hampers policy setting (Lemons 1986).

Models. Conceptual models can facilitate research. The buffer zone issue was subsumed by the umbrella ''boundary model'' proposed by Schonewald-Cox and Bayless (1986), who argued boundary effects were of greater importance than area effects. For example, some reserves in South Asia routinely permitted grazing, logging, and poaching (Schaller and Simon 1970)

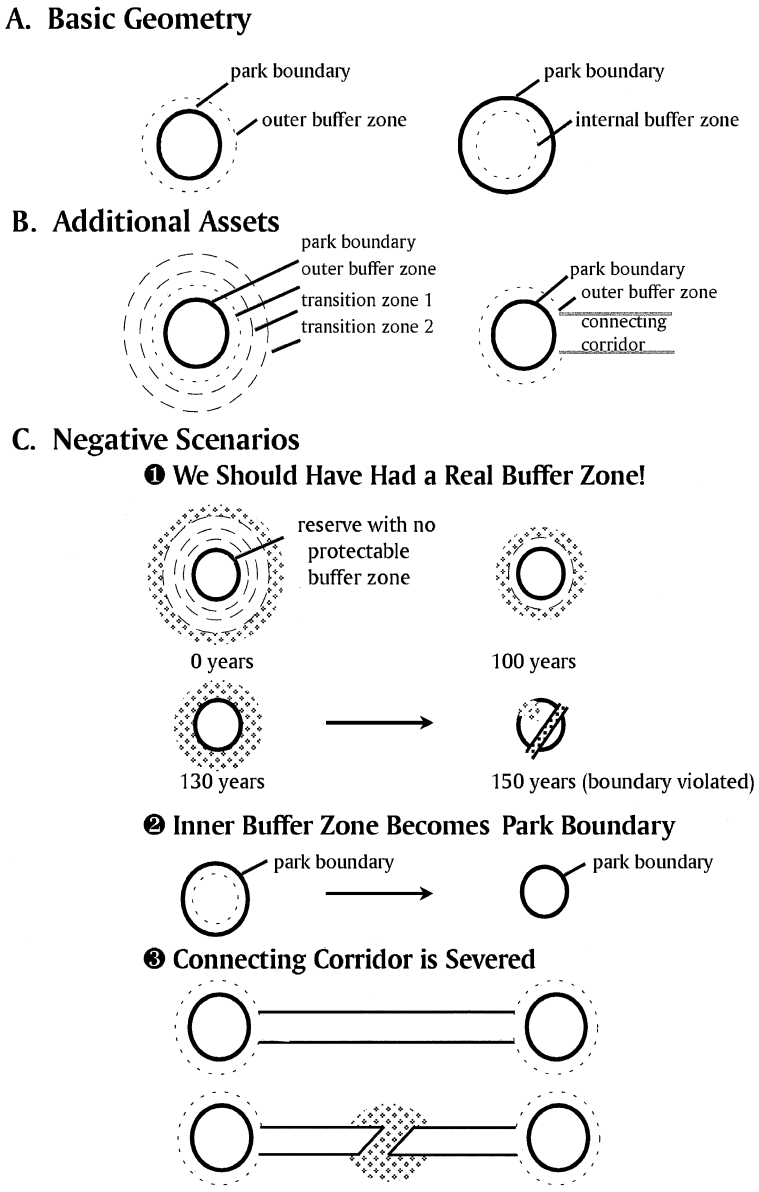

Figure 2. Some very basic buffer zone concepts.

resulting in an "internal" buffer zone and a smaller reserve (Figure 2), which is an inside "generated edge" of Schonewald-Cox and Bayless's (1986) model. Schonewald-Cox and others (1992) and Buechner and others (1992) later focused on land preservation techniques to reduce gradient abruptness.

At the moment, we typically have to guess at buffer zone width to reduce some human impacts. Kelly and Rotenberry (1993) pleaded that buffer zone guesswork be replaced with buffer zone science. Since some land-use impacts can vary greatly along a park boundary (Schonewald-Cox and Bayless 1986, Ambrose and Bratton 1993), more than one buffer zone prescription can be needed for a park.

Facilitating or protecting from natural disturbances. Optimal buffer zone design can vary with the primary management goal. Because natural disturbances are often positive (White 1979), a design for maintaining disturbance regimes may be different from one for maintaining species diversity (Baker 1992). Buffer zones can provide more landscape needed for disturbances such as fire, either at the species level (e.g., Pickett and Thompson 1978, Pickett and White 1985) or landscape mosaic level (e.g., Baker 1989, 1992).

A specific problem NPS must deal with are the number of small private land parcels (inholdings) that would invariably be included in such park buffer zones. Owners with structures on their property may not like a

Figure 3. This December 1996 viewshed contains the Rainbow Gardens development project as seen from the northwest corner of Lake Mead National Recreation Area, Nevada. This project now includes a dam, an artificial lake, homes, and a golf course, with more homes, golf courses, and a casino coming later. (Photo courtesy US National Park Service, December 1996).

general ''let it burn'' policy, a situation that influenced fire suppression at Yellowstone National Park.

Data on Caribbean tropical hurricanes report little change in plant species composition, but Hurricane Andrew in 1992 had negative impacts on some endangered animal species in the Florida Everglades (Loope and others 1994). Buffer zones might reduce the effects of hurricanes if they contained taller trees or sheltering topography (Smith and others 1994.

Limiting Human Impacts

Buffer zones can confine some types of human activity to less-fragile adjacent land (e.g., UNESCO 1974). They might also protect against poaching/collecting if the increase in size reduced the number of access points (Willis 1984) or reduced the patrol perimeter (Ayres and others 1991). Experience tells us buffer zones can help prevent human trampling and off-road-vehicle impacts (see Cole and Landres 1995), interference by boats, trespassing livestock, logging, mining, application of pesticides and herbicides, dust deposition, animal avoidance of adjacent roads, and an array of various forms of development (Figure 3). They also may limit more indirect human impacts, such as retarding the spread of unwanted animals or plants that thrive in more disturbed adjacent areas (Wright and others 1933, p. 109, Janzen 1983, 1986, Hanski 1992). They have been advocated to prevent the spread of fire (Shelford 1933b, Baker 1992) and disease (Shelford 1933b, Dobson and May 1986).

Enhancing Visitor Experience

Buffer zones have more to offer than just eliminating noise. Adding to the visitors' experience of wilderness and peace is another buffer zone asset. The environmental philosopher Rene Dubos (1970) suggested unnatural landscapes may take their toll on human psychological well-being. The idea later broadened into the biophilia hypothesis—speculation about whether man's affinity for nature is genetic (Wilson 1984, Kellert and Wilson 1993). These themes resonate back to the very beginning of the American protected area movement: Frederick Law Olmsted, the famed landscape architect and advocate for Yosemite Valley in 1865, hinted at this very issue (see Roper 1953). Dearden's (1988) survey found that 87% of 500 visitors said even seeing clear-cuts outside a park boundary would detract from their overall park experience. As Dearden points out, local communities profit most when park visitors return. Some may not come back if parks do not provide islands of peace, audible and visual.

Buffer Zone Limitations

Curtailing the movement of exotic pigs (*Sus scrofa*) and goats (*Capra hircus*) into Hawaiian national parks (Stone 1986, Loope and others 1988) requires fences not buffer zones. Air pollution (Udall 1986, National Research Council 1993), including acid rain, will be reduced using regulations, not buffer zones. Similarly, buffer zones are unlikely to retard the spread of exotic plants, nor will they reduce noise from overhead aircraft, but they could reduce noise enough to increase the nesting success of some species of birds. They may not reduce the impact of some weather-related disasters such as flooding, drought, or blizzards but might reduce the impact of high wind. They are certainly not the solution for watershed concerns, such as water pollution or dams, but might reduce near-shore island sedimentation derived from construction (Macdonald and others 1997). The Glen Canyon Dam constructed in 1963 altered the physicochemical and biological characteristics of 446 km of the Colorado River (Johnson and Carothers 1987). The threat of dams outside US national park boundaries continues (NPCA 1993). However, ignoring potential buffer zone usefulness is not an effective way to thwart some cross-boundary park problems.

Legal and Social Considerations

The Good-Old Days: Early National Monuments

National forests were created around Yellowstone in part to aid its large herbivores (Haines 1977, p. 97). This view may account for the remark by Adams (1925, p. 567), ''The first national forests were created about the Yellowstone National Park, in order to protect it . . .'' When some national monuments were carved out of existing national forests using the Antiquities Act of 1906 (Rothman 1989), the surrounding forests became de facto buffer zones. Although 21 national monuments were proclaimed in national forests before 1933 (Mackintosh 1991), we can only speculate about any purposeful buffer zone creation. Leopold (1949, pp. 276–277) recognized that national parks could better accommodate large mammals by managing parts of adjacent national forests just like the park. Opportunities to do it the old way are decreasing because of public opposition (e.g., Wilkinson 1997).

Buffers and the Stigma of Zoning

A buffer zone can be any undeveloped land ringing a reserve, but an optimal one will explicitly regulate land use (e.g., Hiscock 1986). The term's stigma in the United States results from public association of the term buffer zone with zoning and associated private land-use regulation. Zoning in rural areas is common in England and Denmark, and this strategy was once advocated for international adoption (Ordway 1966). In the United States, the late Senator Henry Jackson's 1970 national land use legislation (S 268) did not become law. Sax (1976) indicated a national zoning scheme for national parks is feasible only if Congress favored one. NPS policy is more liberal in endorsing land preservation tools for protection of land inside a US national park (NPS 1988, pp. 3.1-2). There is less hesitancy to give a green light for seeking appropriate regulations, zoning, acquisition of easements, and direct purchase for land inside park boundaries. More benign approaches for land outside park boundaries, such as agreements, donation, exchange, and transfer, appear to raise fewer fears about potential political backlash.

Terminology can raise political red flags. The National Parks and Conservation Association refrained from recommending buffer zones. Instead, they opted for friendlier-sounding ''zones of influence'' (NPCA 1988). Alternatively, the whole outside buffer zone issue can be avoided; for example, Park Canada's five-zone system creates buffer zones inside the authorized park boundary instead of surrounding it (Stephenson 1995).

Examples of Post-1970 Land-Use Planning Prescriptions

Abatement of external threats to national parks is a political issue (Freemuth 1991), intertwined with scientific, economic, social, and legal concerns (Shafer 1994). Aspinall (1970, pp. 82–83) did not recommend zoning by the US federal government, opting instead for acquisition of easements if state / private cooperative efforts fail. The Conservation Foundation (1972, pp. 18, 23) recommended buffer zones / land-use planning controls outside of national parks in cooperation with state and local governments. Kusler (1974) addressed control methods other than direct land purchase, concluding that a range of techniques can be used along with land-use regulations as the primary means to control private development. For subsequent guidance, especially for private land, see Hoose (1881), MLR / LTE (1982), Brenneman and Bates (1984), Diehl and Barrett (1988), Mantell and others (1989), and Propst and others (1990). The Conservation Foundation (1985, p. 266), in its follow-up study 13 years later, recommended a combination of land-use restrictions, cooperation with state and local governments, economic incentives, and technical assistance.

Fear of Control and International Solutions

The creation of buffer zones or connecting corridors for US national parks is a land-use issue. Diamond and Noonan (1996) concluded two things plague past US land-use planning: the private landowners' fear of government and the political problems caused when 34 million landowners control 3.2 billion hectares of land. They recommended that: (1) local governments take the lead; (2) government should not pay to enforce environmental safeguards benefiting most citizens; (3) education and tax benefits be used to encourage benign private land stewardship; (4) partnerships should be created among conservationists, social justice advocates and developers; and 5) disputes should be mediated rather than litigated. Land use in the United States is also hampered by the fragmented jurisdictions of federal, state, local, and municipal regulatory bodies (Platt 1996), which is what frustrates regional planning outside of reserves.

Bolder and ecologically more meaningful, land-use planning initiatives have been taken by other countries. For example, in Denmark, a local authority has to grant permission to eliminate certain habitats (e.g., heathland, peat bogs, salt marshes, lakes, rivers) regardless of who owns the land (Koesler 1984). In South Australia, a private landowner must get permission to clear native vegetation, and if an assessment reveals the land is ecologically important, permission is denied. However, owners are given an opportunity to enter into a type of easement with financial compensation provided (Thackway and Stevenson 1989). European countries are land limited relative to wealth. In the United States, the opposite situation has existed, driving public land policy. Since the United States is moving towards a European land-use configuration, European experience may offer lessons in managing the most highly fragmented US landscapes (Shafer 1997).

Clarification of Threat-Abatement Authority

Authorities do exist to abate external air and water problems using the Clean Water Act, amended in 1987, and the Clean Air Act, amended in 1990. The National Environmental Policy Act of 1969 can be used to thwart other threats on federal land and the Endangered Species Act of 1973 on land of any ownership. The NPS 1916 Organic Act and the Redwood National Park Expansion Act of 1978 together may abate threats on state or private land (Keiter 1985, 1988, 1989).

Sax (1976) and Shepard (1984) argue that the Property Clause of the US Constitution, mentioned in NPS (1991, p. 2:23), grants Congress power to regulate activity on private land transferable to NPS. Mantell (1990b, pp. 240–242) cautiously indicates the Property Clause is largely ''untested'' and its authority ''unclear.'' Coggins (1987, pp. 17–18, 22) said ''. . . such a power does exist, but its nature, scope, and contours are murky. So far, the power has been used successfully only to abate or to punish for closely-adjacent, nuisance-like activities. Whether it will ever be expanded into something more significant is in part a function of agency willingness to assert it, a willingness heretofore largely lacking.'' Keiter (1989) believes the Property Clause is enough authority, in combination with the 1916 Organic Act and its 1978 amendment to abate outside threats on private land. As Lockhart (1997) illustrates, no effort at clarification of such issues has been provoked. The result is agency confusion, and in Lockhart's opinion, great underestimation of the potential legal reach of the amended Organic Act.

There is no consensus about the adequacy of all existing authorities to protect parks from external threats originating on lands of any ownership. Views range from no clear authority existing (NPS 1992, pp. 125–127) or authority is insufficient (Coggins 1987), to more authority existing than is used (e.g., Keiter 1989, Lockhart 1997). For example, after examining land-use conflicts outside Glacier National Park, Montana, Sax and Keiter (1987, p. 214) said ''Glacier is constrained by bureaucratic prudence and timidity. It is reluctant to use the law; highly deferential to the traditional turf prerogatives of its neighbors; and hesitant to subject itself to criticism by speaking out forcefully on transboundary issues.'' Keiter indicates other authorities can be applied to federal lands in coordination with other agencies, e.g., the Wilderness Act of 1964, the Wild and Scenic Rivers Act of 1968, and the National Forest Management Act of 1976 (Keiter 1989).

The issues associated with abating external impacts to US national parks instigated some employee legal training (Mantell 1990a), but more than this is needed. The NPS needs political support to clarify these outstanding legal questions and then courage and political backing to fully assert any and all existing authority in problem situations.

Protection Got Complicated: Private Land Rights

Even if sufficient authority existed, there are other obstacles. The concern about government-imposed restrictions on private land did not recede after the 1980s Sage Brush Rebellion; in fact it apparently changed into the private land rights advocacy of the 1990s. Societal pressure against buffer zones grew to the extent that Knuffke (1993, p. 23) indicated ''every recent western wilderness bill contains the now-standard Congressional prohibition against buffer zones.'' The movement in support of private landowner rights is now a top

issue in the United States, involving the collision between perceived social good and using private land as one chooses (see Echeverria and Eby 1995).

Recent US legislation is revealing. The Shenandoah National Battlefields Partnership bill of 1995 (HR 1091) was introduced 1 March 1995 to shrink the maximum authorized boundaries of Shenandoah National Park, Virginia, so it cannot expand even by private land donation without Congressional approval (see Fordney 1996). It died. The American Land Sovereignty bill (HR 3752) of 1996, reintroduced on 27 February 1997 (HR 901), incorrectly portrays biosphere reserves, World Heritage Sites, and other US international designations as a United Nations takeover of private lands. The 1997 version seeks to abolish all existing US biosphere reserves and specifies that World Heritage Sites will have a ''no economic impact buffer zone'' for a distance of 16.2 km (i.e, no economic hardship can occur to adjacent landowners). It passed the House of Representatives on 8 October, 1997. Yet from 1964 to 1994, the NPS used condemnation for only 13.6% of added park land (GAO 1996b). The fear seems disproportionate to condemnation practice.

American property law has always involved a tension between private and public rights, and the meaning of property changes with public values (Duncan 1996). Property law is based on the ideas of John Locke; however, his writings argue for restrictions on the use of private land if use is counter to the public good (Shrader-Frechette and McCoy 1993, pp. 173–174). Hunter (1988) sympathized with Leopold's (1949) ''land ethic,'' agreeing that land should be treated differently than personal property. In the preface to Leopold's (1949) *Sand County Almanac*, he recognized land was abused because it was regarded as a ''commodity,'' and it still is (see Kuperberg 1978). Hunter (1988, pp. 382–383) concluded:

> Far-sighted officials have responded to environmental problems with innovative and beneficial land-use regulations. All too often these efforts run afoul of a constitutional jurisprudence that is rooted in an economic and development-oriented view of land. Current takings analysis dates from an era when land seemed limitless and the environment too awesome to threaten. Those days are gone. Legislators and the general public have realized this, but courts have failed to instill the obligation of stewardship in the institution of private property.

Caldwell (1970, p. 205) foresaw our present predicament: ''if the management for whole ecosystems becomes a matter of public policy, then [it] . . . must proceed on the basis of the proposition that all land is in some degree public.'' Fifty percent of the United States, 907 million acres, is cropland, pastureland, or rangeland owned by farmers and ranchers, about 4.7 million individuals. Consequently, stewardship of 50% of the land is the responsibility of less than 2% of the people (USDA 1996, p. 7). These individuals are frequently under great pressure to sell to developers. The rest of the country and the world must live with the outcome.

Federal Land Protection

An approach appropriate for Yellowstone National Park in Wyoming, Idaho, and Montana (surrounded mostly by public lands) may be inappropriate for Rocky Mountain National Park in Colorado (surrounded mostly by private development). Federal land represents a special case, the focus of national park protection legislation since 1982. HR 2379 of 1982 and 1983 sought review procedures agencies had to comply with when their actions might adversely affect an adjacent park, review by the Secretary of Interior with his recommendations, and congressional notification if conflicts could not be worked out. By 1992, HR 5738 sought only the development of comprehensive plans of cooperation. Taking a different approach, a 1984 amendment to S 978 sought the following: designation of ''wildlife resource habitat'' on federal land adjacent to parks, subsequent prohibition of federal expenditures if deemed detrimental to this habitat, and NPS review of other agency activities outside park boundaries. None on these legislative initiatives became law.

Basically, there is a valid recognition that diverse federal agencies cannot always work together informally and resolve their differences; this is also true of their dealings with state and municipal governments. Although informal networks such as the Greater Yellowstone Coordinating Committee, created using interagency agreements, are helpful, something with more force would be preferable (Keiter 1985, 1989).

Canada: A Neighbor with Similar Problems

Other national governments are aware that optimizing the future of reserve biota by intervening in private land use outside reserve boundaries will result in social backlash. For example, Nicholson (1982, p. 60) described a 1974 interim policy by a Canadian regional planning commission to restrict development within 16 km of Canada's Waterton Lakes National Park. By 1980, this policy was overturned by landowners because ''the restriction was an unacceptable imposition on their property rights.'' The biosphere reserve approach in some parts of Canada (Francis 1989) has striking similarities to the US approach. Park managers avoid mentioning zoning but emphasize the ''protected area/zone of cooperation'' concept, which is voluntary, informal, and fosters more agreeable interactions.

Dearden (1988, p. 264) mentions a small but important success story outside the Waterton Lakes National Park Biosphere Reserve: six ranchers and two park staff members formed a ''management committee'' for lands adjacent to the park. Dearden then explained ''The park superintendent can veto decisions concerning the park, and the ranchers decisions concerning their private land. Both, however, have found it possible to cooperate on several ventures of mutual benefit to themselves and the reserve.'' Although Canada does have far less private land than the United States, in Canada the issue and problem of dealing with private land in regional landscape conservation strategies is more openly recognized (e.g., Nelson 1984, Wildlife Habitat Canada 1991). The US situation is more like Varley (1988, p. 222) portrayed it: ''No one, it seems, wants to tackle the issue of threats to the park or ecosystem (Yellowstone) that arise on private lands.'' Sax (1980, p. 739) may be correct: ''Only the Congress, by adopting policies of general application, can insulate the Park Service from the intense pressure it receives from private landowners.''

NPS Bufferlike Activity Examples

Easements at Acadia

A Congressional mandate to secure scenic easements next to Blue Ridge Parkway in Virginia and North Carolina, and Natchez Trace Parkway in Mississippi, Tennessee, and Alabama, was provided to NPS in the 1930s, followed by a national parkway manual (NPS 1938). Easements, then and now, can provide buffer zones. Since 1970, there has been an ongoing program at Acadia National Park in Maine, in cooperation with the Maine Coast Heritage Trust, to secure easements outside the park boundary on Mount Desert Island and on numerous smaller nearby nonpark islands (Endicott and contributors 1993, pp. 206–207).

Attempts at Zoning at Saguaro

In the Sonoran Desert in the American Southwest, land-use zoning has been tried outside of Saguaro National Monument, Arizona (WRI / IUCN / UNEP 1992, p. 131) to curb urban problems. This bold initiative was met with resistance (Stone 1989, Probst and others 1990, pp. 171–172). Resolution of conflict relied on workshops, conferences, attempts at referendum, formal mediation, and open space and trail plans (Davis and Halvorson 1996). In spite these efforts, NPS land purchases (about 2500 ha), and land-exchange negotiations (Weesner personal communication), impending development directly outside Saguaro's boundary may run for 8 km contiguously (Briggs and others 1996). The problem is that home-buyers often select tracts near national parks like Saguaro because they enjoy its close proximity (Shaw and others 1992, Harris and others 1997). Saguaro will then serve as a buffer between distant subdivisions. Growth of rural subdivisions next to other federal land in the American West has been in full swing (Knight and others 1995, Gersh 1996) (Figure 4). This demands that priorities be set for buffer zone creation with innovative strategies to create them, not excluding cooperative development planning (Howe and others 1997).

Mammoth Cave Biosphere Reserve's Protective Area

Septic tank and sewage drain-field effluent were entering the groundwater of the 272,932-ha recharge basin surrounding Mammoth Cave National Park, Kentucky, posing the threat of polluting the park's groundwater. At the suggestion of NPS, the Barren River Area Development District (BRAD) selected the UNESCO (1974) biosphere reserve model as a tool to manage water quality. In Mammoth Cave Biosphere Reserve, created in 1990, the national park became the core and two, large, nonencircling managed-use areas abutted the park's boundary. Both the core and managed-use areas are circumscribed by an area of cooperation.

Chartered by the state, BRAD is responsible for regional planning in ten counties. BRAD's board of directors, all locally elected leaders, manage the biosphere reserve based on advice from their own council of technical specialists. The managed-use areas correspond to the park's recharge basin, while the area of cooperation takes in nonpark groundwater. Here, a mechanism is in place that can potentially influence the way private land in the managed-use areas is used. This biosphere reserve pseudo-buffer zone has the potential of functioning like a real one without employing stringent land-use restrictions (Bradybaugh 1996, and personal communication). Similar strategies have been employed outside other areas, for example, at Lake Tahoe on the Nevada–California border (Byron and Goldman 1989) and Lake Washington in Washington State (Edmondson 1991).

Santa Monica Mountains National Recreation Area: Multiple Activity

On the West Coast, the creation of Santa Monica Mountains National Recreation Area, California, in 1978 is an experiment still underway (Sax 1980, The Conservation Foundation 1985, pp. 219–232). Reportedly borrowing from the British ''greenline park'' idea, Congress established its 364,390-ha core surrounded by

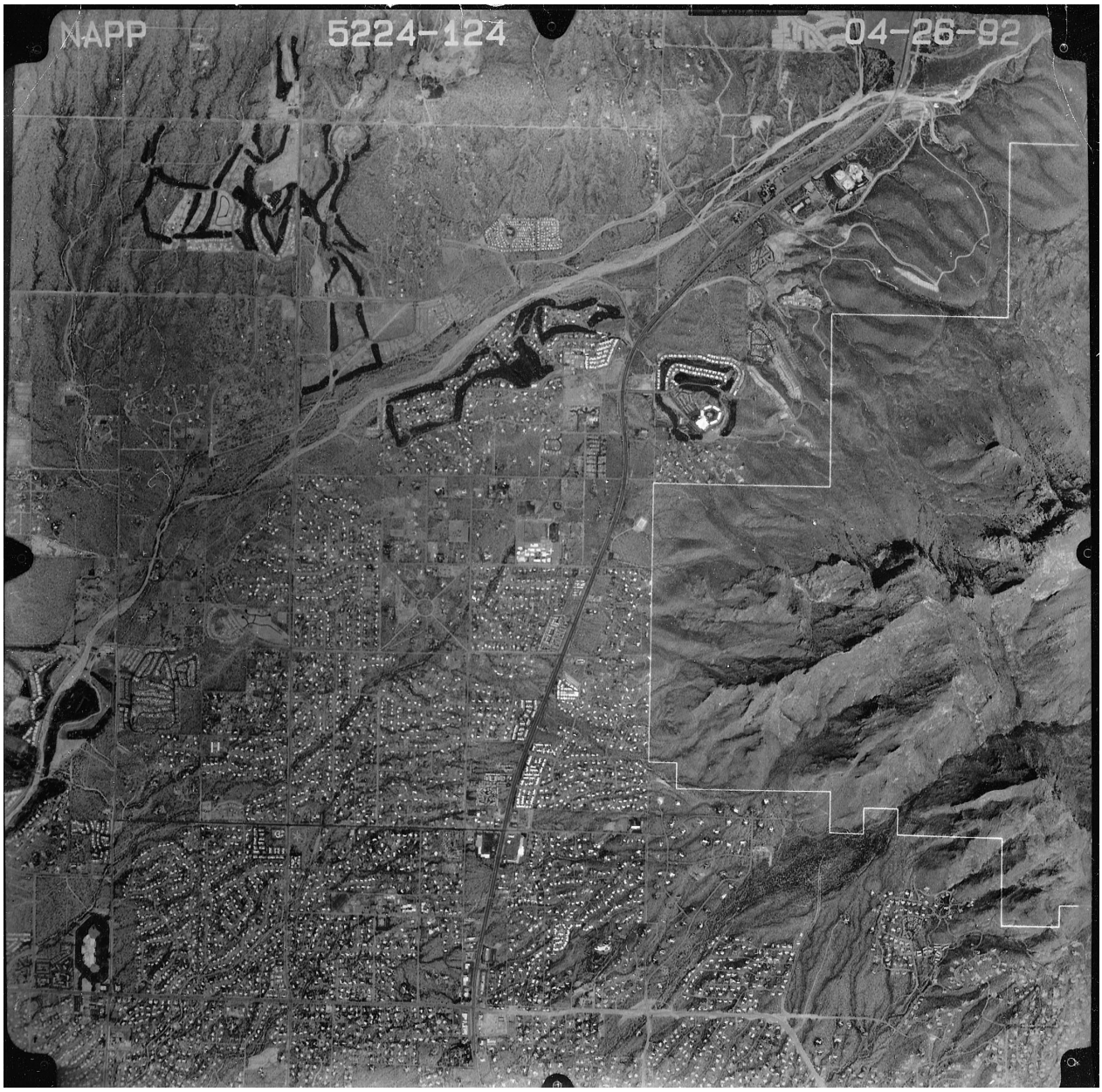

Figure 4. Homes adjacent to Pusch Ridge Wilderness Area, Coronado National Forest, in the Oro Valley suburb of Tucson, Arizona. The solid line is the wilderness boundary (Photo from the US Department of Agriculture Aerial Photography Field Office, April 1992).

a 555,981-ha zone of influence. As of 1985, about 35,000 people were living in 15,900 private homes in the recreation area, also encompassing 323.7 km^2 of undeveloped land in 3000 privately owned tracts. ''The aim is to stitch together, under the federal umbrella, recreational land and open space that will continue to be privately owned, and a core of land resources to be purchased conventionally in fee by the federal government'' (The Conservation Foundation 1985, p. 225). The NPS plan was to buy about one quarter of the land to provide the recreation area's natural core with habitat connections to other state and private property and to encourage developers to donate private land corridors in return for approval to build near the boundary. To make the concept work, NPS has been coordinating with a vast number of organizations and landowners outside and inside this urban park. Public agencies have regulatory responsibility inside the recre-

ation area boundary. Here we find many land protection methods going on at the same time: land purchase, easement acquisition, land-use regulation by other agencies, and cooperation/persuasion. Corridors are also being sought (Smith 1993). Another approach worth mentioning is ''clustering'' development and leaving large tracts of common open space (Arendt 1996). When well orchestrated, it is a potential buffer tool.

Pinelands National Reserve, New Jersey

The IUCN reserve classification Protected Landscapes (category V) (see Lucas 1992) is similar to land-use practices common in buffer zones. It can ring a core reserve (e.g., a category V area surrounds the Annapurna Conservation Area, Nepal) or it can apply to the whole reserve. In the United States, the Pinelands National Reserve in New Jersey corresponds closely to this category. The NPS considers it an ''affiliated area,'' i.e., not federally owned or administered but some federal assistance went into establishing it.

Pinelands is a success in many ways (Good and Good 1984, Lilieholm and Romm 1992); however, by other measures, it has done less well. The data of Luque and others (1994) indicate that from 1972 to 1988, forest patch size outside the reserve decreased (from 56.4 to 23.6 ha) and so did patch size inside it (from 332.9 to 168.5 ha). This suggests trade-offs occurred while seeking compatibility between human economic/social welfare and biodiversity protection using this alternative reserve concept. It is important to decide what a buffer zone is expected to accomplish for species preservation, i.e., whether it will be an extension of the reserve or a shock zone where species loss is expected, that is, is it a source or a sink (Pullium 1988)? This illustrates the usefulness of quantitatively assessing how well a reserve is doing before concluding goals are being achieved.

NPS successes in creating effective, permanent, real buffer zones circumscribing large, natural area units of the US national park system from nonfederal land by nonlegislative methods could not be found. However, this does not mean the mechanisms are not available, providing the will and political go-ahead exist.

Protection Options: Bland, Impelling, Forceful, and Revolutionary

The Cooperation Approach

Cooperation can work, but only sometimes. There have been success stories in abating external threats to US national parks without relying on buffer zones (NPS 1987), accomplished by working with other agencies, planning boards, councils, local groups, and landowners. The NPS readily endorses this approach, often called ''cooperative regional planning.'' Education, influence, and persuasion, not forcible compliance, define this approach. Coggins (1987, p. 27) said ''a program to combat external threats should have some elements of coercion. Reliance on voluntary cooperation alone has never worked well. . . .'' He does admit persuasion, when coupled with public sentiment, can be powerful (Coggins 1987, p. 21). The problem is that a checkerboard landscape of willing and unwilling cooperators may not provide land animals can traverse. Cooperative regional planning is too ad hoc for consistent long-term planning to protect public lands.

Easements with Incentives

Private land is key to regional conservation strategies (e.g., Eisner and others 1995), as recently quantified in the Olympic Peninsula and Southern Appalachian Highlands watersheds. When Turner and others (1996) compared private to public land in both regions, the private land had less forest cover and a larger number of small forest patches. Therefore, how can we conserve private land?

Since the 1930s, NPS acquired within-park easements on more than 323.7 km^2 in at least 86 park units (W. Brown 1993). On 14 January 1986, the US Internal Revenue Service issued regulations offering federal income tax incentives to landowners who donate conservation easements on land adjacent to public parks to qualified public or private conservation organizations. More recently, the Taxpayer Relief Act of 1997 raised estate tax exceptions for land within 25 miles of a national park or wilderness and for family farms. A revival of the past easement focus of the NPS is worth considering: encouraging others to facilitate the donation of ''outside'' park easements to nonfederal conservation organizations. Purchase of easements in the United States can be expensive; providing tax breaks for an easement is less of a burden. Easement variations have been used with success elsewhere. ''Thousands of square miles of Britain have been kept green in perpetuity without any money changing hands. Private owners have been persuaded to sign conservation agreements with the National Trusts. These agreements provide that the land will not be built upon or substantially changed in perpetuity without concurrence of the owner and of the Trust'' (Phillips 1979, p. 690). They might work in the United States when land values are low and of limited development potential. However, land values adjacent to US national parks and some other federal land have escalated independently of the local or national real estate market.

Figure 5. El Malpais National Monument, New Mexico, was legislatively created in 1987 with a ''conservation area'' buffer zone adjacent to most of the monument's boundaries. Although the monument is now part of the US National Park System, the buffer zone is on land administered by a sister government agency, the Bureau of Land Management (Photo by Craig Shafer, March 1997).

Congressional Action

Sax (1980) highlighted two methods Congress has used to encourage preferred land use in or around a newly created unit of the US National Park System: (1) facilitating local and state zoning by providing funds, as at the Santa Monica Mountains National Recreation Area, California (The Conservation Foundation 1985, pp. 219–232), or (2) enacting laws that force communities to choose between enacting zoning or facing land condemnation, as at Cape Cod National Recreation Area, Massachusetts (see Thomas 1985). This illustrates that the US Congress has not hesitated, in some situations, to use forceful approaches if viewed in the public interest.

Carhardt (1961) advocated buffer zones around wilderness while Leopold and others (1963) proposed that federally managed national recreational areas serve as buffer zones around national parks. El Malpais National Monument, New Mexico, was created in 1987 with a Bureau of Land Management administered ''national conservation area'' bordering most of its boundary, including wilderness sections (Figure 5). As Coggins (1987) pointed out, Congress, if it wished, could designate lands next to parks as ''national preserves'' under NPS jurisdiction. However, if the outside land is private, cost can be prohibitive. For example, private land for Redwoods National Park in 1968, plus its 1978 Congressionally created buffer zone to thwart outside logging, cost the government $1.5 billion (Mackintosh 1991). Congress did not even appropriate funds to buy land for park purposes until 1961 for the Cape Cod National Seashore in Massachusetts.

Keiter (1985) recommended Congressional creation of ''national resource areas'' out of federal land next to national park boundaries. These areas would not change in agency administration but would have stiffer land-use prescriptions. A more extreme approach would be Congressionally legislated zoning for surrounding federal, state, and private lands (Sax 1976, Keiter 1985). However, before any form of Congressional action could be a realistic expectation today, large numbers of US citizens would have to change their attitudes towards public land.

A Whole Different Viewpoint

There are potential incentives besides tax breaks. Kuperberg (1978, p. 447) suggested private landowners could be relieved of excessive regulation in exchange for protecting natural ecosystems via ''restrictive covenants, transfer of development rights, land banking, planned unit development, variance, special consideration laws, and other legal mechanisms already in

existence.'' Such thinking was compatible with an emerging new transdisciplinary field of inquiry—ecological economics. It seeks to better understand linkages between natural ecosystems and human economic systems in order to develop policies that foster sustainability (Costanza 1995, 1996). Institutional reforms have been recommended to induce private users of natural resources to be responsible for the social costs of their actions and to provide them the right incentives to protect ecosystems (Arrow and others 1995). Such ideas are also part of this field.

Some elements of Costanza's strategy include:

1. Determining the costs of environmentally hazardous activities and charging those costs to the parties responsible (Costanza 1987), thereby raising public revenue by a natural capital depletion tax (Costanza and Daly 1992). Other potential incentives involve permits, fees, bonds, and other means (Costanza 1995).
2. Causing institutional reform for better cost–benefit analyses, long-term planning, changes in inappropriate assignment of property rights, and more flexible bureaucratic organizations (Costanza 1995).
3. Using computer models to understand economic and ecological interaction, impacts on ecosystems, dependence on ecological services and capital, and even building regional stakeholder consensus in landscapes and regions (Costanza 1996).

Essential Buffer Zone Appendages: Corridors

Corridor Awareness

Although this review is about buffer zones, without usable corridors, their usefulness in increasing the long-term viability of reserve biota is compromised (Shafer 1990, 1995). The need to have corridors connecting reserves was not made explicit until the 1960s (Preston 1962). The idea of combining concentric buffer zones (nodes) and corridors within a park was proposed by Forster (1973, p. 52). Later, buffer zone nodes connected by corridors were proposed as a regional landscape strategy outside reserves (Harris 1984, p. 160, Noss and Harris 1986). Dyer and Holland (1991) recommended that the biosphere reserve system incorporate connecting corridors, a policy adopted on paper (MAB 1994). However, the notion that buffer zones could provide a corridor between two protected reserves goes back several decades (e.g., UNESCO 1974, p. 49, Miller 1978, p. 200, Lusigi 1981, p. 91).

The wisdom of advocating corridors as part of an overall reserve design strategy remains controversial (e.g., Mann and Plummer 1995; Rosenberg and others 1997). Not all animals require a corridor to cross a landscape (Hobbs 1992), and an inadequate corridor may prove no better than no corridor at all (Henein and Merriam 1990). Nevertheless, data on the actual use of corridors by animals is slowly accumulating (e.g., Downes and others 1997). As Noss (1987) argued more than a decade ago, maintaining natural habitat connectivity is the prudent path to follow. A recommendation for a connecting corridor should not be interpreted as approval to fragment all habitat adjacent to the proposed corridor (Rosenberg and others 1997).

Corridor Implementation

Legislation in 1968 authorized the creation of wild, scenic, and recreational river units of the national park system, established in part to better protect fish and wildlife habitat. However, the idea of fostering landscape connectivity was not a primary consideration. A widespread awareness of the need for animal corridors in the scientific community arose later.

The need to create corridors next to US national parks to facilitate animal movement is vaguely in NPS policy—cooperation with others can involve ''establishing native wildlife corridors and providing essential habitats adjacent to park boundaries'' (NPS 1988, p. 4:5). Although an agency record of accomplishment exists for providing requested assistance to other organizations in creating trails and greenways (C. Brown 1993), corridor projects are rarely initiated for the primary purpose of facilitating movement of large mammals. Forming external partnerships with other groups, for example, the cultural landscape ''heritage corridor'' concept (Oldman 1991), has taken precedence over protecting vitally needed landscape connections to permit biota to move.

Recommendations: Highlights

Many of the following ideas are not new, appearing in previous articles, reports, workshops, or legislation. The following short list nevertheless provide a suggested strategy. Shafer (1998a,c,d) elaborates on some points.

Planning

- The reserve goal must first be clearly articulated.
- National park planning and management must proceed hand in hand with surrounding regional land-use planning.
- Working together to achieve park goals is key. Land managers must recognize their outside park boundary problems are shared by other bureaus, state/

local governments, and many private organizations and individuals, and fragmentary management can be alleviated through communication.

- Identify all regional stakeholders, understand the history of the region, and be sensitive to stakeholder needs. Invite them to planning sessions before any formal protected area plans are drawn up.
- Although not the sole solution to conterminous incompatible land-use and cross-boundary impacts, buffer zones and corridors can provide a method to counter some cross-boundary impacts and decrease biotic isolation. More specifically:
- On private land, buffers might be created at some locations by using direct acquisition, purchase of easements, tax incentives, state/county zoning and regulation, cluster development, persuasion, and other methods.
- On federal land, congressional action could expand the parks through land purchase and transfer from other agencies; create national preserves, wildernesses, or wild and scenic rivers on adjacent property; or designate natural resource areas. Other potential congressional actions include establishing formal interagency consultation or veto procedures or prohibiting federal expenditures for detrimental activity on private property.
- Regardless of land ownership, Congress could give NPS additional authority, if needed, or even create a national zoning scheme outside the parks.
- Sister agencies could withdraw their park perimeter federal land from some consumptive uses, e.g., mining.
- Planning grants and technical assistance could be provided to state and local governments. Some formal consultation procedures or umbrella coordination organizations could be established.
- Include in individual park planning documents regional and cross-boundary goals, so adjacent property is regarded as important to the park as land inside its boundaries.
- Work closely with land trusts, private conservation organizations, and local constituencies because they can achieve things in the best interest of a protected area that a site manager or planner cannot.
- Encourage and facilitate habitat restoration projects outside reserve boundaries.
- Set priorities in dealing with site-specific incompatible conterminous land use.

Education and Demonstration

- Natural resources management must be the primary focus and mission, overshadowing any lingering orientation towards custodianship or tourism management.
- More education of the general public, land managers, and legislators is needed about how the viability of park biota depends on land use outside parks.
- In-house training for land managers must be expanded on outside-park land protection tools and the basic principles of conservation biology, and this training should be mandatory.
- Develop methods to communicate with regional stakeholders outside parks on a regular basis and provide educational information.
- Develop a few US showcase biosphere reserves corresponding to the original biosphere reserve model in terms of geometry, protection, and function.

Information Transfer

- Clarification of existing federal authorities is needed.
- Agencies must have ready access to individuals with expertise in benign land-use planning tools and recruit many of these experts.
- Synthesize more scientific and technical information into a form that is comprehensible to land managers with varying backgrounds and illustrate its application.

Research, Inventory, and Management

- Develop comprehensive inventories of protected area biota and other natural resources.
- Design indexes of ecosystem condition and use these indexes to measure planning and management progress.
- Develop long-term monitoring for key parameters.
- Focus more study on patterns and processes, especially regional trends, regional processes, and external threat influences.
- Provide more incentives for scientists to do natural resources management side by side with managers of protected areas.

Professionalization

- Increase the level and type of professional credentials needed to be land stewards of natural area national parks.
- Hire more professionals in diverse natural resource and other specialized fields, e.g., conservation biology, geology, GIS, computer science, and others.

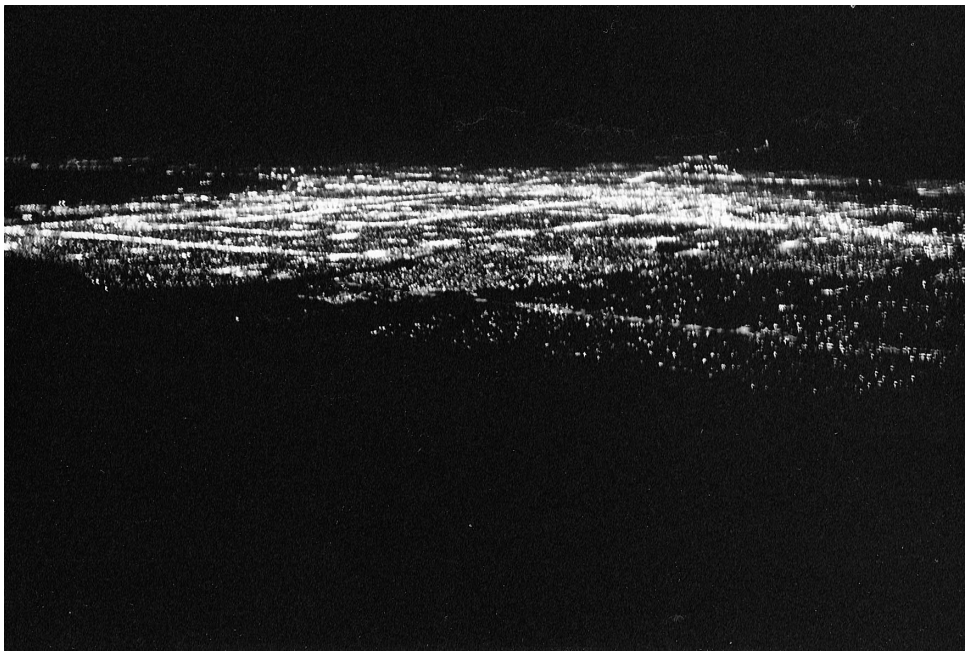

Figure 6. The city of Albuquerque, New Mexico, directly abutting the Sandia Mountains Wilderness Area in the Cibola National Forest (Photo by Craig Shafer, March 1997).

Institutional Reform

- Decrease political interference in agency decision-making.
- Encourage the exercise of all available legal authority to abate external threats.
- When parks are under severe threat, methods should be investigated to allow agencies to add significant blocks of land to a park without waiting for Congressional action.
- Discourage quick site manager turnover, so personal relationships built with stakeholders have more longevity.

Economic Incentives

- Lastly, and possibly most importantly, devise more incentives so private landowners easily recognize their voluntary participation in more optimal regional land use, in terms of protecting a park, is in their economic best interest. Cooperation works best if there is obvious mutual benefit or, alternatively, penalties to pay for degrading the common natural environment.

Afterthoughts

The national park idea is often attributed to the American Indian painter George Catlin, who wrote in 1832 at Fort Pierre, South Dakota, of the need to set aside a ''nation's park, containing man and beast, in all the freshness of nature's beauty'' (Catlin 1851, p. 262). Henry David Thoreau, in a 1858 article in the *Atlantic Monthly,* wondered ''why should not we . . . have our national preserves . . . in which the bear and panther, and some even of the hunter race, may still exist'' (cited in Nash 1973). Sixteen years later, George Perkins Marsh said ''It is desirable that some large and easily accessible region of American soil should remain, as far as possible, in its primitive condition, at once a museum for the instruction of the student, a garden for the recreation of the lover of nature, and an asylum where indigenous tree . . . plant . . . beast, may dwell and perpetuate their kind'' (Marsh 1874, p. 327).

Such noble beginnings, and early inspiration such as ''perpetuating their kind,'' can benefit from current thinking about reserve design only if social and economic considerations do not override their potential application and implementation. One can justifiably worry whether this US national forest wilderness area illustrates the future landscape pattern for some US national parks (Figure 6).

Orr (1994, p. 70) observed that ''The primary causes of biotic impoverishment are . . . invariably political, having to do with 'who gets what, when and how'.'' Human ignorance and self-interest, coupled with law that guards the rights of the private landowner, are

obstacles to long-term protection of national park biota. The salvation of protected areas rests heavily on innovative methods to reward landowner cooperators or penalize those who degrade land outside park boundaries (e.g., Constanza and others 1997, Daily 1997), regular communication with regional stakeholders (e.g., McDowell 1989), reduction of political interference in agency decisions (e.g., Lockhart 1988), institutional reform (e.g., Yaffee 1996), use of adaptive management philosophy (e.g., Gunderson and others 1995), and last but not least, enormous amounts of public education. Society must think carefully about what is of primary importance to its future well-being: long-cherished individual freedoms or biologically diverse countries? The latter, once gone, is not reversible.

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