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Managing Ecosystems for Viable Populations of Vertebrates: A Focus for Biodiversity

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ABSTRACT Different areas in large regional ecosystems must be managed under coordinated goals and strategies to sustain their biological diversity. One park, wilderness, forest, or refuge, unless it has millions of acres, cannot sustain a broad enough distribution of seasonal habitats to supply the needs of all species. This is especially true for animals with large home ranges (wolves, bears, eagles, large cats) or distant migrations (salmon, elk, and many birds). Population viability for such species depends on favorable conditions in many different places and freedom for individuals to move throughout a population of large size. This paper discusses the biology of population viability, the potential areas in the United States where coordinated management of large regional ecosystems can sustain viable populations of native species, and the use of an indicator species (the spotted owl) to delineate a coordinated ecosystem management system across geographic scales and land use classes and ownerships.

Aldo Leopold (1966) captured the essence of a goal for biological diversity when he said that the first step is to save all the parts: "To keep every cog and wheel is the first precaution of intelligent tinkering." Recovery of threatened or endangered species and maintenance of viable populations of all other species is thus the foundation for any policy. But the scope of biological diversity extends beyond the parts to include processes through which the parts interact: biological diversity is the variety and variability of life and its processes in an area (U.S. Congress 1987). This paper is about keeping the parts around, especially the species parts. We must assume that if all the parts are healthy, the processes are free to work.

The biological diversity of an ecosystem can easily encompass thousands of species. Many of these species are microscopic; some have not even been identified or classified. Biodiversity also includes assemblages of plants and animals that are recognized as distinct communities. And it includes countless processes and pathways through which species interact, such as mutualism, competition, predation, and parasitism. This richness of species and their interactions continually changes and is difficult to measure. Compounding this difficulty, scientists often debate the limits of acceptable variation within species—the points at which different species, subspecies, or races are recognized. This makes it difficult to know when one part is really two or two really one. The result is that biological diversity defies precise definition. It is a concept that must be translated into tangible, measurable aspects. Unless managers identify specific aspects of diversity to focus planning and management, it will never be clear when the goal is achieved.

Two kinds of indicators have been used to focus conservation plans: species and communities (Holbrook 1974, Siderits and Radtke 1977). This paper shows the use of species as management indicators and how planning for viable populations of vertebrates integrates actions across ownership boundaries and geographical scales. Using species as indicators is complementary to using biological communities. Since most species cannot persist without an array of communities, planning for species helps determine the kinds, amounts, and arrangements of communities needed in an area. If there are concerns for biological communities that are not well served by indicator species, those communities should also be used as management indicators.

Concerns about biological diversity often focus on viability of particular species populations. For example, recovery to self-sustaining condition of threatened or endangered species and protection of declining species are commonly identified as diversity issues. Current cases in the United States include grizzly bears (*Ursus arctos*) in the northern Rocky Mountains and spotted owls (*Strix occidentalis*) in old-growth forests of the Pacific Northwest (Heinrichs 1984, Simberloff 1987).

The key to sustaining the full variety of species in an area is to reduce, minimize, or mitigate threats to the continued existence of those species most in jeopardy. Many, perhaps most, species in large areas of wildlands are not vulnerable to extirpation. Prudence dictates that attention be directed to those that are. Several scientific theories and methods are useful in planning a management strategy. But none are complete or universally applicable; feasible strategies cannot be derived solely or conclusively through science and technology. Broadly coordinated, adaptive resource management that includes monitoring and research as active parts of the whole strategy is also needed (Holling 1978, Walters 1986).

To illustrate these points, the paper is divided into three parts: (1) brief discussion of the biology of population viability, (2) presentation of potential areas in the United States where coordinated management of large regional ecosystems can sustain viable populations of most, if not all, native species, and (3) the use of a management indicator species, the spotted owl, in coordinating ecosystem management across geographic scales and land use classes and ownerships.

THE BIOLOGY OF POPULATION VIABILITY

Viability for individual organisms is the ability to survive to reproductive age. For populations it is the ability to continue to exist through their own reproductive success: a self-sustaining population (Soulé 1980, Shaffer 1981, Salwasser et al. 1984, Samson et al. 1985, Soulé 1987a).

Shaffer (1981) proposed that a viable population would have a 95% likelihood of existing in 1,000 years. The implications are that (1) future existence cannot be guaranteed; a viable population has some chance of not surviving, and (2) viability is a long-term concept; centuries rather than years or decades are involved. Shaffer's parameters—likelihood of existence and time—are accepted by many scientists (see Soulé 1987b). But there is nothing sacrosanct about 95% and 1,000 years. Public policy or social preferences may legitimately argue for criteria of 75% for 100 years or 99% for 50 years. A major problem with any long-term standard is that existing models and theories do not provide for long-term predictions with much realism or precision. And what, for example, should managers do if it is not physically possible to provide for high likelihoods of survival for long periods? As Soulé (1987a) points out, the biological issue remains alive until the last individual is gone. In any case, policy and strategy for population viability are not purely biological issues, because solutions will be shaded by costs, trade-offs, balances of land uses, and the risk tolerance of the shapers of public policies. Rather than search for standard scientific criteria for viability, it is more useful to understand the factors that can jeopardize the existence of a species in an area and implement management plans to limit their potential effects.

Extirpation of Populations

The basic task in preventing loss of species from an area is to minimize or mitigate threats to their future existence. There are two kinds of threats: those that operate internal to populations and those that are external.

Internal Threats: The Importance of Numbers. Three factors that affect viability operate internal to populations: demographics, genetics, and behavior. And they interact. The demography of a population is its vital statistics: number, sex ratio, age structure, natality, survivorship, and recruitment rates. The demographics of a viable population provide resilience to the random variations in birth and death rates, migrations, colonizations, weather, and resources that occur in all populations (Soulé 1980). Over the long term, net recruitment (births plus immigration minus deaths plus emigration) must equal or exceed zero.

Population number is perhaps the most important demographic factor, because large numbers buffer the effects of extreme events, and small numbers make even minor fluctuations critical (Belovsky 1987, Goodman 1987). Population numbers that buffer effects of random variations in births and deaths depend on the life history of the species. Long-lived animals with low reproductive rates, such as large birds and mammals, may only need populations on the order of high tens to low hundreds for demographic resilience over the short term. Conversely, species like mice and songbirds may require populations on the order of thousands for similar resilience.

Genetic variation in a viable population provides for continual adaptation of the species. Environments are constantly changing and species must possess the ability to adjust to those changes and produce offspring that can persist in the face of new environments, new competitors, and new predators. Viewed over a sufficiently long period, this whole process is called evolution. On a human time scale the effects of change are less noticeable, though still important.

As with demographics, numbers that provide sufficient genetic variation vary according to life history. An additional concern is that not all members of a population make equal contributions to the genetic makeup of subsequent generations. Therefore, geneticists have developed the concept of an effective population number to describe the genetic characteristics of actual populations (Lande and Barrowclough 1987). If there are an equal number of adult males and females in a population, they all have an equal likelihood of reproducing with one another and contributing offspring to the next generation, and if total population number is constant, the genetically effective population number (N_e) is approximately equal to the total number of adults (N). This is rarely, if ever, the case with wild populations of vertebrates, and effective population numbers are often lower than census population sizes by a factor of 0.5 to 0.1 (Soulé 1980).

The importance of effective population number is due to the relation between effective number and loss of genetic variation over time in populations of various sizes and demographics. The smaller the population and the faster the turnover of generations, the quicker inbreeding may occur and genetic variation be lost. Scientists are currently debating the importance of genetic variation to viability and the ability to be precise in estimating effective population numbers and their meaning. In any case, effective numbers should be relatively high, ideally greater than high hundreds or low thousands, and it must be kept in mind that actual population size may need to be two to ten times larger than a desired effective size (Lande and Barrowclough 1987).

The third internal factor is behavior. Many vertebrates function through complex social systems, such as packs or matriarchies, and depend to some extent on transmission of learned behavior from one generation to the next. Reductions in density or total numbers, or even alterations in sex ratio or age structure, may disrupt behavior that is critical to survival or reproduction. A viable population would possess a wide range of behavior and the social structure needed for survival in an area.

External Threats: The Importance of Distribution. External threats include many things, and they can be either chronic or acute. For example, chronic factors could include invasion of an area by a superior competitor (often humans); gradual, unfavorable changes in climate, such as described in this volume by Brubaker; or systematic alteration of suitable habitat, as through agricultural development, atmospheric acidification (Grigal, this volume; Schofield, this volume), reservoir construction, or permanent deforestation. Acute external threats might include volcanoes, fires, violent storms, or epidemic disease.

Because external threats vary greatly over time and space, an essential attribute of a viable population is broad geographic distribution. Distribution is the location of individuals or groups of individuals within a population relative to the geographic range of the species. It must buffer the effects of unfavorable local events, and provide for the continued functioning of individuals as parts of a larger biological population. That is, distribution must minimize the likelihood for small, permanently isolated populations that would have low total numbers and low genetically effective numbers. Such populations would lack the ability to disperse throughout the species range to colonize new or vacated habitats and naturally restore individuals following local extirpations.

For population viability, distribution must allow for (1) survival and reproduction of a relatively large number of individuals in many different places, (2) periodic recolonization and genetic interchange throughout the population, and (3) occupancy of the array of environments to which the species is adapted. A general rule emerges with regard to numbers and distribution and their effects on viability (one might argue it is just common sense): more is better. Its corollary is: there is no magic number.

A General Model for Population Viability

Providing for demographics, genetics, behavior, and distribution that buffer internal and external threats to a population translates into high population numbers and, for many species, large geographic areas. High numbers provide protection from the negative effects of random changes in demographics and genetics and for high retention of learned behavior. Broad geographic distribution allows for resilience to change and for local catastrophic events to occur without significant threat to the total population.

A general model of these relationships is that viability is proportional to numbers and distribution (Figure 5-1). The quantitative relationships of such a model would vary according to species life histories in different environments. Species with high turnover rates, high reproductive potentials, and short life spans, such as mice and songbirds, would require higher numbers and more locations of occupancy for a given likelihood of continued existence than would a species with low turnover rates, low reproductive potentials, and long life spans, such as bears, eagles, and mountain sheep. The differences for a similar viability between mice and bears could easily be an order of magnitude or more.

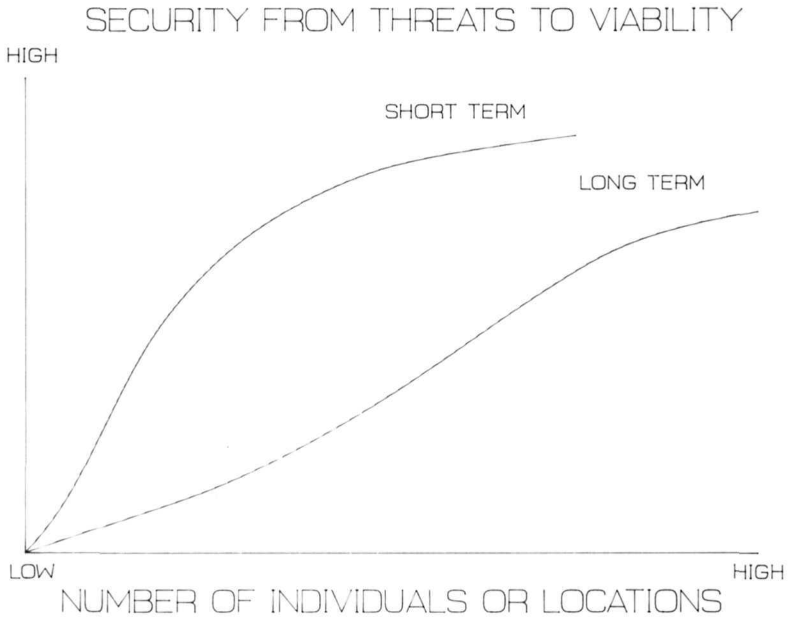


Figure 5-1. A general model of population viability. The likelihood of continued existence for a population increases in proportion to the number and geographic distribution of individuals. Below a lower threshold of numbers or distribution, changes do not significantly affect viability: the population is in great jeopardy of extirpation from demographic, genetic, or catastrophic threats. Above an upper threshold, changes in number or distribution do not measurably add to viability: a point of diminishing returns has been reached and there are few threats to viability. Exact, quantitative relationships between numbers and viability have not been determined for any species. This model is intended as a general guide, not a precise prediction tool.

The relationships between numbers and viability in the general model are hypothetical. It may be years or decades before the relationships for many species will be known precisely. But that does not weaken the utility of the model. Its purpose is to offer general guidance on adaptive management, not to predict with the illusion of science or precision. For example, if existing conditions or a proposed management strategy appear to result in unacceptable high risks to the viability of a species, cooperative agreements with other landowners or a different management strategy can be employed to yield higher total numbers or a broader distribution. If that is not possible, intensive management of habitats, populations, competitors, or predators; research; and monitoring might be employed as parts of a strategy to minimize a particular threat, say barriers to dispersal. If high value trade-offs are involved, such as recreation facilities, timber, minerals, or water development, the relative effects of altering population numbers and distributions can be assessed as part of determining mitigations or enhancements to offset the effects.

The viability model is intended to focus planning, management, research, and monitoring on the major factors that control viability, and allow comparison of the relative merits of alternative public policies. For population viability there are no scientifically correct or incorrect answers, just shades of better or worse. Only future conditions will tell if a particular strategy sustained viable populations as part of overall biological diversity.

COORDINATED MANAGEMENT OF LARGE REGIONAL ECOSYSTEMS

The general model shows that a public policy for biological diversity that includes viable populations of large or wide-ranging animals will require management of areas that can sustain thousands of individuals in many different locations if that is possible. This is supported by empirical evidence on carnivorous mammals (Schonewald-Cox 1983) and recent planning for the spotted owl (USDA Forest Service 1988). Areas exceeding millions of acres may be needed to support populations of large vertebrates with demographics, genetics, and distributions that would provide a high likelihood of continued existence well into the future. In the United States no such area exists as a distinct unit of any one management agency or owner. Nor is it politically or economically likely or feasible to combine enough area under one ownership. The only reasonable option is to manage different areas as if they were integral parts of a large ecosystem (Salwasser et al. 1987).

Can coordinated management of large ecosystems work? Only broad coordination has characterized interagency relationships to date. And it has been argued recently that individual units of protected lands, such as national parks in western North America, function as if they were land-bridge islands surrounded by an ocean of inhospitable habitat (Newmark 1986). If such is the case, the faunal richness of parks or wilderness areas would reflect size and time since isolation. It doesn't (Quinn et al., in preparation). National Park mammalian faunas are richer than would be predicted from island biogeography theory. Furthermore, mammalian richness of surrounding managed forests is as high or higher than that of the parks.

Managed wildlands that surround parks in western North America are not always, perhaps not often, inhospitable to wild vertebrates. This indicates that a network of different kinds of conservation areas, managed under similar policies and practices, can sustain biological diversity while producing natural resources. Such a network exists in national parks, national forests, and the matrix of other public and private lands surrounding them in the United States.

There are approximately 19.6 million acres (8 million ha) in the National Park System in the contiguous forty-eight states (all land area data from USDI 1985). These lands are managed primarily for recreation and protection of natural diversity. Wilderness areas in the National Forest System in the same states comprise 26.8 million acres (nearly 11 million ha). They are managed for minimal human impact and primitive recreation experiences. Together these constitute 2.3% of the area of the lower forty-eight states.

Approximately 176 million acres (71 million ha) of public lands in the forty-eight states are managed by the USDI Bureau of Land Management; 141 million acres (57 million ha) of lands not in the wilderness system are managed for other multiple uses by the USDA Forest Service (a total of 168 million acres including wilderness areas in the National Forest System in the forty-eight states); 9.4 million acres (3.8 million ha) of national wildlife refuges and about 28 million acres (11 million ha) of other federal lands, including military reservations, are protected in these states. Thus approximately 400 million acres (162 million ha) of public lands in the lower forty-eight states are managed for a variety of uses, including protection of natural resources. That is about 21% of the entire area of those states.

Many of these public lands occur as large areas of contiguous wildland (Figure 5-2). If one uses the criteria that (1) no significant barriers to free movement of ground-dwelling or flying animals exist, (2) large amounts and multiple locations of suitable habitat exist, and (3) human activities, as regulated by state and federal laws and rules, do not threaten the resilience or productivity of populations, the following areas of contiguous public and intermingled private lands could function as large regional ecosystems. They

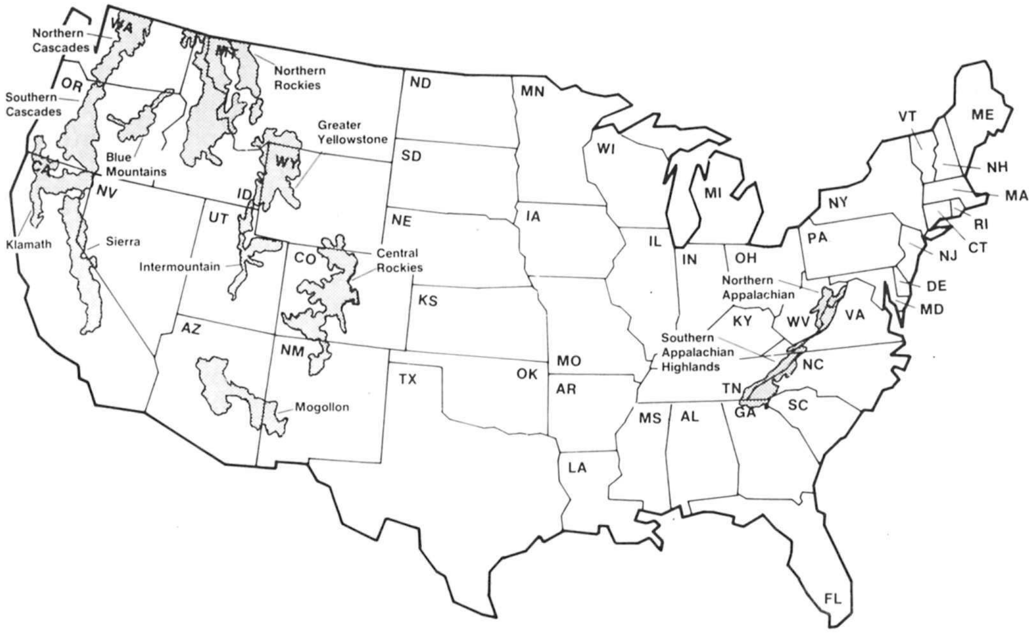


Figure 5-2. Selected areas of the United States that contain contiguous public wildlands that are managed under policies to protect biological diversity (after Salwasser et al. 1987).

hold a high potential to sustain vertebrate diversity under existing land uses and designations (approximate area is principally the national park and national forest lands in each ecosystem aggregated from USDI and USDA data presented in National Geographic Society 1984):

Northern Cascades: 7.9 million acres (3.2 million ha); a large national park and several national forests that contain large wilderness areas

Southern Cascades and Klamath Mountains: 14.1 million acres (5.7 million ha); several small national parks, many national forests with large wilderness areas, and other public forest lands

Sierra: 11.1 million acres (4.5 million ha); several large national parks, many national forests with large wilderness areas, and adjoining public and private forest lands

Grand Canyon and Mogollon: 14 million acres (5.7 million ha); a large national park, many national forests with large wilderness areas, and adjoining public forest and rangelands

Central Rockies: 11.4 million acres (4.6 million ha); a large national park, many national forests with large wilderness areas, and large areas of other public lands

Greater Yellowstone: 16 million acres (6.5 million ha); a large national park, many national forests with large wilderness areas, and adjoining public and private wildlands

Northern Rockies: 32.4 million acres (13.1 million ha); several large national parks, many national forests with large wilderness areas, several large Indian reservations, and large areas of other public lands; contiguous with similar lands north into Canada

Southern Appalachian Highlands: 3.1 million acres (1.3 million ha); a large national park, and several national forests with small wilderness areas

These are only a few prominent examples. There may be other large ecosystems, and there are undoubtedly many effective smaller ones. These areas have the biological capability to sustain their full biological diversity, though protection of large predators may require special actions due to human intolerance. Each "regional ecosystem" is managed under policies to recover threatened or endangered species and maintain diversity. Additional policies and plans provide for many human uses of various plant, animal, geological, and scenic resources. These are multiple-use ecosystems at the regional scale with dominant uses at any point in time at local scales.

In addition to public wildlands there are approximately 817 million acres (330 million ha) of forests, parks, wetlands, and rangelands managed by states, counties, and private owners. These have a variety of purposes, but many of them are compatible with goals for biological diversity. This is about 42% of the area of the lower forty-eight states. If some or all of these lands make contributions to viability of different species populations while meeting people's other needs for resources, then up to 63% of the area of the lower forty-eight states could be considered as informal parts of a conservation network. These data are not presented to argue for new laws, regulations, land acquisitions, exchanges, or easements. They merely show the potential for different ownerships with different goals and management practices to contribute to overall biological diversity.

Improving coordination and cooperation between management agencies and private landowners in large regional ecosystems should prolong their effectiveness in conserving biological diversity while meeting people's many needs for wildland resources (Salwasser et al. 1987). Park and wilderness areas must be managed within that context—for their roles in contributing to the overall diversity and values of the ecosystem, not as if they were preserves that function as isolated islands with distinct biological boundaries.

Vertebrate populations are one of the influences that can bring management of disparate units of land into coordination. This is especially true for species that have large home ranges or that range widely in their annual movements. Goals for vertebrate population viability can shape management of a large, regional ecosystem in ways that also provide protection for smaller or less demanding species. The indicator species that will be used to illustrate this is the spotted owl, a medium-size bird that inhabits mature and old-growth forests of western North America. It is related in size, habits, and habitat affinities to the barred owl (*Strix varia*) of eastern North America and the tawny owl (*Strix aluco*) of Europe and Eurasia, though these two species appear to be more adaptable to open, wooded areas (Mikkola 1973).

Habitats suited for spotted owls are also used by dozens of other birds, mammals, amphibians, reptiles, and hundreds of invertebrates and plants. Since managers cannot plan for all of these species individually, they use the spotted owl, which appears to require the largest tracts of such habitat, to help determine the kinds, amounts, and distribution of habitats to provide in an area (the spotted owl is not the only indicator used to make these determinations).

Management of forest ecosystems to maintain viable populations of spotted owls is a major conservation issue. Its preferred habitats also have high value as a source of timber (Heinrichs 1984). It is not the purpose of this discussion to argue the merits or demerits of a specific course of management for spotted owls (see Dawson et al. 1986, Marcot and Holthausen 1987, Simberloff 1987, Salwasser 1987, USDA Forest Service 1988). The case is used to illustrate how a strategy for population viability of a rare but wide-ranging vertebrate can integrate policies and practices of ecosystem management across agency jurisdictions and at several geographic scales. The cases of grizzly bears or red-cockaded woodpeckers would provide similar examples of the use of vertebrates to integrate ecosystem management at the regional scale.

Species Range and Biology

In the United States, the spotted owl occurs throughout forests of the Pacific Rim states and across the southwestern states north into the central Rocky Mountains and south into northern Mexico (Figure 5-3). Forest types occupied vary as well as elevation zones. But preferred habitats have the common traits of containing large diameter trees, relatively closed canopies (often of several distinct vertical layers), and the presence of standing and fallen dead trees. These traits are believed to be critical to production of prey, arboreal rodents primarily, and thermal regulation for the owls (Carey 1985). Such habitats commonly occur in natural, old-growth stands, but have also been induced by historic selective logging in some areas. Young stages of forest development, such as occur following clearcutting and planting of closely spaced trees of a single age and species, are not suitable for the spotted owl.

Studies of spotted owls fitted with radio-transmitter devices show relatively large home ranges, varying from 1,250 to 10,450 acres (500 to 4,300 ha) (USDA Forest Service 1988). Amount of suitable habitat in these home ranges varies from 370 to 3,800 acres (150 to 1,500 ha). Juvenile owls have been observed to travel up to 62 miles (100 km) during dispersal from their fledging area, but only 20% of 58 juveniles studied traveled more than 20 miles (32 km) (USDA Forest Service 1988). Empirical data indicate that

Figure 5-3. Geographic distribution of spotted owls in western North America.

home range sizes and amounts of suitable habitat within home ranges tend to increase from south to north in the species' range.

Current taxonomy recognizes three subspecies, but recent studies of morphology and field distribution (USDA Forest Service 1988) indicate that spotted owls are contiguous from the southern Sierra Nevada in California to Canada. They also show that (1) a small population may be isolated on the Olympic Peninsula of Washington State, (2) the Columbia River Gorge may present a partial barrier to free movement north and south, and (3) high fragmentation of forests characterizes several areas in Washington, Oregon, and California. Spotted owls in southern California and the southwestern United States are believed to be disjunct from northern populations.

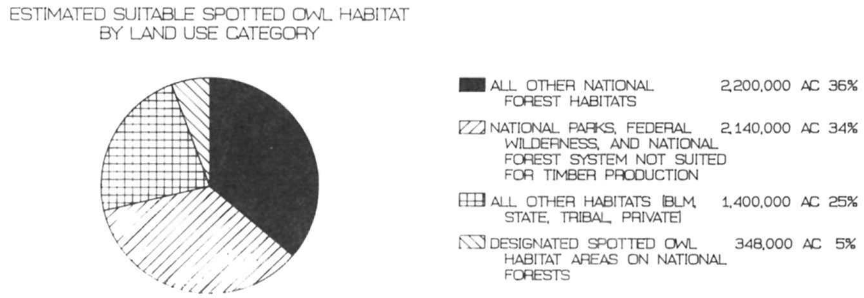
Demographics, as with all wild populations, are only generally known (USDA Forest Service 1988). There are an estimated 2,700 pairs of owls from the southern Sierra Nevada in California north to Canada, and population trend is declining at approximately 1 to 2% per year in direct response to harvest of old-growth forest (USDA Forest Service 1988). Affinity for large areas of mature and old-growth forests coupled with declining population due to continued harvest and fragmentation of habitats led to concern for the long-term viability of the spotted owl in the Pacific Northwest. Projection of historic trends showed increased fragmentation and isolation of subpopulations in an overall population of smaller size. Spotted owls would thus be increasingly vulnerable to threats from random variations in births and deaths, inbreeding or loss of genetic variation, and local catastrophes.

Policy

The National Forest Management Act of 1976 (16 U.S.C. 1604) requires that national forest plans "provide for diversity of plant and animal communities in order to meet overall multiple-use objectives." Diversity is defined in regulations for implementing the act (Federal Register 1982) as "the distribution and abundance of plant and animal communities and species within the area covered by a land and resource management plan." The regulations further identify criteria for distribution and abundance of animal species as "[f]ish and wildlife habitat shall be managed to maintain viable populations of existing native and desired non-native vertebrate species in the planning area. For planning purposes, a viable population shall be regarded as one which has the estimated numbers and distribution of reproductive individuals to insure its continued existence is well-distributed in the planning area."

Current Status

Habitat inventory is available for only the states of Oregon and Washington. In 1988, there were approximately 6,100,000 acres (2.5 million ha) of spotted owl habitat in those states on all ownerships. Nearly 1,300,000 acres (500,000 ha), or 21%, occur in federal parks and wilderness areas. Approximately 4,145,000 acres (1.7 million ha) exist in the National Forest System, 68% of all spotted owl habitat in Washington and Oregon. National forest lands suitable for timber production hold about 2,560,000 acres (1 million ha), and lands not suited for timber production and outside of wilderness hold the remaining 820,000 acres (300,000 ha). Thus 2,120,000 acres (800,000 ha), or 34%, of all existing spotted owl habitat are in wilderness, national parks, or national forest areas unsuited for timber production. The USDI Bureau of Land Management manages about



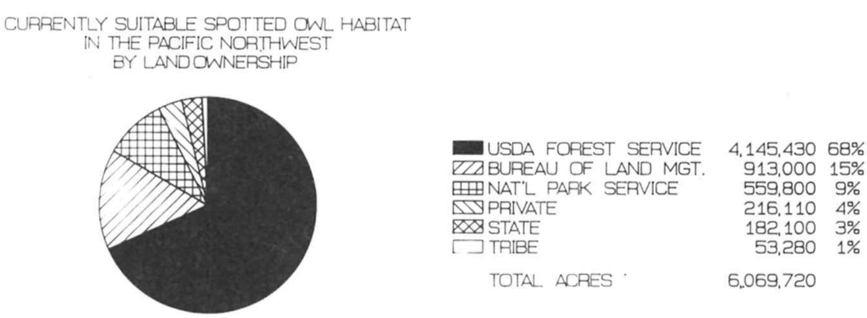


Figure 5-4. *Top*: projected relative contribution of different land use classes and ownerships to population number of spotted owls in the Pacific Northwest during the next ten to fifteen years. *Bottom:* currently suitable habitat in the Pacific Northwest by landownership.

900,000 acres (370,000 ha), 15%, and all other state, tribal, and private lands hold about 450,000 acres (180,000 ha), or 8% of the total (Figure 5-4).

Many large reserve areas with numerous pairs of spotted owls are currently under management policies that will protect owls. Major concern is over what will happen to owl habitats and the population on the remaining 66% of the habitat that could be under timber production. Most pressing is how much change is likely to occur during the current planning period of the next ten to fifteen years. Without specific action to protect habitats outside of wilderness and national parks, spotted owls could eventually become restricted to those areas in small, isolated populations that would be highly vulnerable to extirpation threats.

A Strategy to Integrate Biological and Geographic Scales

Providing for the future of any wild population requires attention to different biological and geographic scales. In this case the biological scales are breeding pairs, local populations, and the regional or species population.

Breeding Pairs. Breeding pairs must have sufficient amounts and arrangements of suitable habitat to survive from year to year and periodically produce enough offspring to replace themselves. This occurs at the geographic scales of single forest stands and watersheds of approximately 5,000 to 10,000 acres (2,000 to 4,000 ha). It requires that plans specify conditions for suitable stands and how those stands should occur on the landscape of a watershed—that is, the biogeography of the watershed. For example, managers may establish standards, based on field studies, that suitable stands are greater than 60 acres (25 ha) in area and have large diameter trees with moderately dense canopy closure and standing dead trees. Each pair of owls in a particular area would be provided

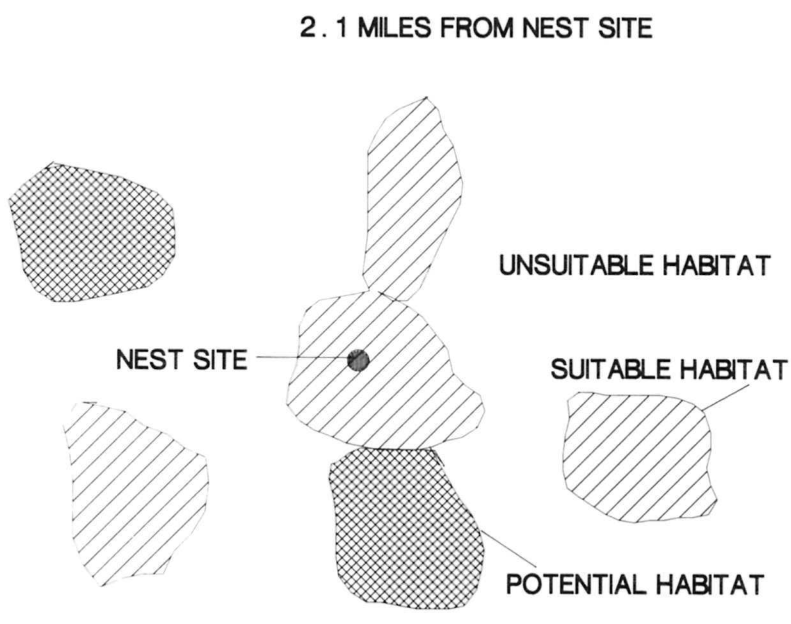


Figure 5-5. Schematic representation of an area designated to provide habitat for a breeding pair of spotted owls.

with at least 2,200 acres (900 ha) of such habitat within 2.1 miles (3.4 km) of the nest site. And those stands should be contiguous or separated by open areas of not more that several hundred yards (meters) in width (Figure 5-5). These specifications are illustrative only, but are within the range of options considered for planning spotted owl habitat management by the Forest Service (USDA Forest Service 1988).

Local Populations. Local populations must have sufficient breeding pairs to provide for yearly replacement of individuals lost to mortality or emigration, and withstand normal, annual fluctuations in births and deaths (Soulé 1987a). If such populations are not significantly isolated from the rest of the species' population, they should behave as if they had the demographics and genetics of the larger population. This is ideal. However, if fragmentation or geographic barriers isolate local populations, threats to existence will increase and extra management attention will be needed. For example, it may be necessary to provide breeding pairs with larger amounts of suitable habitat to increase the likelihood of survival and reproductive success. And it may prove useful to provide for periodic genetic interchange by introducing individuals from larger populations.

Local populations should ideally have at least several hundred pairs of adults in a network of habitats that allows for adequate recruitment to offset mortality, dispersal of juveniles throughout the population, colonization of vacant habitats, and interchange of genetic materials. This calls for attention to hot spots, where reproduction is atypically high, and for connectedness of areas suitable for occupancy by pairs (Harris 1984). For example, plans may call for spacing of habitat areas for pairs of owls to be not more than 6 miles (10 km) apart for areas that can sustain fewer than three pairs, and not more than 12 miles (24 km) apart for areas that sustain three or more pairs. And special provisions for travel corridors, such as riparian forests or ridge tops, may be specified.

A pair of spotted owls can be protected in a single watershed completely under the jurisdiction of one owner or agency. But local populations of several hundred pairs will cross administrative and ownership boundaries. And it is highly unlikely that a single park or wilderness area could sustain even this size population. In the southern Cascades of Oregon, for example, a population of several hundred pairs of spotted owls would depend on the USDA Forest Service, USDI Bureau of Land Management, USDI Park Service, and state and private forest managers of more than twenty specific ownerships or administrative units working in coordination.

Regional Populations. At the scale of regional or whole species populations, total population number and connectedness are crucial. Barring total isolation of local populations, all individuals in a regional population can contribute to viability. Populations at the regional scale should have the characteristics described above for local populations, but ideally would also have population numbers in the thousands rather than hundreds of pairs. This, and the presence of the species at many more geographic locations, provides for long-term security from genetic erosion and large-scale catastrophes. Plans at the regional scale thus focus on sustaining relatively high total numbers and ensuring that those numbers do not occur in small, isolated, local populations. Special attention to areas of current or potential isolation and high fragmentation is important. For the spotted owl, regional population issues include dealing with possible isolation on the Olympic Peninsula, where large areas of private land separate public forests, and preventing further isolation in other parts of the species' range.

Sustaining spotted owls as part of the biological diversity of a park, wilderness, or single forest thus requires a regional ecosystem strategy. It calls for integration of actions at three geographic scales (Figure 5-6): stands and watersheds for individuals and breeding pairs, and larger areas for local and regional-species populations. It therefore requires coordination across agency and ownership boundaries. These are relatively new issues in natural resources planning and management. If spotted owl habitat was "free" (unencumbered by other uses or values), the planning and coordination task would be relatively easy: protect all the habitat that exists and grow more if necessary. This is rarely the case for rare or endangered species. It is certainly not the case for spotted owls.

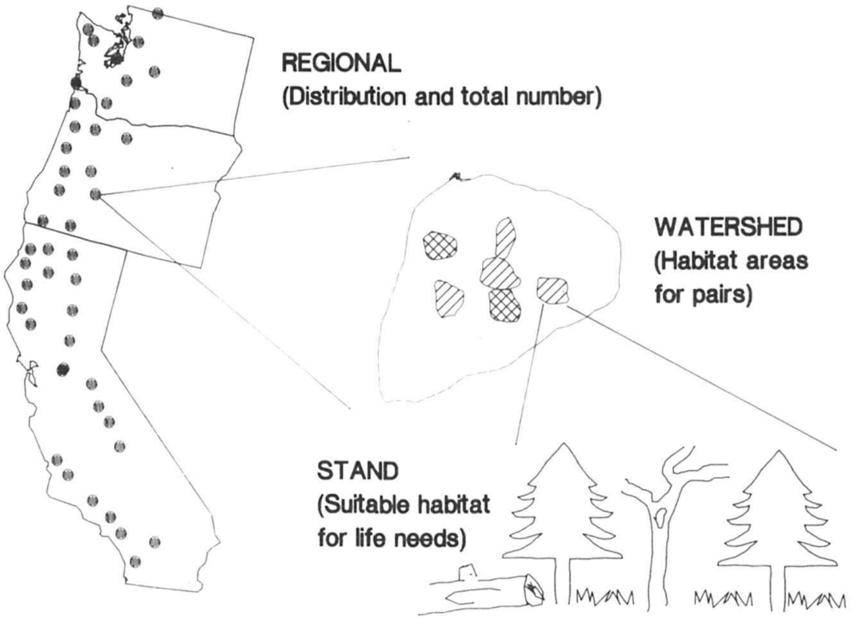


Figure 5-6. Principal geographic scales at which land and resource planning must address kinds, amounts, and distribution of habitat to sustain population viability of large or wide-ranging vertebrate species.

Integration of Land Use Classes

Protecting spotted owl habitats outside of national parks and federal wilderness areas will affect timber-based industries, jobs, and regional economies. An estimated 44 and 28% of the economies of Oregon and Washington, respectively, depend on timber supplies from national forests. Approximately 30% of those supplies come from stands that are also suitable spotted owl habitat (USDA Forest Service 1988). Thus protecting the biological diversity of parks and wilderness areas, which depends on ensuring regional viability of spotted owls, has significant economic overtones.

The task in such situations is to build upon the effectiveness of areas that already provide suitable future environments, such as the large reserve areas of parks and wilderness plus other lands that will be managed under compatible uses. The ways that people are dependent on the resources, and especially the significant negative effects on their livelihoods and life-styles, should be weighed against what is necessary to protect the species. Thus a critical planning issue is how to determine criteria for deciding when measures to conserve biological diversity must take precedence over the other needs of people from an area.

There are several approaches to this task, ranging from a kind of analytical imperative, or urgency, to various forms of adaptive planning and management. The former is warranted when uncertainties are few and conditions are at a crisis stage—that is, population numbers or distribution are known to be so low that immediate extirpation or extinction is likely. In such cases, scientific evidence or analysis would argue for immediate and drastic actions to protect the species regardless of costs to other uses of the land. If conditions are not at crisis proportions, say long-term trends are down but there is time to learn more and adjust management, the adaptive approach is prudent.

The adaptive approach is proposed for spotted owls, because 6,100,000 acres of habitat remain in Oregon and Washington alone, the entire population exceeds 2,700 pairs, including those in California, and trends are only minus 1 to 2% per year. The current planning period covers only the next ten to fifteen years, and a major research and development effort is under way.

The most important issue in current plans is the extent to which activities carried out or committed to under the plan would compromise long-term viability or cause irreversible processes of decline to begin. The important reference points are (1) now, (2) the end of the plan period, and (3) a future time when effects of actions taken during the plan period would have played themselves out. Since the spotted owl lives to age 15 to 20 years, lag effects might show up for several decades following the plan period.

Any plan to meet a future goal entails costs, risks, and uncertainty. In general, those increase as the goal becomes longer in time. When costs are high or uncertainty jeopardizes success of the plan, monitoring and research are warranted. In this case, there are potentially high costs in forgone timber revenues and loss of jobs. And there are risks to spotted owls due to small population dynamics and isolation. Therefore, a Research, Development, and Application Program of intensified inventory, monitoring, and research is part of the overall management strategy (USDA Forest Service 1988). This will allow revision of plans in five years if new information indicates the necessity.

The framework of a regional strategy for spotted owl population viability during the current plan period of the next ten to fifteen years is generally the following:

Use wilderness areas and national parks in Oregon and Washington as large reserve areas to contain an estimated 1,300,000 acres (526,000 ha) of suitable habitat with capability to support 270 pairs of owls.

Assume that lands outside of the national parks and National Forest System in Oregon and Washington will sustain not more than an estimated capability to support 70 pairs of owls throughout the period.

Use lands in the National Forest System that are technically not suited for timber production, yet outside of wilderness, to sustain an estimated 822,000 acres (333,000 ha) of suitable habitat.

Augment the above habitats with Spotted Owl Habitat Areas designated in lands suited for timber production on the national forests at approximately 6 to 12 mile intervals to prevent isolation and extreme fragmentation of habitats. The designated areas could contain up to 348,000 acres (140,000 ha) of habitat depending on forest-level decisions. Designated areas would support several hundred pairs, but their principal purpose would be to provide for interchange of individuals throughout the population and prevent isolation of owls in the large reserve areas.

Remaining lands in the National Forest System will be under a variety of uses. At the end of the plan period they will still contain at least 1,935,000 million acres (780,000 ha) of suitable habitat. In total, all National Forest System lands in Oregon and Washington will sustain capability for about 1,130 breeding pairs of spotted owls after fifteen years under the plan.

Other owl habitats, principally in California, will contain an estimated 1,050 pairs within the contiguous biological population, thus contributing to an overall population of 2,180 pairs. The genetically effective population number should be on the order of 1,000 pairs or more (Salwasser et al. 1984).

Projecting the strategy out to fifty years, which implies three successive decisions to continue following the same strategy or to increase or decrease habitat protection, would result in a population of 1,600 to 2,000 pairs depending on the decisions, and assuming no new information that spotted owls are more or less numerous and adaptable than now thought.

In addition to intensive inventory and monitoring of the above estimates, the Research, Development, and Application Program is carrying out detailed research on habitat affinities, population dynamics, genetic interchange, and potential for silvicultural enhancement of habitats. Analysis indicates that the strategy described for the next ten to fifteen years would not jeopardize the long-term continued existence of spotted owls in the Pacific Northwest. However, the strategy will not work without coordination across agency and ownership boundaries or provision of sufficient kinds, amounts, and distributions of habitats at all geographic scales (Figure 5-6). And major assumptions and unknowns, along with adherence to planning direction, must be evaluated frequently through a wide array of studies and reviews.

SUMMARY REMARKS

The purpose of this paper was to present a perspective on population viability as an aspect of biological diversity in wildland ecosystems. Population viability is certainly not all there is to diversity in wildlands. But the continued existence of large vertebrate species will always be one important indicator of the health of wild ecosystems. Therefore, it will guide much of the management of those systems.

The perspective included an overview of the population viability concept. It was a simple discussion without pretense of precision or sophistication. It employed general models and rules of thumb. That is sufficient for most people to understand that large ecosystem areas under coordinated management are necessary to sustain the biodiversity of specific places within those areas. Many areas of the United States still have the capability to function as ecosystems that are effective in sustaining regional biological diversity. Several prominent examples were illustrated. More detailed discussions of population viability appropriate for scientists and technicians can be found elsewhere, most notably in Soulé (1987b).

The paper concluded with a presentation of how population viability for one indicator of diversity is approached for a large region of North America. The purpose was not to argue that the specific strategy described is correct or better than another possible strategy. Only time and continued research and monitoring will show that. Rather, the paper was intended to accomplish three things. First, it was to show that managing park or wilderness ecosystems for biological diversity that includes vertebrates with large home ranges must entail coordinated management of the larger ecosystems in which those park or wilderness areas are embedded. Second, it was to offer a glimpse of the type of guidance that appears to be needed at different geographic scales—stands, watersheds, and regional distributions—to integrate ecosystem management from local to regional areas and across ownerships or administrative units. That guidance would be even more complicated if human activities had a significant direct bearing on the goal, as would be the case for grizzly bears and wolves. Third, it was to show that biologically and politically complex cases such as the spotted owl probably cannot be resolved by force, however sound the evidence and analysis; they need an iterative approach that employs planning, monitoring, and research as active parts of adaptive resource management. The spotted owl could be used as one indicator of how well a coordinated ecosystem management is working from the Sierra to the northern Cascades.

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