Advances in Ecoregional Conservation

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Abstract

Biology–the science of life–and planning (for example, regional planning or land-use planning) have been considered totally separate disciplines, pursued by different people with different training and different interests. But, at a time when biological diversity is declining rapidly and human land use is the major cause of this decline, effective conservation requires that we bring biology and planning together. Where we put our developments and infrastructure on the landscape should depend on the requirements of nature's infrastructure.

I am a conservation biologist, trained as a scientist, but I work mostly in this new, hybrid area I call conservation planning. In both conservation biology and conservation planning, what we are most interested in is maintaining or restoring biodiversity–the variety of life on Earth. Biodiversity and the related idea of ecological integrity–the healthy, complete condition of a natural landscape--provide a solid conceptual foundation for modern conservation.

Expanding Our Scale of Concern

But let's throw our lofty concepts aside for a moment. When most people think about nature, it is the big, charismatic wildlife they are concerned about. It is well documented that most funding for wildlife has gone toward a small set of attractive and usually huntable animals. In practice, the species level of biodiversity is where we have focused almost all of our attention, and to a very select group of species, at that.

Recently there has been increasing concern about another kind of species–endangered species. This concern is certainly warranted. Endangered species, by definition, are in imminent danger of extinction. If we do not do something for them soon, they will be gone. But the limitations of the endangered species approach are becoming increasingly obvious. For many species, such as the California condor, many millions of dollars have been spent without any assurance of recovery in the wild. In the U.S., 50 percent of listed species occur only on private lands, where regulatory authority is increasingly limited. Most actions under the U.S. Endangered Species Act and under similar laws and policies at the state level have taken place species by species, site by site, and threat by threat. Conservation actions are not well coordinated and are incapable of reconciling the sometimes-conflicting needs of different species.

Hence, for a variety of reasons, people from several camps have been talking about the need to get beyond endangered species and try to do something a bit more proactive. The increasing interest in conservation at the ecosystem level is entirely consistent with the U.S. Endangered Species Act of 1973, whose stated purpose is "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved." Even in conservation situations where no endangered species are involved, it usually makes more sense to manage at an ecosystem level. Conservation biologists today are in general agreement with the idea that maintaining viable ecosystems is likely to be more efficient, economical, and effective than a species-by-species approach.

So, what is the new approach people are advocating, which presumably moves us beyond endangered species? It has been variously called an ecosystem approach, a greater ecosystem approach, ecosystem management (or ecosystem-based management), a coarse filter, a landscape approach, a bioregional or ecoregional approach, or a "big picture" approach. I am sure we could think of more descriptors. Different people, of course, interpret these approaches in different ways.

Might some of the confusion about these terms be eliminated if we had clear definitions? It would seem that, if we are going to talk about managing and conserving ecosystems, we ought to have some general agreement on what an ecosystem is. In his influential third edition of "Fundamentals of Ecology" (1971), Eugene Odum defined an ecosystem as "any unit that includes all of the organisms in a given area interacting with the physical environment so that a flow of energy leads to clearly defined tropic structure, biotic diversity and material cycles." This definition seems reasonable enough, but for practicing conservationists and land managers, we can see how it might seem a bit abstract and difficult to implement. Ecosystems are open systems, exchanging matter, energy, and organisms among them. Where we draw the lines between them is largely arbitrary.

Although some people are troubled by the arbitrary boundaries of an ecosystem, I believe that the flexibility of the ecosystem concept is one of its strengths. Depending on the problem or conservation objective at hand, we can be concerned with a particular plant community type or the whole mosaic of communities across a broad landscape, say, from the scale of a single stand of old-growth red pine in northern Minnesota to the huge Great Lakes Basin Ecosystem. So we have a nested hierarchy of ecosystems within ecosystems. What level in this hierarchy we focus on depends on the problems we seek to address.

So, increasingly, people are recognizing the need to conserve and manage ecosystems on a regional scale – so-called ecoregion-based conservation. Ecoregions are basically regional ecosystems: relatively large areas of land or water that harbor characteristic species, communities, ecological phenomena and processes, and environmental conditions. It is well recognized now that patterns of biodiversity are better reflected in ecoregional than political boundaries. World Wildlife Fund, The Nature Conservancy, the Sierra Club, and other conservation groups in North America and worldwide are now taking an ecoregional approach to conservation, or at least talking seriously about it.

The Status of Ecosystems

World Wildlife Fund recently completed an ecoregion-based conservation assessment for the U.S. and Canada. Among the goals of the WWF assessment were to (1) identify ecoregions that support globally outstanding biodiversity and emphasize the global responsibility to protect or restore them; (2) assess the types and immediacy of threats to North American ecoregions; and (3) identify appropriate conservation activities for each ecoregion based on its particular biological and ecological characteristics, conservation status, and threats. The 116 terrestrial ecoregions identified for the United States and Canada were divided into ten Major Habitat Types to ensure good representation of terrestrial ecosystems and to compare only similar ecological systems. Regional and taxonomic experts assessed the biological distinctiveness and conservation status of each ecoregion at a workshop in August of 1996. Biological distinctiveness was determined through an analysis of species richness, endemism, distinctiveness of higher taxa, unusual ecological or evolutionary phenomena, or global rarity of Major Habitat Types.

The conservation status of ecoregions was based on an assessment of landscape and ecosystem-level features such as habitat loss, habitat fragmentation, the size and number of large blocks of habitat, the degree of protection, and current and potential threats. Different combinations of biological distinctiveness and conservation status were used to prioritize ecoregions for conservation action and identify the most appropriate suite of conservation activities to be undertaken within them. A summary map illustrates ecoregions of highest and most urgent conservation concern, and suggests appropriate conservation actions for all ecoregions.

One of the more important questions for those engaged in conservation planning is how the region of concern has changed over time. Some of the changes in the North American landscape have been dramatic–for example, the 95-98 percent loss of old-growth forests in the lower 48 states. Changes in ecological processes have also been severe. Among the best documented changes have been related to fire suppression. In ponderosa pine ecosystems of western North America, nearly a century of fire suppression has changed open, park like forests maintained by frequent, low-intensity fires to dense, crowded forests containing many fire-sensitive species that invaded from off site when fire was eliminated. When fire now occurs in these forests it is often catastrophic crown fire.

The ecological analog of ponderosa pine in eastern North America is the longleaf pine ecosystem of the southeastern coastal plain. This is one of the most endangered ecosystems in North America and has declined by approximately 98 percent since European settlement. The early causes of decline were heavy logging and agriculture. Many sites logged in the 19th and early 20th centuries recovered their longleaf pines over time because the logging was graciously sloppy and left a few live trees. Most of these recovered forests, however, have been hit by a second round of much more intensive forestry, where logged sites are stripped to bare soil and planted with dense stands of faster-growing slash or loblolly pines. Fire suppression, both active and passive (i.e., through habitat fragmentation, which prevents the natural spread of fires) has converted many longleaf pine forests to hardwoods. Some 27 federally listed species, plus, as of 1993, 99 species that were candidates for listing are associated with longleaf pine and its dominant groundcover, wiregrass (Aristida sp.). The best known of the listed species is the red-cockaded woodpecker, but most of the diversity and endangerment in this community is in the herbaceous layer, which is among the most species-rich in the world. The huge number of imperiled species associated with this and many other endangered ecosystems proves a point that should be obvious–as ecosystems or habitats decline, so do the species that compose them.

Natural ecosystems of all types that remain today in much of North America have suffered from habitat fragmentation. A recent study by World Resources Institute (WRI) searched for forests on each continent that remain relatively pristine and exist in blocks large enough to accommodate natural disturbance regimes and, at least in the short term, populations of all native species, including large carnivores. WRI called these forests "frontier forests." The remaining frontier forests in North America are almost entirely in the boreal zone. The few forests that marginally qualify as frontier in the 48 coterminous states–the Greater Yellowstone, Selway-Bitterroot, Northern Continental Divide, and Northern Cascades ecosystems–exist as habitat islands and are considered threatened.

In most ecoregions of North America, then, we’re dealing with landscapes that have been degraded to one degree or another, often to a very significant degree. Hence, the conservation paradigm for these degraded ecoregions must be one of ecological restoration. An essential first step in a restoration strategy is determining the changes that have occurred in the region or landscape of interest, and which have been associated with losses of biodiversity and other values. Such trends for forests, for example, include a shift from old to young forests, from structurally rich to simplified stands, from large and connected patches to smaller and more isolated patches, from no roads to high road density, and so on. Knowing what these trends are, we can set out to reverse them. Where we stop in such a process of restoring an ecosystem to natural or historic condition depends on many factors, socioeconomic and cultural as well as biological.

Developing Conservation Plans

Knowing the present status of an ecosystem and how it has changed over time, how can science be applied to the design and management of regional landscapes for maintenance of biodiversity? We must begin by recognizing that conservation is a value-laden exercise. These values should not be hidden. A conservation plan should be founded on a set of explicit goals, determined by the shared values of those engaged in the planning exercise. Not everyone will accept these goals, and a conservation plan that seeks to achieve complete consensus among all stakeholders will inevitably flounder. It is often difficult enough just to find consensus among those people sincerely interested in biological conservation. Yet, these are the people, local and otherwise, who care about the non-human life of a region and have a legitimate say about what becomes of it. Polls say this group includes the majority of Americans, although it obviously does not include others – such as most of the congressional delegationUniversity of Idaho.

Commonly accepted goals of conservation include (1) representing all kinds of ecosystems, across their natural range of variation, in protected areas; (2) maintaining viable populations of all native species in natural patterns of abundance and distribution; (3) sustaining ecological and evolutionary processes within their natural ranges of variability; and (4) building a conservation network that is adaptable to environmental change. These goals are ambitious and inclusive. Hence, any strategy for attaining these goals must be similarly broad and pluralistic. Yet, a strategy that seeks to protect absolutely everything is not practical; some species and habitats are common, well represented in existing reserves, adaptable to human disturbances, or otherwise at low risk of loss. Or perhaps they are being addressed adequately by existing conservation initiatives. Thus, the challenge is to design a non-redundant strategy that has a high probability of protecting those species and habitats that might otherwise disappear within the foreseeable future.

Traditionally, protected areas have been the cornerstone of conservation. I believe they remain an essential element, but we need to look beyond core reserves themselves in landscape design and consider other components such as buffer zones, corridors, and the surrounding matrix. Most core reserves are too small to remain viable in the long term unless they are connected and buffered. Most species are distributed largely outside reserves. We may never have enough area in reserves to meet conservation goals, though I do not think it is unreasonable to strive for an order-of-magnitude increase over our present, pitiful 3-5 percent (depending on definition).

Surprisingly, the reserve idea – zoning some areas for strict protection – has come under attack lately. Some proponents of ecosystem management, including scientists and managers in the federal land-managing agencies, favor a "landscape without lines," approach to ecosystem management, which is absent any zoning and meaningful protected areas, and instead seeks to manage for all uses across the entire landscape. The critical assumption in this approach is that managers have learned from past mistakes and are now capable of managing forests, rangelands, and other environments in an intelligent way compatible with biodiversity conservation. Two Forest Service scientists (Richard Everett and John Lehmkuhl) who have led the charge against protected areas recently explained their rationale as follows: "We think the reserve model is not flexible and often inefficient because it focuses too much on allocating the landscape to specific uses...(We should) try to minimize balkanization of the landscape with permanent land allocations and standard prescriptions, and attempt to manage the landscape as an integrated whole..." What this usually means in practice is manage every place for consumptive human uses. This philosophy is exemplified by the interagency Interior Columbia Basin Ecosystem Management Plan, released in 1997 and covering some 58 million acres, which lacks any recommendations for new protected areas and instead proposes relatively minor changes in management practices.

I consider the landscape without lines approach – and other proposals that lack meaningful protected areas – naive, arrogant, and dangerous. Consider the well-publicized boundary contrast between Yellowstone National Park and Targhee National Forest. I don't like this line one bit. But without this line there is a significant chance that the entire landscape would look like the Targhee. Such is the arrogance of many land managers. Management approaches that lack meaningful protected areas assume a level of ecological knowledge and understanding – and a level of generosity and good will among those who use and manage public lands – that are unfounded. I trust that most conservation biologists will reject ecosystem management plans that offer no meaningful protection to imperiled species and habitats. Yet, we must remember that the people in power at this time (including both Republicans and Democrats) seem to have embraced the view that enlightened management can substitute for strict protection. Perhaps that would be true if management were truly enlightened. But it is not. Hence, it is incumbent on scientists to educate the public and decisionmakers about the perils of the landscape without lines approach and the need for a greatly expanded system of core areas.

Among those who do accept the need for protected areas, the most commonly asked question is "How much is enough?" This is an unfortunate question. I argue that we cannot answer this question in the abstract or come up with a precise percentage that applies across ecoregions. Rather, we must approach the question empirically, case by case, while relying for a foundation on a series of empirical generalizations that serve as guiding principles.

Three Tracks of Science-Based Conservation Planning

Since scientists became involved in conservation planning, many different methods have been used to identify areas for protection, but most are variants of three basic approaches that, in turn, reflect different goals: (1) protection of special elements, such as rare species hotspots, old growth, critical watersheds, and roadless areas, (2) representation of all habitats, vegetation types, or species within certain "indicator" or "surrogate" taxa such as vertebrates or butterflies, within a network of reserves, and (3) meeting the needs of particular focal species, especially those that are area-dependent and sensitive to human activities. Some colleagues and I are attempting to unite these three streams in a research project currently underway in the Klamath-Siskiyou ecoregion of northwestern California and southwestern Oregon. We are treating the three major approaches to conservation planning as three tracks or streams of a comprehensive approach to identifying and protecting areas of high biological value.

The first track, special elements, seeks to identify areas of concentrated conservation value. Perhaps the best known special elements are the "elements of diversity" ranked and tracked by the natural heritage programs established by The Nature Conservancy. The elements of greatest concern are those species and plant communities ranked as "critically imperiled globally" (G1) and "imperiled globally" (G2) based on their rarity and threats. "Element occurrences" are mapped locations of these elements. At the scale we are working in the Klamath-Siskiyou region, we look not for individual occurrences but for geographic clusters of occurrences ("hotspots").

Besides hotspots, other special elements we are mapping include roadless areas, areas of low road density, and other relatively pristine sites; old-growth forests; serpentine areas; Port Orford cedar sites (especially areas uninfected with root disease); important bird habitats; and watersheds of high value for native fisheries and aquatic biodiversity. Watersheds were rated as class one (pristine), class 2 (recoverable), or class 3 (severely degraded), according to presence of alien species, dominance of hatchery-produced salmonids, proportion of watershed uninfected by Port Orford root disease, water withdrawal, deforestation, mining, density of homes, presence or rare/threatened aquatic animals, presence of alluvial valleys or alluviated canyons (which are hot spots for aquatic biodiversity).

Protection of special elements–which often comprise the rare and unique in Nature–does not assure that all species and habitats in a region will be adequately protected. In particular, species groups that are poorly known or inventoried (for example, soil invertebrates, fungi) may be missed. Hence, our second track of planning is a "coarse filter" or representation approach, which seeks to protect intact examples of each vegetation and physical habitat type in the region. Representation can be considered complementary to special element protection. The assumption is that, because species distributions correspond to physical habitat gradients, protecting examples of all habitat types (i.e., complete environmental gradients) will capture occurrences of a vast majority of species. The gap analysis projects in the U.S., Canada, and several other countries are examples of this approach.

In the Klamath-Siskiyou we are conducting gap analyses of both physical habitats and vegetation.

Our gap analyses are not completed yet, but one striking result is the familiar pattern of high-elevation sites being well represented in protected areas and low-elevation sites poorly represented. Our classification of physical habitats is based on climate and soil variables, which are known to be important for determining the distributions of organisms. A gap analysis of these habitats, using an early classification that we are still refining, overlaid designated wilderness areas and determined that 65 percent of the current protected area includes just three classes of habitats representing cool, high-elevation sites and areas with poor soils. Fully 47% of the coldest, poorest soil class is protected (some 26 percent of the total area in wilderness), compared to only 0.1 percent of the low-elevation, warm, best soil class. These results are similar to findings in other regions, where protected areas tend to be concentrated in extreme, low-biodiversity sites that are not useful for timber or other resource production.

Focal species analysis is the third track in our research, and again it is complementary to the other two tracks. Whereas the locations of special elements and under-represented habitats point to particular sites and landscapes that require protection, focal species analysis identifies additional high-value habitats and addresses the questions, How much area is needed? And, In what configuration should habitat areas be designed? These questions form the linkage from reserve selection to reserve design. For example, one cannot design meaningful habitat corridors between reserves without knowledge of the species expected to use the corridor, what kinds of habitats they will and will not travel through, how far individuals will disperse, and so on.

The Klamath-Siskiyou region, together with the adjacent California North coast or redwoods region, is one of the last refuges of the Pacific fisher, a threatened forest carnivore in the weasel family. Based on the presumed importance of the Klamath-Siskiyou region for the fisher, the concern about the species' status, and preliminary information linking it to older forest and suggesting sensitivity to fragmentation, we selected the fisher for analysis as a potential focal species. By combining data from regional forest carnivore surveys with habitat data derived from satellite imagery, we were able to predict with great accuracy the distribution of the fisher in the large portions of the region that have not been surveyed. Critical core areas and landscape linkages were identified, which will be incorporated into the mapped conservation plan.

Two more general conclusions emerged from analysis of the fisher as a focal species. The most important fisher habitat lies outside existing protected areas, primarily in low to mid-elevation, biologically productive forests with a significant hardwood component. Many of these areas have been degraded to some extent by logging and roaming. Although they may not have previously attracted conservation interest for this reason, this research found they represent critical habitat for mesocarnivores and may need to be "re-wilded" to restore these species. Secondly, the presence of fishers in any particular watershed is determined by regional population processes operating at scales larger than those usually considered by agencies. Hence, a successful conservation plan for the Klamath-Siskiyou will require a multi-ownership, regional strategy that insures that habitat areas will be large and connected.

Although the fisher study provided important insights for our conservation planning effort, studies of other potential focal species are also needed. For example, the fisher is a habitat specialist on older forest but appears relatively tolerant of roads. Therefore, it would not make a good umbrella for wilderness-dependent species. In order to incorporate the needs of species with the greatest sensitivity to human activities, we have recently begun a second phase of our focal species analysis. This project will evaluate the feasibility of reintroducing large carnivores to the Klamath-Siskiyou region. The potential focal species are the gray wolf, grizzly bear, and wolverine. These species are either extirpated (wolf and grizzly) or believed extirpated or present at very low densities (wolverine). The grizzly’s extreme sensitivity to roads and human disturbance make it a valuable umbrella species for defining core reserves. The gray wolf is a habitat generalist with relatively high fecundity whose survival is mainly limited by human persecution, often associated with roads. The wolf may prove useful to help define buffer zones and corridors, as it is more tolerant of human presence than is the grizzly. The wolverine has an extremely large home range size (an average of 1500 km2 for males in Idaho). In the long term, all of these carnivore species will require inter-regional habitat linkages (for example, to the California and Oregon coastal ranges, Cascade Mountains, and Sierra Nevada) in order to maintain viable populations. Evaluation of these species will help initiate a campaign to restore the ecological integrity of the region by restoration of the full complement of native predators. Our strategy for all these species is to study biological feasibility first. If reintroduction is biologically feasible in the near or medium term, we will then proceed to investigate socioeconomic feasibility.

Because species biology is more advanced than most areas of conservation biology, we have lots of principles to guide reserve design based on the needs of focal species. They include such well-accepted empirical generalizations as: (1) Species well distributed across their native range are less susceptible to extinction than species confined to small portions of their range. (2) Large blocks of habitat, containing large populations, are better than small blocks with small populations. (3) Blocks of habitat close together are better than blocks far apart. (4) Habitat in contiguous blocks is better than fragmented habitat. (5) Interconnected blocks of habitat are better than isolated blocks. (6) Blocks of habitat that are roadless or otherwise inaccessible to humans are better than roaded and accessible habitat blocks.

Although these principles are well supported by empirical data, they have exceptions and their application to specific cases is not usually straightforward. Proper interpretation of these principles can only be made by competent biologists familiar with the organisms and landscapes in question. Simplistic and uncritical application of general principles is distressingly common and threatens to undermine the contributions that science can make to real-world conservation. For example, corridors have become somewhat of a fad in conservation, to the point that well-meaning conservationists often draw corridors into their proposals without doing the necessary work to determine which species in their region might benefit from corridors and what design of corridors will work best for these species. In some cases corridors–especially narrow ones that favor weedy, edge-adapted species–may do more harm than good. Unfortunately, we know little about what determines functional connectivity for most species sensitive to fragmentation. In the absence of case-specific information, it is virtually always a good idea to maintain natural connectivity in a landscape and restore it where we can.

Joining the three tracks--special elements, representation, and focal species--together into a comprehensive assessment and plan for the Klamath-Siskiyou ecoregion will be challenging. We are developing a series of landscape design options, each reflecting different emphasis given to the three tracks. For example, we will produce maps showing a series of near-optimal reserve designs for special elements, other maps emphasizing representation, and still others for focal species and for all three tracks combined. Our recommendations will include a temporal sequence of designs to assure that urgent conservation actions are taken before they are precluded by further logging, road-building, mining, and other developments, while identifying other actions that are needed for long-term biological integrity of the region but which can wait a few years or decades before being fully implemented. We will also identify critical ecological processes--such as fire--that must be restored in order to maintain certain plant communities, such as oak woodlands and savannas, in optimal condition.

Ecosystem Management

Finally, there is the question of how the conservation networks that emerge from science-based conservation planning will be managed. The prevailing model for public lands management today is ecosystem management. But how ecosystem management is interpreted is a matter of philosophy and values. Values determine the fundamental insights and goals of managers.

The dominant paradigm of ecosystem management is one where human interests are considered most important. This model, which I call the Forest Service version because it has been endorsed in many Forest Service publications, carries the implicit, anthropocentric assumption that human needs and desires–and the needs of an expanding economy and technology–can be met mostly independently from the land. I believe this assumption is indicative of what David Ehrenfeld has called "the arrogance of humanism." The assumption is also dead wrong. In my view, any ecosystem management project that operates under this assumption is doomed to eventual failure.

An alternative paradigm of ecosystem management would be a biocentric one, where human needs and desires, as well as the realities of economics and technology, are acknowledged, but along with the needs of nonhuman species. Furthermore, this new paradigm would recognize that none of these needs can be met independently from land ecology. This paradigm places us, in Aldo Leopold's words, as plain members and citizens of the biotic community. I – for one – do not think that is a bad place to be.

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