A Regional Landscape Approach to Maintain Diversity

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Diversity of habitats and species has been a primary consideration for deciding which sites should be preserved (Goedert 1979, Mague et al. and Usher 1983) as well as in management plans for parks, forests, wildlife areas, and nature reserves (Sistelius and Radiek 1977, Thomas et al. 1978). But with recent developments in applied biogeography and landscape ecology, the maximum diversity concept has been complicated. At what scale should diversity be measured and managed?

It is not often that conservation-oriented ecologists and land managers interact and discuss the issues, choices, and consequences involved in particular management decisions. I accept with this paper to provide a basis for such communication and to examine the concept that long-term maintenance of diversity requires a management strategy that considers regional biogeography and landscape pattern above local concerns. Managers of parks, wildlife areas, and other protected lands have traditionally been interested in maintaining maximum habitat diversity within each unit. This minimum local diversity strategy, although based on good intentions, may operate at the expense of the species and communities most in need of protection at a regional level (Fahrig 1980, Noss 1979, 1981, Summon 1980, Summon and Knopf 1982, Verner 1980).

A major goal of preservation is the perpetuation of indigenous ecosystem structure, function, and integrity. Furthermore, in a deteriorating landscape, all parks, preserves, and wildlife areas should have perpetuation of natural ecosystems as a principal goal. But individual ecosystems, the traditional focus of ecology, should not be seen as separate entities (Haines 1977). Almost all ecosystems are "open" and exchange energy, mineral nutrients, and species. Particularly in highly heterogeneous regions, the landscape mosaic may be a more appropriate unit of study and management than single sites or ecosystems. Landscape has been variously defined, usually in somewhat ambiguous terms. I follow the more precise definition of landscape by Forman and Gordon (1980) as a "kilometers-wide area where a cluster of interacting stands or ecosystems is repeated in similar form." A landscape is therefore an ecological unit with a distinguishable structure. The importance of the landscape concept is its recognition that the structural components of a landscape interact (Forman 1981, Forman and Gordon 1981).

WHY MAINTAIN DIVERSITY?

Conservatists are very much concerned with diversity, striving "to preserve viable populations of as many as possible of the species that inhabited the pristine landscape" (Terborgh 1976). Of course, each species is ultimately doomed to extinction as it fails to keep pace with changes in the environment, many brought on by evolutionary "advances" in other, interacting species (Stevens 1979, Vae Valem 1973, 1977). The goal of conservation is not to stop a natural process, but rather to abate the accelerating pace of species loss associated with human dominance of the biosphere (Ehrlich and Ehrlich 1994). Biologists have learned that individual species harbor unique genetic material and are components of functional ecosystems, systems that provide a vast spectrum of essential "public services" (Ehrlich 1980, Ehrlich and Mooney 1983). It is in this sense that preservation of species diversity assumes incontestable importance.

It is helpful to recognize three basic scales of diversity. Alpha diversity is the number of species within a single habitat or community (Whitaker 1972). In most cases, a single habitat is assumed to be a small area (a few hectares or less) of uniform vegetation structure. Beta diversity reflects the change in species composition along an environmental gradient or series of habitats. Russell Karr (1976) in interpreting alpha and beta diversities as roughly equivalent to the within- and between-habitats diversities of MacArthur (1965). This is counter to a strict definition of beta diversity, but is more useful for land managers. Finally, the total species diversity of a geographic region (e.g., a landscape or ecoregion) has been called gamma diversity (Whitaker 1972). These three basic scales or types of diversity may be affected differently by human land use practices in a given area. The habitat diversity for which land managers often strive is artificial beta diversity, c patchwork of different habitat types. For simplicity, the term diversity in this paper
WHY MANAGE FOR EDGE AND Beta DIVERSITY?

The "edge effect" has been a fundamental principle of wildlife management (Allen 1962, Dasmann 1964, Leopold 1953) and is a major factor encouraging a man to manipulate land and plant communities. Direct support of wildlife, or within plant communities come together (Thomson et al., 1959). It has been observed that edges are rich in wildlife, since "wild" occurs where the types of food and cover which it needs are closest together. "Edges" can be used for the intensive study of two ecotone or habitat complexes. Meanwhile, plant communities or vegetation types may be found together with animals that make frequent use of more than one vegetation type and those that actually specialize on edge (Johnston 1947). Edges have high cover density (Johnson et al., 1979) and food availability, in accordance with a high primary productivity (Rany et al., 1961). Game animals are commonly edge-dependent, as are the animals (e.g., birds of least numbers and many urban and agricultural landscapes (Buehler et al., 1981). Whithcock et al., 1976).

Work has been done on relating birds to habitat conditions than for any other found group. The vertical distribution of foliage within a habitat is correlated with the number of resident bird species (Kerr and King 1971). MacArthur 1964, MacArthur et al., 1967, Reder 1969), as is the interconnection of vegetation types. This patchiness in horizon diversity of vegetation products is a major determinant of the variety of breeding trees in a particular area (MacArthur and MacArthur 1941, Roth 1975, Temple et al., 1979). This beta diversity principle was supported by Lay (1938) who demonstrated an increase in bird species with the establishment of small woodlots in a Texas forest.

Managers increase beta diversity primarily by maintaining a variety of patches of different vegetation age. This also increases edge effect. Meadows are predominantly burned or mowed. thickets and row crops are intensive. plots of hardwoods are cut here and there. and pines and fruiting trees often mixed mesophytic species are planted. Trails wind everywhere. These management practices are implemented to increase the variety of habitats and therefore likely favor a wide variety of shrub and semi-natural wildlife (Fainberg 1989). The species maximum habitat diversity philosophy is deeply entrenched in the land management profession is evident from the literature. For example, in a chapter of a widely used wildlife management text (Gilbs 1971), Yomkum and Dasmann (1973) urge managers to "develop as much edge as possible" in a product of the places where two habitats meet. The National Forest Mves- Grant Act of 1910, requires that a diversity of plant and animal communities be maintained to meet multiple-use objectives (Yomkum and Cost 1973). Many have followed the advice of Slossers and Mylnke (1977) that a "diversive wildlife population will require a planning ap-

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bough and Winter 1980). Whitham et al. (1981) determined that the birds least tolerant of forest fragmentation in the eastern deciduous forest region (USA) tended to be open-country migrants. Forest interior specialists, open nesters (or exposed to eastern nesters, and ground nesters. No statistical analysis, which typically comprised 60-90% of the breeding avifauna in expansive tracts of eastern deciduous forest, account for less than half the birds of small, isolated tracts (Whitham et al. 1976, 1980). Thus history strategies can be an important component of vulnerability in a human-dominated landscape, as Severson (1981) and Hestrin (1981) have also concluded for plants. Continental flow of native species from a landscape is certainly contrary to goals of preservation. The determination of regional diversity vs. individual habitat patches becomes smaller follows from the minimum area requirements of many populations. Management for maximum diversity within individual units could exclude many species from the regional landscape if patch sizes fall below the threshold required for colonization or persistence of populations of area-dependent species. Relative to thousands of square kilometers in extent may be necessary to sustain populations of some forest species and migratory birds (Kerby 1979, Terborgh 1979, Whitham 1977). If habitats are fragmented within preserves in addition to outside them, the area-sensitive species may gradually drop out of the regional biota (Vaughn 1980, Severson 1981, Samson and Knopf 1982). 

DETRIMENTAL EFFECTS OF INDUCTED EDGE

The few species of "undisturbed" forests are particularly sensitive to habitat alteration (Poole et al. 1979), and human disturbance to forest stories can have pronounced effects on species presence and frequency (Fahy 1981, Whitham et al. 1976). Management for edge effect through habitat subdivision is clearly a peremptory concern of considerable magnitude to forest interior specialists, particularly in forest islands with large perimeter/area ratios. The perimeter of any forest island is edge habitat. Edges commonly extend 10-15 m into the forest on the east, north, and south sides, and up to 30 m on the west side (e.g., in southern Wisconsin forests, Runyan et al. 1981). When forest islands become small, there is an increase in edge area relative to interior. Edge flora, more tolerant of dry conditions, may replace interior species in small forests (Ganey et al. 1981), with the result that forest islands below a certain size may become dominated by the pre-settlement forest ecosystem. A very small forest may be entirely edge habitat, and may, in fact, be considered seral. As the forest islands in the study area have been isolated for less than 100 years, the edge flora may maintain their population centers, but edge effects are still measurable. This increase in edge habitat may be significant, even if not easily detected by the naked eye. But forest interior specialists may become more important in local landscapes, particularly in the southeastern United States, where the forested landscape is fragmented. In upland areas, the forest interior may be a "reserve" for many species (see also Silverstein and Silverstein 1979). These results support the hypothesis that birds characteristic of forest interior habitats are unable to maintain their populations where edge is abundant (Robbins 1979). Management for high habitat diversity and edge not only degrades forest communities, but may also accentuate negative effects of fauna on flora. Brattstrom and White 1980 reported that manipulation of habitat to support a sustainable deer herd can result in heavy browsing in adjacent natural areas, which can lead to a multitude of novel plant species. An important assessment of the overall impact of deer on forest vegetation and landscape succession may be inimical to the preservation of regional diversity if applied routinely in a number of mixed deciduous and coniferous forests. Although local (i.e., forest interior) diversity may be increased by management practices that enhance habitat structure, the edge effect, this local increase is obtained at the expense of those species that are common in the urban-agricultural matrix. Even the local increase in diversity may be ephemeral if forest interior species gradually drop out of the biota. Clearly, management for maximum diversity can be a "trade" varner 1980). Some positive and negative effects of management for each of the three spatial scales of diversity are summarized in the box (next page).

A REGIONAL LANDSCAPE APPROACH

Ecologists, land managers, and planners have traditionally ignored interactions among the different elements in a landscape and, with rare exceptions, have considered land use decisions in separate ecosystems (Foramin 1981). A criterion of habitat homogeneity is often applied to land use decisions. This homogeneity is to be found on a tractable set of variables. But field naturalists have found a long time ago that any given location may be seen among "different" communities. MacArthur and MacArthur (1961) recognized that some bird species may require two or more types of vegetation profiles rather than some mean profile. Karr (1980) suggested that, although edge is important in the natural world as many variables as possible in a scientific endeavor, it is also necessary to determine what occurs in areas characterized by an intergradation of habitat types. Those observations open the door to landscape ecology, the study of the interactions and fluxes of energy, mineral nutrients, and species among clustered stands or ecosystems (Foramin 1981). Foramin and Godron 1981 studied the ecological role of patches with continuously varying degrees of connectivity and recognized the importance of matrix and corridors to terrestrial habitat island dynamics.

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Managing for Different Scales of Diversity*

SCALE

Alpha (within-habitat)
Achieve optimum levels of limiting resources (e.g., achieve a competitive
stratified/representative community); increase structure complex-
ity (e.g., vertical, seral, succession) to provide more physical niche space above uninvaded species.

Beta (between-habitat, including 'edge effect')
Maintain variety of putational
habitat types; interconnect roads, lines, and other swaths.

Gamma (regional)
Preserve sufficiently large areas of uninvaded indigenous ecosystems on a regional scale; interconnect regional patches; limit human intrusion in sensitive areas.

ADVANTAGES

Increased number of species within habitat, thus increasing population levels of particular species; desired community structure maintained.

Increased local species richness; increased population levels of edge-adapted species (e.g., man- game invasives); increased human recreational potential.

Adequate population levels and genetic variation of indigenous species maintained; critical ecosystem processes preserved; long-term human welfare ensured.

DISADVANTAGES

May be arduous and costly to implement; considerable uncertainty about direct effects of management actions on particular species (unpredictable); species could react to pest proportions, and critical species could decline.

Decreased populations levels or extinction of interior special-
species; proliferation of "weedy," opportunist species; commu-
nity destabilization; possibility decreased regional diversity (may limit options for regional diversity).

Some loss of local species rich-
ness with declines in alpha spe-
cies; more land taken out of "productive" human use; short-
term economic losses.

*The three strategies are not necessarily mutually exclusive.

For any landscape, the natural ecosystem complex is the preexistent vegetation and associated biotic and abiotic elements. Preservation activities would ideally maintain high-quality examples of preexistent-tree ecosystems in approximate proportion to their former abundance in the region. This does not mean trying to hold nature static. Rather, preservation should simply perpetuate the dynamic processes of preexistent landscapes. Landscapes are constantly changing, gradually or episodically, over geological and evolutionary time with geomorphological processes, climatic change, and the origin and extinction of species. They change more quickly with local or regional spe-
cies turnover, meteorological events, and other aspects of disturbance. Within a landscape, the suite of distur-
bances and successions within a cluster of stands is relatively constant (Forman 1978).

A regional landscape approach to preservation demands an integrative of ecological evaluation methodologies, co-
ordinating data from individual species occurrences to regional landscape pat-
terns. Rare species are generally the most vulnerable to extinction and must therefore receive priority attention in evaluation and protection programs (Adams and Clough 1978, Terborgh and Winter 1980); but there is danger in over-
emphasizing rarity to the exclusion of other criteria. There are several catego-
ries of rare species, some of which may not be overly prone to further endanger-
ment. Some rare species, such as key products of poorly regulated diversity of lower levels in the food chain, may have pro-
found ecological importance: others may be redundant or nonexistent in ecosys-
tem functions (although they nonetheless constitute unique genetic material and would be worthy of equal-then-strict consideration). There is also a problem of scale: species rare locally may be relatively common regionally or race versa (Margules and Usher 1981). With regional diversity and ecological integ-
rity as the goal, the rarity criterion is probably most appropriately applied re-
gionally and/or globally.

Debate continues over whether one large preserve or several smaller pre-
serves are optimal for preservation of regional diversity, with theory often yielding conflicting advice (Higgs 1981, Margules et al. 1982, Simberloff and Abele 1982), but in a human-dominated landscape, as Diamond (1976) pointed out, "the question is not which preserve system contains more species, but which contains more species that would be doomed to extinction in the absence of refuge;" much of the preservation controversy has hinged on this important ques-
tion, although Humphreys and Kitch-
er (1982) showed that vegetation least in need of protection (located only in preserves) are favored by large reserves. Moreover, the focus on numbers of spe-
cies tends to obscure the fundamental point that having complete ecosystems in what is at stake, and natural ecosystems do seem to have a minimum critical size (Lovejoy and Ohm 1978, Nikon 1978) in regional landscape planning, preser-
vation of whole ecosystems with the full complement of indigenous genetic diver-
sity is the ideal. This demands a complex of both large and small preserves and as many as possible, taking advantage of auspicious protection opportunities when they arise. This "combined strate-
gy" (Kushlan 1979) is designed to main-

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The IMPORTANCE OF INTERCONNECTIONS

The interconnections among the patches in a landscape may be as least as significant to maintenance of diversity as the size of the patches. It has been suggested that linking devices, such as
forest corridors or stepping-stones of small forest tracts, might encourage dis-
semination of interior species between forest islands (Butchess et al. 1991, Diamond 
1975, Willis 1944). Disseational between patches is crucial to the prevention of 
genetic drift on small or isolated populations (Miller 1979). Wegener and 
Merriam (1979) found that birds and small mammals use fencerows between 
woodlots much more than they travel across open fields, and they suggested that se-
lected vegetative fencerows may help to create a corridor system.
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