AN ISLAND ARCHIPELAGO MODEL FOR MAINTAINING BIOTIC DIVERSITY IN OLD-GROWTH FORESTS

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ABSTRACT

Three aspects of changing forest conditions throughout the world are 1) reduction in overall forest acreage, 2) conversion of old-growth forests to more intensively managed plantations, and 3) fragmentation of formerly expansive forests. All three have significant negative consequences for the preservation of biotic diversity. This paper develops a forest planning strategy whereby remaining old-growth forest fragments are conceived as an archipelago of forest habitat islands and integrated into a more intensively managed forest plantation landscape. The energetic basis of landscape formation and energy transformation is invoked to help guide planning decisions.

Forests that covered approximately one fourth of the global land area in 1960 cover only about one fifth of the land area now and will most likely cover only one sixth of the land area by the year 2000. It is hoped that the decrease in forest acreage will stabilize at about one seventh of the global land area by the year 2020 (C.E.Q. 1980, p. 117). In addition to the loss in total acreage, the fragmentation of formerly expansive tracts into remnant patches and the conversion of old-growth into younger age, short rotation stands pose serious threats to the maintenance of biotic diversity. Not unexpectedly, as demands for fuelwood, pulpwood, and timber increase to crisis proportions in many countries, the threats to wildlife communities increase proportionately. Reconciling the need for wood production with the maintenance of biotic diversity and wildlife communities will become increasingly challenging.

Prior to 1900 the word "conservation" referred to preservation from loss or injury and prevention of natural decay of domestic products such as food, health or social order. After choosing this same word to describe Roosevelt-administration renewable resource policies (Pinchot 1947), Gifford Pinchot and others were compelled to define its new meaning. Pinchot's 1910 definition of the word and concept as "the first great fact about conservation is that it stands for development" (Pinchot 1910, p. 42) may seem surprising. A more recent recommendation from the United States Strategy Conference on Biological Diversity reconfirms the same theme: "Diversity can only be maintained by incorporating conservation planning into development planning" (U.S. Dept. State, 1982, p.6). Because of the high efficiency of producing fuelwood, pulpwood, and timber in intensively managed short-rotation plantations, the prospect of integrating both high productivity and preservation of biotic diversity within the same stands is slight. An alternative is to more explicitly differentiate a system of conservation areas from production areas and attempt to spatially integrate the two systems. I believe the degree to which conservation areas must be differentiated from production areas is directly proportional to the intensity with which the wood production areas are managed. Reliance on intensively managed plantations for wood production will necessitate the setting aside of more acreage specifically committed to conservation of biotic diversity than would reliance on lower intensity silvicultural systems. This paper describes a landscape approach toward integrating conservation planning into a matrix of intensively managed forest. It is an extension of work reported on by Harris et al. (1982) and ideas in Harris and Kangas (1979) and Harris and Marion (1982). A larger and more thorough discussion is being published elsewhere (Harris 1984).

APPLIED ISLAND BIOGEOGRAPHY THEORY

A large and significant body of information of use to forest planners falls under the heading of Island Biogeography Theory. Conservationists are particularly receptive to this information because characteristics of the biological communities and processes in fragmentary forest habitat islands greatly resemble those of true islands. At least in qualitative terms the theory predicts that 1) old-growth habitat islands that remain as fragments of a formerly expansive tract will support more old-growth wildlife species than a comparable replacement stand regenerated in isolation from existing old-growth 2) Old-growth patches with larger effective island size will support more old-growth species than stands with smaller effective size under comparable conditions. A definable relation between number of resident species and stand size also exists. 3) When a patch of old-growth habitat is transformed into an island by cutting away the surrounding timber, the number of resident old-growth species will decrease with time. 4) The rate of decrease in resident old-growth species will be greater in islands that are more isolated than those that are not so isolated. Degree of isolation is determined by distance to the nearest species source pool, level of connectivity between the island and other old-growth forest, and the degree to which the habitat matrix within which the island occurs is distinct from old-growth. Islands existing in a matrix of similar habitat are not as functionally isolated as those existing in a highly dissimilar habitat type. 5) the number of resident old-growth species in a old-age stand regenerated in isolation from contiguous old-growth may increase as the stand progresses in age provided that a species source pool exists. But it is doubtful that regenerated stands will ever achieve the same species richness as comparable old-growth stands that derive from former old-growth forest. 6) It should be expected that certain resident old-growth species will die out and become locally extinct from any given habitat island. Not all species are equally probable to become extinct and the time until recolonization will depend upon the characteristics of the species in question as well as characteristics of the habitat island and its setting.

Important forest planning strategies emerge from these principles. However, there are many other factors to consider before meaningful forest management applications can be made. This paper is aimed at extending the principles so that they are even more applicable to old-growth conservation planning.

AN ISLAND ARCHIPELAGO APPROACH

To date, the greatest emphasis of applied island biogeography theory has centered on the dynamics of species within specific habitat islands. Properties such as the relation between island size and species richness, the rate of species loss, colonization rates, and the nature of surviving species versus those that typically go extinct have been highlighted. Applications of the theory rely heavily on the implicit premise that individual habitat islands can be chosen such that they will maintain viable biotic communities of natural integrity within their bounds. Many of the most endangered and difficult to manage species, however, exhibit such large home ranges and/or migratory habits as to invalidate the premise. In the cascades of western United States, the grizzly bear (Ursus horribilis), gray wolf (Canis lupus), cougar (Felis concolor), bobcat (Lynx rufus), lynx (Lynx canadensis), wolverine (Gulo luscus), fisher (Martes pennanti), marten (Martes americana), and spotted owl (Strix occidentalis) have home range sizes larger than single old-growth islands can reasonably be expected to encompass. Even though these are not obligate old-growth species, they are all carnivores and no doubt play active roles in the maintenance of integrity and biotic diversity in the natural old-growth islands. The hope of maintaining biotic diversity without considering the preservation of these top carnivores and their biological functions is short-sighted. It is more important to focus on a strategy that will maintain the native fauna and flora than a strategy that simply maintains or enhances species diversity.For this and several additional reasons I believe both the validity and utility of island biogeography applications to forest management can be enhanced by considering an entire system of habitat islands and the forest context in which it occurs. Specifically, some of the emphasis presently put on the internal functioning of the old-growth ecosystem might better be put on the system of old-growth islands. This will facililate the planning process and allow consideration of the full gamut of reasons for conserving old-growth in the first place.

An archipelago is an island system and by referring to the archipelago approach I hope to highlight the importance of the overall system as opposed to individual old-growth stands. Key characteristics of the old-growth island system include the number, average size, and size frequency distribution of islands, location of the islands in relation to one another (their dispersion) and in relation to topographic and other relevant landscape features, and the degree of interconnectedness between patches of old-growth and relevant species source pools. It would greatly facilitate the long-term planning process if these characteristics can be considered as constants rather than variables.

Long-Rotation Islands vs Old-Growth Islands

There are several reasons why forest planners should think in terms of a system of long-rotation management islands rather than individual old-growth islands. Even if we had a system of old-growth islands designated as preserves, numerous natural forces such as succession, fire, landslide, and insect outbreaks would work against these forest remnants persisting in perpetuity. It is essential that we think in terms of replacement stands that will serve the old-growth function 100 or 200 years in the future. It would facilitate long-term planning to know that replacement stands will occur in approximately the same location as existing old-growth islands. If the replacement stands are actually contiguous with existing old-growth, several other benefits will accrue. Old-growth stands that are either totally or partially surrounded by clearcut or regeneration planting will be climatically impacted around their exposed periphery. Wind penetration and attendant micro-climatic changes within these stands will necessitate that larger acreages be set aside in order to maintain the biotic integrity of the old-growth ecosystem. On the other hand, old-growth that is surrounded by mid- to mature-aged timber will be buffered against these peripheral climatic impacts. These buffer stands will therefore serve to increase the effective size of any old-growth stand that is surrounded by them. Buffer stands of mid-to mature-aged timber will also reduce the danger of wildfire from sources such as the burning of slash. Ensuring that replacement stands are contiguous with present old-growth will allow plant and animal species with limited dispersal ability to colonize the replacement stand as soon as habitat characteristics permit rather than at some uncertain time in the future when presence of colonizing individuals and appropriate habitat occur simultaneously.

Similarity between the vertebrate fauna of old-growth Douglas-fir (Pseudotsuga menziessii) and mature stands of Douglas-fir is about 97 percent whereas the faunal similarity between old-growth and young regeneration stands is less than 50 percent (Harris 1984). This means that for many resident old-growth vertebrates, the effective habitat island size may be increased by nearly as much as the acreage of buffer timber surrounding it.

Assuming that a limited amount of acreage will be committed to old-growth management areas, the total acreage can either be allocated to a large number of patches with a small average size or a small number of patches with a large average size or some combination in between. Surrounding old-growth islands with a long-rotation buffer zone effectively increases the size of each island and thus effectively increases the commitment to old-growth species conservation. One implication of this is that for any specified total acreage commitment a greater number of patches can be chosen. Specifics of long-rotation island cutting schedules can be found elsewhere (Harris 1984).

Island Size Frequency Distribution

Given that reference is to old-growth conservation areas in a managed forest landscape and not to parks and wildlife refuges, I believe the numerous advantages of an interconnected system consisting of many islands of modest average size far outweigh those of a system of fewer, less interconnected islands of larger average size (see Simberloff 1982, Harris 1984). It is important to bear in mind that in addition to average size, the old-growth patch size frequency distribution and dispersion about the mean (variance) are equally important characteristics.

Assuming a commitment of 20 percent of commercial forest acreage to long-rotation islands it is possible to ensure five percent in old-growth at any point in time (see Harris 1984 for details). Based on an average old-growth patch size of 122 acres and a log-normal size frequency distribution (many considerations favor it), it would be possible to designate about 500 old-growth patches in the Willamette National Forest of Western Oregon. Many old-growth islands of very considerable size could be included in the selection since the distribution would appear as follows:

Number	Ave. Size (acres)
400	62
50	185
25	370
10	620
5	990
5	1235

One great advantage to dealing with such a large number of old-growth patches is that the potentially competitive arguments favoring inclusion of any given patch can all be accomodated. For example, some can be included because of their location, others because they support endangered or endemic species, still others because of overall species richness etc.

Travel Corridors and Connectivity

If the archipelago of habitat islands is to function as a system, then movement of animals and plant propagules from one island to another should be facilitated. Travel corridors or "turkey trots" that consist of closed-canopy forest and provide a physical connection between islands are strongly recommended. Riparian strips, scenic roadside strips, ridge systems and "stringers" of old-growth or mature timber should all be considered. Riparian strips are critically important conservation areas in their own right. Thus, in addition to enhancing the biotic diversity of individual islands, connecting travel corridors may allow the entire conservation area system to support wide ranging species that cannot be contained or supported by any single habitat island. A prime criterion for choosing old-growth stands should be proximity to a riparian strip or comparable travel corridor that links the island to other islands, faunal preserves or wilderness areas.

FITTING THE SYSTEM TO THE LANDSCAPE

Resources are distributed throughout the landscape in identifiable and predictable patterns. Because of this, physiographic and topographic characteristics can be used as landscape "templates" for designing resource development and conservation strategies. In rugged terrain such as the Cascades the dendritic pattern appears to dominate. Erosion over millenia has caused the stream and river system to appear dendritic and this, in turn, governs much of related resource distribution such as anadromous fish and hardwood forests. Even the distribution of many terrestrial vertebrates (e.g. amphibians, aquatic birds, and mammals), the road network, and the distribution of resource users such as fishermen, hunters, and campers largely follow this same template. The presence or absence of a species may be more dependent on topographic position or aspect than on the age or condition of forest occurring there. Rather than designing the island archipelago system to function on a two-dimensional homogeneous plane it would be better to design it to function in this three-dimensional heterogeneous landscape.

While importance of solar energy processes is generally known, the importance of non-solar energy sources is generally disregarded. Nonetheless, anyone associated with the Mount St. Helens volcano or strong Oregon tides is aware of the more dramatic forms of non-solar energy. Equally functional non-solar energies are responsible for structuring landscapes. For example, when the kinetic energy deriving from 100 inches of rainfall per year is integrated over several millenia a highly structured landscape results. The potential energy associated with 100 inches of rainwater positioned at 5000 feet elevation is even more significant. These and related energy sources lead directly to the higher production and wildlife habitat value of certain ecosystem types. Riparian forest organisms that occur in valley bottoms not only have permanent access to water, but also have access to the organic and inorganic energies that are washed down from higher elevation sites. Lower elevation sites and benches that are rich in organic matter are recipients of energies collected from higher elevation sites. (i.e. the energy of carbon bonding in live plant foodstuff is well appreciated, energy of carbon bonding in "dead" organic matter should be considered in the same light.)

Combined energy sources and processes should be considered when designing a conservation area system. As presently structured, the large parks and wilderness areas generally occur on low productivity, high elevation sites. Due to their size, these areas have great potential as biotic diversity conservation areas. But the sites with greatest species richness and productivity occur at low elevations. This is also the zone where forest liquidation and short rotation plantation establishment has been the greatest. There is a major need for more old-growth set asides on low elevation sites.

When designing an ideal old-growth archipelago system, all of the above considerations should be brought together and integrated. An ideal system might consist of a large number of old-growth stands, each surrounded by a long-rotation management unit to increase effective island size. The old-growth islands might exhibit a log-normal size frequency distribution that is matched to the log-normal distribution of stream sizes. The fewer but larger old-growth islands could occur at lower elevations where species richness and productivity and the need for old-growth set-asides are greatest. The more numerous, but smaller old-growth islands could be positioned along the more numerous, but smaller-order streams occurring at higher elevations. These small and medium sized islands might serve as "stepping stone islands" for animals dispersing from the wilderness area system into the habitat island system. The entire system of habitat islands and parks and wilderness areas should be interconnected by travel corridors. The dendritic riparian strip system will serve this function best.

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