Analyzing Ecotones to Predict Biotic Productivity

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Abstract / A technique for predicting the potential biotic productivities of areas is presented. The simple method uses maps or other techniques of remote imagery in comparing adjacent terrestrial and/or littoral areas for investigations when ground reconnaissance is not feasible. The edge index, the statistical basis for comparison, is calculated as the ratio of the length of a particular ecotone (for example, timberline or shoreline) that would be affected by a proposed development to the affected land area. In similar habitats an unbiased comparison results at the ordinal level of measurement. The method predicts that a higher edge index will correspond to a higher productivity. But because it is not established whether or not the relationship is somehow scalar, the method is not recommended for comparing greatly dissimilar or far distant areas.

It has long been observed that ecotones (edges) where two biotic communities meet often produce more game than pure stands of either community. The reasons for this edge effect are reviewed. The demonstrably higher productivity of ecotones is partially explained in terms of the mechanisms that also account for diversity of species.

An attempt is made to reconcile theoretical treatments of species diversity with the pragmatic methods for reaching conclusions, which are employed by specialists in resource management.

Introduction

Practical resource managers, such as wildlife biologists and consulting ecologists, are frequently asked to evaluate the biological productivity of areas which, for a variety of reasons, cannot be visited. Limited time or insufficient personnel can make it impossible to visit all the areas that are candidates in a site-selection study. Considerations of confidentiality may restrict investigations to indirect means. In such situations the useful information obtained from a variety of remote imagery techniques permits evaluations to be made wholly objectively.

This paper describes a simple method for comparing adjacent areas of similar biotic composition to discover which is more likely to have greater productivity as a wildlife habitat, and by implication, greater value for outdoor recreation. These analyses are also useful in suggesting the best ameliorative treatment for a given sort of development.

To be practical, such a method must meet a number of criteria. One needs a comparative and predictive method that can provide qualitative data in siting studies and other studies that must be done quickly. Usually the evaluation of habitats from aerial photographs or other remote imagery cannot indicate conditions as well as the evaluation of a site by an experienced investigator. The method must be cheap, replicable, and immediately usable in any season. There should be little dispute over the valid use of the method. The method should be simple, requiring little equipment, calculation, or training of personnel. It should be applicable in a variety of ecological situations. And finally, it should be reputable, and acceptable to most practitioners of applied ecology. Consequently, the method must be based on well-established principles with the underlying statistics set forth clearly and unequivocally.

History and Theoretical Discussion

A biotic community is a group of plants and animals displaying some degree of interdependence. The community is broadly defined, but the central idea in the community concept is the interaction and mutual influence of populations of several species. The most inclusive communities are characterized as ecosystems, but the ecosystem unit is usually too large and complex to be manipulated in managing living resources. The practical manager attempts to identify communities at the level of complexity that best suits a particular purpose. As a result, many studies are performed qualitatively, and rely strongly on the judgment of the evaluator, because they do not require the costlier techniques of quantitative study. At the level of precision needed to reach judgmental evaluations, the most useful community ordinarily corresponds to the plant association or formation.
This is usually the least inclusive kind of community that can be recognized without quantitative study. Even though animals are essential members of a biotic community, communities are usually characterized by, and named for, their dominant plants. Often, the dominant plants in biotic communities share distinct life forms, as they do in marshes, grasslands, and evergreen forests. These life forms are sufficiently distinct to be distinguished easily on aerial photographs, and they are commonly mapped on topographic maps. In maps prepared by the United States Geological Survey, such characteristics of vegetation are indicated by green tones and patterns.

The edges of forests, and other ecotones, commonly have larger populations of game and other animals than do pure stands. The reasons for this edge effect (Leopold 1933) are complex and varied, depending on the situation. However, the larger variety of organisms in ecotones is undoubtedly a central reason for their productivity. An ecotone shares the characteristics of both communities that meet and intergrade there. In addition, there are plant and animal species that are better adapted to live in ecotones than in other communities. Part of the greater productivity of ecotones is associated with the mobility of animals. Because they can move about, animals are able to utilize the particular advantages offered by both abutting plant communities.

At the edge of a forest, where it meets a grassland, more light can penetrate into the forest from the side than from above. Consequently, the growth of plants near ground level is favored. In the depth of unbroken forest there is frequently very little ground cover and what exists is characterized by a very specialized, shade-tolerant nature. Because too little light penetrates for much of it to be fixed chemically by photosynthesis, the productivity in a dense forest is concentrated in the upper part of the canopy. In a grassland community, by contrast, photosynthesis carried on by the grasses is restricted to almost ground level. In the forest food production for herbivores is restricted to the high trees, and in the case of the grassland to the open area. For such terrestrial herbivores as deer, mobility across the ecotone provides protection in the woods from predators and weather, and access to food in the grassland. Moreover, because of microclimatic conditions, the ecotone may be the site of continuing successional change; early seral stages produce an abundance of browse.

Other animals may be more abundant in ecotones than elsewhere for quite different reasons. At the edge of a forest, song perches are available for ground-feeding birds, and hawking perches for those like flycatchers (Tyrannidae) that wait for insects.

There are many other potential reasons why ecotones should have a higher biotic productivity than pure stands of vegetation. Most of these are connected with the larger number of species nearby. In harsh climates or otherwise unfavorable environments, populations of single species often occur. In the arctic diversity is low because few species can survive. Nearer the equator there are fewer individual members of more species in progressively more favorable habitats. The same sort of ecological relationship has been demonstrated between mountaintops and sea level. A variety of indices of species diversity has been developed in recent years. Such species diversity indices have been used, not always justifiably, to indicate indirectly various conditions of biotic communities, especially disturbances.

It seems likely that edge effect is a result of interactions of organisms and interactions of communities. It seems, intuitively, that all edges display higher species diversity than the communities that meet at those ecotones but I know of no definitive evidence from field studies. Obviously, simply combining species lists will give larger lists for two communities than for individual ones. Evidence regarding mechanisms could be developed easily enough but it would be unsatisfactory to the degree that it was arbitrary.

Practically speaking, the reasons for the existence of edge effect are less important than the widely accepted view that edge effect does exist, and is empirically important in habitat manipulation. For example, producing edge by cutting openings in forests is a widely practiced technique to increase browse for white-tailed deer (Odocoileus virginianus).

It is not clear to what degree species diversity is associated with the greater productivity of ecotones, but the identification of ecotones has practical significance. This paper does not attempt to evaluate the several species diversity indices, nor to quantify considerations of species diversity in relation to edge effect. Rather, it describes a practical means by which measuring visible community edge can be used to help predict the effects of very destructive alterations of terrestrial biotas. The technique is based on the notion that overlapping communities are apt to increase the number of species—the diversity of the ecotone.

The Edge Index

The edge index is the calculated ratio between a measured length of community edge and the area af-