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A Review of Indicator Species for Monitoring Ecological Integrity

Navneet Vishnoi, Assistant Professor,
College of Computing Sciences and Information Technology, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India
Email Id- navneet.vishnoi@gmail.com

ABSTRACT: ***Designers examine at some of the most important factors to consider when choosing indicator species for a monitoring program aimed at preserving or restoring ecological integrity. First, we weigh the benefits and drawbacks of several management methods for use in conservation programs, concluding that ecosystem management is the best option. The next step is to find possible indicators of ecological integrity at different stages of the ecosystem, with a focus on species level indicators. Although the use of indicator species is controversial, we conclude that it can be beneficial if many species representing various taxa and life histories are included in the monitoring program, their selection is primarily based on a sound quantitative database from the focal region, and caution is used when interpreting their population trends to distinguish actual signals from variations t. Finally, we show and analyze the various approaches for selecting indicator species.***

KEYWORDS: ***Birds, Bogs, Conservation, Ecological Integrity, Ecosystem Management, Forest, Indicator Species.***

1. INTRODUCTION

Plant and animal species were assigned to certain "life zones" by Hall and Grinnell, who were among the first to utilize the indicator idea. Since then, the idea has advanced significantly, and it is now extensively used in a variety of circumstances, from verifying industry compliance with particular anti-pollution regulations to assessing habitat quality. In order to monitor the ecological integrity of watersheds, lakes, semi-natural pastures, rangelands, and forests, indicators have often been integrated into laws and regulations. Conservationists, land managers, and governments all benefit from indicators since they are a cost- and time-effective way to evaluate the effects of environmental disturbances on ecosystems[1]. Many of the important problems connected with the selection of indicator species in a monitoring program aimed at maintaining or restoring an ecosystem's ecological integrity are addressed in this article.

The ability of an ecosystem to sustain and maintain a balanced, integrated, adaptable community of organisms with a species composition, diversity, and functional organization equivalent to that of similar, undisturbed ecosystems in the area is referred to as ecological integrity[2]. Despite the fact that many articles have been written about the concept of indicator species, our goal is to compile information from a variety of sources, both supportive and critical, in order to reassess the concept and identify criteria for selecting an appropriate set of indicator species for the purpose of monitoring ecological integrity. To do this, we analyze and evaluate the issues that have previously been linked with indicator species, as well as the qualities that ideal indicators should possess. We also assess the various methods for selecting indicator species that have been

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suggested. To set the scene, we evaluate the benefits and drawbacks of various management methods when developing a conservation program[3].

Management Methodologies

Natural resource managers may choose from three kinds of management approaches: coarse-filter, fine-filter, and ecosystem management. Coarse filter methods attempt to conserve whole communities of plants and animals by conserving vast swaths of habitat and, in certain instances, by preserving the essential biological components and processes that keep them alive. The main assumption behind this method is that the status of each particular species is linked to the availability of suitable habitat. Because a species' abundance in a particular location isn't always linked with reproductive success and likelihood of persistence, there's a chance that certain conservation sites may serve as demographic sinks for at least some years, while other demographic sources will go unchecked[4]. Furthermore, although coarse-filter methods may accurately identify the habitat characteristics and processes needed for a group of species to exist in a landscape, they may fall short in determining the amount and configuration of those components [5]. Fine-filter methods concentrate on the preservation of a small number of components, believing that their condition in the ecosystem reflects the status of other elements in the ecosystem. The issue with this technique is not so much the method's application as it is its effectiveness in protecting non-target species. Vast animals, for example, may be excellent markers for species that need large, continuous tracts of habitat, but they may fail to preserve species like certain insects that thrive in a naturally fragmented environment, according to the study. As a result, if the majority of species are to be preserved, careful consideration must be given to the selection of an adequate collection of indicators for such methods to be effective. The majority of conservationists now acknowledge that components of both fine-filter and coarse-filter methods should be incorporated in conservation planning, based on the previous reasons. This has given rise to the concept of ecosystem management, which is defined as "management guided by explicit goals, carried out through policies, protocols, and practices, and sustained through monitoring and research based on our best understanding of the ecological interactions and processes required to maintain ecosystem composition, structure, and function." stated that "the ambiguity of the word [ecosystem management] guarantees that individuals can make it anything they want," a condition that they acknowledge may be rectified if clear objectives are set. The five most often stated objectives of ecosystem management have been identified after a study of the concept[6]:

- Protect representative examples of all native ecosystem types throughout their natural range of diversity
- Maintain evolutionary and ecological processes
- Manage landscapes and species in a way that allows them to respond to both short- and long-term environmental change.
- Work within these limitations to accommodate human activities.

Numerous terminologies have been suggested to characterize the status of a managed ecosystem, i.e. to assess whether the sustainability objectives have been met. The most often mentioned factors have been ecological integrity and ecosystem health[7]. For most of us, these words may seem

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interchangeable, and they are in many publications since they refer to the same objective. The connotations of each word, on the other hand, are fundamentally different. suggested using the ecosystem health metaphor to promote sustainable development and improve the general public's knowledge of ecosystem functioning. 'Commonly observed ecosystem characteristics such as disintegration under stress... indicates that [the idea] has merit as a heuristic instrument,' they claim. Authors like as have, on the other hand, questioned the usage of this metaphor. They argued that ecosystems cannot be compared to organisms because:

- each ecosystem has a unique set of structural and compositional characteristics shaped by a combination of deterministic and probabilistic processes specific to its region
- They lack a unique undisturbed endpoint naturally maintained by homeostatic processes. These writers prefer the words quality or sustainability because they are less open to interpretation and also because they tacitly acknowledge that people are a component of ecosystems, making them simpler to accept by different interest groups.

Indicators to be used because managers can't monitor everything that may be of interest in an ecosystem, deciding what to measure is crucial. This is one of the most difficult and contentious steps in creating a monitoring program. Some or all of the following qualities may be found in useful indicators:

- Provide early notification of natural reactions to environmental changes.
- Rather of merely stating the presence of change, directly state the reason of the change.
- offer continuous evaluation over a broad variety of stress levels and intensities. This enables for the detection of a variety of ecological effects, as well as the assurance that an indicator will not bottom out or level out at specific thresholds.
- Can be properly assessed by all employees engaged in the monitoring and are cost-effective to measure.
- Ecological integrity indicators may be found at various levels of organization, including species, stands, landscapes, and ecosystems[8]. An indicator is an element, activity, or characteristic of the environment that cannot be accessed directly for whatever reason (logistical, budgetary, technical) regardless of the level at which it is chosen:

At the species level, a broad range of possible indicators were proposed:

- Keystone species: species that have significant interactions with other species and have enormous impacts in comparison to their abundance.
- area-limited 'Umbrella' species are those that need vast expanses of appropriate habitat to sustain healthy populations and are thought to contain the needs of a wide range of related species. These species' home ranges are typically very vast.
- Dispersal-restricted species: species with a limited capacity to migrate from patch to patch or who face a significant danger of death if they do so.
- Species with restricted resources: species that need particular resources that are in short supply either temporally or geographically. Snags, nectar supplies, fruits, and other resources are examples of these resources.

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- Process-limited species are those that are sensitive to the intensity, pace, geographical features, or timing of certain ecological processes such as fire, flood, grazing, alien species competition, or predation.

Connected Problems with Indicator Species

When utilizing indicator species, two assumptions are often made:

- Species richness of the indicator taxon is linked to the number of species in other less well-known taxa across vast regions.
- The presence of rare or endangered species is linked to a high species richness or habitat diversity.

They found no evidence to support either hypothesis. It seems that spatial autocorrelation in taxonomic species richness is scale-dependent: it is easily visible at the global scale but more difficult to discern at smaller sizes. Other research also contradicted the original hypothesis. Butterflies, for example, were shown to be excellent markers of anthropogenic-induced vegetation heterogeneity but poor indicators of plant species richness. Despite some general parallels in diversity across taxa, bird species turnover rates were not always consistent with those found in ants and vascular plants, according to the study. The use of vascular plants as markers of bird species richness was shown to be unreliable. They hypothesized that the diversity and occurrence of particular bird species may be more strongly influenced by meso-scale habitat features than those of plants, which are more closely connected to local circumstances[9].

Which Animals Should We Pick?

Plants, insects, benthic invertebrates, butterflies, amphibians, fishes, birds, and mammals have all been utilized or proposed as indicator species in the past. Each research makes a case for each taxon's appropriateness as a possible indicator. Mention how many studies have shown that invertebrates in general are good markers of ecological health. Environmental variables such as competition, predation, and parasitism are usually more strongly linked with their existence than biological factors such as competitiveness, predation, and parasitism. Invertebrates and plants should be used with care as indicators since they primarily respond to disturbances at small spatial scales and therefore may be insufficient indicators for species that primarily respond to larger-scale disturbances. Larger creatures, however, may be poor markers of species that primarily respond to fine-scale changes. noted that the lack of overlap between the two groups may be due to variations in population growth rates, generation time, and habitat specialization, which could also explain the observed heterogeneity in the time needed for each group to respond to disturbance. Birds have been proven to react to environmental changes across a wide range of geographical scales, thus they may serve as a link between these two groups. They're also great for monitoring since they're so little[10].

- They use vocalizations to announce their existence, making them reasonably simple to discover and identify.
- they can be effectively sanctioned at broad geographical scales, and

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- The type and layout of adjacent ecosystems have been found to affect their occurrence, abundance, and reproductive success.

2. DISCUSSION

The suitability of ecosystem management as a conceptual framework seems to be widely agreed upon among natural resource managers and conservation biologists. Because it is difficult to quantify everything that might be relevant within an ecosystem, indicators can be used to minimize the number of components that must be examined and monitored in order to establish whether resource harvesting is done sustainably. The validity of indicators at higher levels is debated less than that of indicators at the species level. In order to explain the problems at hand, we concentrated on the latter. We discovered two major objections to the use of indicator species. First, no one species can be expected to serve as an indicator for a whole ecosystem since no two species occupy the same niche. As previously stated, this does not rule out the idea of indicator species entirely. Rather, it means that many species representing various taxa and susceptibility to various perturbations should be observed in order to more accurately identify the sources of change and minimize interpretation mistakes. The second reason is that numerous variables unrelated to the loss of ecological integrity may influence the population status of an indicator species, making population trends more difficult to detect and understand. This argument does not rule out the use of indicator species, but it does suggest that changes in their demographic characteristics and distribution be interpreted with care. As a result, if management recommendations are to be made based on changes in the status of indicator species, it is critical to have a thorough understanding of possible causative variables unrelated to ecological integrity deterioration. Finally, we stated that when choosing prospective indicator species for a focus area, quantitative criteria are preferred above qualitative ones. Using a database from the focus area guarantees that possible indicator species are chosen based on local ecological circumstances rather than their perceived significance. If qualitative criteria are utilized, they should be used in conjunction with a set of quantitative criteria.

3. CONCLUSION

The purpose of this article was not to come up with the ideal technique for determining ecological integrity. Individually, each of the techniques described in this article will fall short of providing a comprehensive evaluation of an ecosystem's ecological integrity. Because defining what constitutes an ecosystem with a high degree of integrity is subjective, it seems doubtful that any technique will enable such a claim to be made anytime soon. However, we think we have created a strong framework for using indicator species that will, at the very least, offer insight into whether ecological integrity is growing or deteriorating within the ecosystem. Managers may enhance their capacity to understand the reactions of indicator species to changes in their environment by connecting the responses of indicators across levels by monitoring indicators at other levels of the organization at the same time. A conservation program that takes into account the problems raised in this article should provide valuable information for managing natural resources and determining desirable ecological integrity levels.

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