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Review

Evaluating the conceptual tools for forest biodiversity conservation and their implementation in the U.S.

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Abstract

While much has been written describing biodiversity, its global decline, and the need for action, the scientific underpinnings guiding conservation practice have received little attention. We surveyed 10 large-scale forest management plans in the U.S. to establish which ecological concepts are commonly used to guide forest biodiversity conservation and evaluate the relative importance of these concepts in processes related to forest stewardship. We then reviewed the scientific literature to assess the degree to which these concepts are founded in antecedent ecological theory, the extent to which they have been tested, and the limits of those tests. We found that the concepts of filters (fine, meso, and coarse), reserves, matrix management, hotspots, emulating natural disturbances, diversity begets diversity, patchworks, networks, and gradients are extensively employed in the forest planning efforts we surveyed. While most of these concepts received high utility scores, coarse filter was most commonly used, closely followed by matrix management and fine filter. A survey of the literature review suggests that all concepts have both direct and indirect relationships with foundational ecological theories, such as niches, natural selection, and island biogeography. All concepts also have some empirical support based on field tests and most have received some testing in an experimental framework. Yet, experimental tests of the concepts are far from comprehensive as, among other reasons: (1) many species are yet unknown, (2) many species are difficult to measure, (3) the occurrence of taxa that are often measured do not correspond well with the occurrence of those less frequently measured, and (4) although site conditions may be replicated, the historical and landscape contexts of each test are unique. Although we document wide use of these concepts, significant constraints hinder further incorporation into forest stewardship. Predominant among these is a lack of empirical support at the spatial and temporal scales over which forest management is implemented. Practical ways to advance conservation concepts include implementing effective, efficient monitoring protocols and establishing experimental tests in an operational context. Constructive bridges must be built between science and practitioner communities to realize these goals.

Keywords: Conservation biology; Forest planning; Forest management; Reserves; Matrix management; Operational experiments

Contents

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1. Introduction

Because forest planners and managers must often make decisions with less than complete information, assumptions founded on concepts are often substituted for empirical data as a basis for action. Although a growing body of literature is being developed to assist the transition between scientific theory and its application (Shrader-Frachette and McCoy, 1993; Noss and Cooperrider, 1994; Czech and Krausman, 2001; Lindenmayer and Franklin, 2002; Groves, 2003), substantial concern remains as to whether the conceptual basis for biodiversity conservation has received sufficient testing to be recommended for wide application (Simberloff, 1995, 2001). In particular, few efforts have specifically evaluated the practical utility and scientific support of the suite of conceptual tools available for biodiversity conservation (Doak and Mills, 1994; Prendergast et al., 1999). We begin to fill this knowledge gap by asking: what conservation concepts are commonly being used in forest management planning efforts? To what extent are they founded on ecological theory? What is the empirical support for these concepts? And, how can they be advanced in both strength and utility?

Several in-depth works have been published that address the development of scientific theory in ecology and conservation biology (Peters, 1999; Shrader-Frachette and McCoy, 1993; Pickett et al., 1994; Ford, 2000). Our goal is to evaluate scientific concepts that guide the conservation of forest biodiversity in forest planning and management settings. We achieve this goal by evaluating 10 large-scale forest management plans and through literature synthesis. Although a multitude of forest plans could be considered, we limited our analysis to those from the continental United States. The plans we reviewed represent a variety of geographic regions, ecological systems, scales, and organizations involved in forest stewardship. We then reviewed the literature to evaluate the degree to which these concepts are founded in antecedent scientific theory, the degree to which they have been tested, and the limits of those tests. Based on our analysis, we provide recommendations for how future efforts may enhance both conservation science and its practice.

2. Conservation concepts

Conservation concepts are important to forest scientists and managers in that they provide: (1) a scientific basis for predicting species response to conditions for which no data exist (e.g., locations, scales, management actions), including projecting to the future (Miller et al., 2004), (2) benchmarks for evaluating the outcome of management actions (MacNally et al., 2002), and (3) a creative framework for developing alternative management actions (Palik et al., 1997). We identified 11 concepts that we expected to have some relevance to forest planning and management, including reserves, matrix management, coarse filter, mesofilter, fine filter, hotspots, diversity begets diversity, emulating natural disturbances, patchworks, networks, and gradients. We chose not to include ecosystem management because of its breadth, which includes socioeconomic perspectives, and its overlap with several of the other concepts. We additionally solicited conservation practitioners for other relevant concepts through interviews; redundancy, population viability, and flagship species were mentioned by single practitioners. Though a standard conservation tool, we chose not to address population viability analysis because we considered it a component of the fine filter approach. Similarly, flagship species was not included because it is founded in social dimensions of natural resource management rather than ecological dimensions. For these reason and because most interviewed practitioners indicated that our list was comprehensive for the concepts they utilized, we did not expand our analysis beyond the 11 initial concepts.

Our definitions and descriptions for these concepts follow. We also provide key references that discuss the concepts more fully, although they are not necessarily the originators of the concepts:

- *Coarse filter.* Coarse filter assesses the conservation value of broad-scale ecosystems and landscapes throughout a bioregion (Noss, 1987; Hunter, 1991). The concept suggests that systematic protection of representative ecosystems should conserve the vast majority of species within that bioregion without the necessity of considering each species individually.
- *Mesofilter.* Mesofilter lies conceptually between coarse filter and fine filter; its core idea is that by protecting key habitat elements that have exceptional benefit to species but are too small to set aside in separate reserves, many species will be protected without the necessity of considering them individually (Hunter, 2005). Examples of the mesofilter concept in action include conserving logs and snags, riparian zones, vernal pools, seeps, rock outcrops, and hedgerows.
- *Fine filter.* Fine filter conservation deals with individual species directly that are assumed to be inadequately protected by coarse filter conservation, typically uncommon species or those jeopardized by over-exploitation (Noss, 1987). Species conservation is achieved by either protecting populations from over-harvest or other direct, negative impact, or by conserving their habitat.
- *Hotspots.* With hotspots, preservation is achieved by identifying and protecting locations of high species richness, especially of endemic species, that are threatened by human