Scaling Up From Stands to Landscapes

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ABSTRACT

Stand-level experiments are critical to understanding the effects of innovative silvicultural practices on biological diversity. However, stand-level information is not sufficient to understand how management practices influence ecological, economic, or social outputs and outcomes. Landscape and regional studies are also needed, but experimental approaches are difficult to impossible at broad spatial scales. Consequently, other research approaches are needed at this scale, including modeling, retrospective studies, and monitoring of natural experiments. In this paper I examine some lessons learned from landscape-scale modeling studies that incorporate stand-level information. In particular, I focus on what we have learned from the Coastal Landscape Analysis and Modeling Study (CLAMS) as it pertains to estimating the effects of different forest management practices on biological diversity and timber production across landscapes. The simulations indicate that ecological effects of stand-level practices at landscape scales are influenced by (1) area of treatment as proportion of total area; (2) environmental variation; (3) diversity of initial biotic conditions (including vegetation and animals); (4) species and ecosystem processes; (5) dispersal effects (6) rate of change and time frame of analysis; (7) stochastic processes, e.g., disturbance; and (8) management practices and patterns. Large multi-owner landscapes, where many of the above influences are important, pose significant technical and institutional challenges to implementing new approaches to balancing ecosystem values. Significant advances can be made if we can do a better job of coordinating and integrating different research approaches to address sustainability questions that span multiple spatial and temporal scales.

KEYWORDS: Forest biodiversity, multi-ownership landscapes, spatial simulation models, Pacific Northwest.

INTRODUCTION

Issues of forest sustainability are inherently issues of scale (Spies and Johnson 2003). Forest structure and composition vary over a wide range of spatial and temporal scales. Likewise, forest goods and services vary with scale and with objectives and values of different forest owners. Many gaps in our understanding of sustainability problems have risen from the changing priorities of society for goods and services from forests. For example, the biodiversity and recreation values of forests have increased worldwide. Experimental approaches can be used to identify the most effective management practices to meet the new goals; however, classic experiments are difficult or impossible to implement at broad scales, where many ecological and social processes operate (fig. 1). Consequently, other scientific approaches such as historical studies, long-term monitoring, and simulation modeling are needed to address the multi-scale nature of forest sustainability problems.

Over the last several years, the Coastal Landscape Analysis and Modeling Study (CLAMS) conducted research on scaling problems and policy effects in the Oregon Coast Range (Spies et al. 2002) (see also www.fsl.orst.edu/clams). Based on this experience, I will briefly identify several influences that must be considered when scaling up stand-level information to landscape and regional scales.

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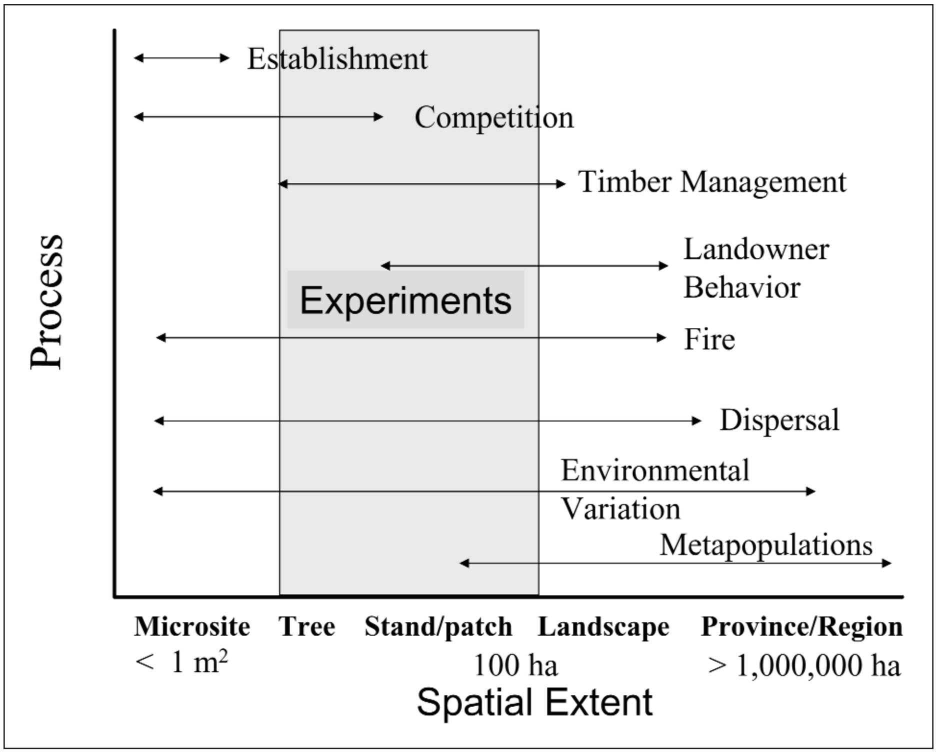

Figure 1—Spatial extent of management and natural processes and typical spatial extent of manipulative field experiments.

INFLUENCES ON EFFECTS OF STAND-LEVEL PROCESSES AT LANDSCAPE SCALES

The following factors influence how stand-level processes and patterns affect processes and patterns at broader scales.

1. **Area of treatment as proportion of total area.** It is easy to forget that the landscape-scale effects of stand manipulations depend on the total area treated. For example, thinning thousands of hectares of young stands on federal lands in the Coast Range may sound like a lot, but when those hectares are a part of a 2.5 million hectare province, the effects of the treatments on habitat can be small at the scale of the province.

2. **Environmental variation.** Reactions of forest vegetation to human and natural disturbances will vary with site productivity, climate zone and topography (Wimberly and Spies 2001a). Most experimental studies can only capture a small portion of the environmental variability that occurs within a region. Consequently, one must exercise caution when extrapolating results to large, diverse landscapes and regions.

3. **Initial biotic conditions.** The response of plants and animals to silvicultural manipulations will depend on the organisms that are present on the site at the time of the treatment. Extrapolating treatment effects to large scales must take into account the diversity of stand conditions. New models such as Gradient Nearest Neighbor (Ohmann and Gregory 2002) that use remote sensing and geographic information systems provide a good way of retaining and spatially distributing the variation in vegetation that is found in a landscape.

4. **Variation in responses of species and ecosystems.** Again, it may seem obvious that not all species will respond to management practices and forest structure in the same way (Johnson and O'Neil 2001). However, this fundamental truth is often forgotten in debates about forest management impacts.

5. **Dispersal effects.** Most of the effects I have mentioned so far are simply additive effects—if one knows the areas of treatment and the species involved, it is possible to estimate effects with some certainty. In other words, knowledge of spatial arrangement of vegetation at landscape scales is not needed. When it comes to plant

establishment and animal colonization, however, it is important to know the landscape pattern of seed sources or source populations around a particular site. The patterns of seed sources in a landscape can affect the pattern of forest development even for such common species as western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) (Wimberly and Spies 2001b).

6. **Rate of change and time frame of analysis.** Most of our long-term studies of ecosystems are less than 25 years old, and few forestry and agricultural long-term studies are more than 100 years old. Ecologists are well aware that early responses to experimental treatments may change with time. New species may colonize a site and competitive interactions may cause some species to drop out and others to assume dominance. These patterns can take decades and centuries to play out. In the case of thinning to accelerate the development of old-growth forest structure, changes may take more than a century to appear (Garman et al. 2003).

7. **Stochastic processes.** Although growth patterns and species compositional changes resulting from physiological and competitive processes may be relatively easy to predict during stand development, it is far more difficult to predict disturbances or climate changes that can totally alter the course of development of a forest stand or landscape. We can try to estimate the probability of fire, insects, disease, and wind, but ultimately we really can not predict when and where these disturbances will occur. At landscape scales, these types of dynamics must be handled using probabilistic models and scenario analysis that identify alternative pathways.

8. **Management practices and patterns.** Multi-ownership landscapes pose special challenges for scaling up the effects of forest management. Management goals (Spies et al. 2002) and practices can differ widely among landowners. Policies and plans that owners operate under may look very different when implemented on the ground than they do on paper. Policy changes can occur for economic and political reasons that are impossible to predict. The effects of management practices may be a result of interactions between environment and forest conditions. Biophysical information needed to estimate management effects is typically not available in a uniform way in multi-ownership landscapes. Finally, simulation models that can integrate stand and landscape processes across large forests are only in the early stages of development.

CONCLUSION

Scaling up from stands to landscapes and regions is not easy to do. Yet, we must undertake this task to more fully understand how forest management practices affect biodiversity and other values. The variety of influences on the expression of stand-level process and patterns at broad spatial and temporal scales argues strongly for using multiple research approaches to fill critical information gaps. Too often research approaches such as stand-level experiments, retrospective studies, and landscape simulation models are not carried out in a coordinated fashion. Information from one type of approach cannot be readily linked to another. This reduces the effectiveness of our efforts to understand how human activities influence species and ecosystems. Significant advances can be made if we can do a better job of coordinating and integrating different research approaches to address sustainability questions that span multiple spatial and temporal scales.

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