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Review

Spatial forest planning: A review

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Abstract

This paper is a comprehensive review of spatial forest-planning initiative that has been carried out in forest-management planning over the last 2 decades. It describes, first of all, the conceptual framework of spatial forest planning by identifying spatial and non-spatial forest-planning concepts. The paper focuses on the spatial considerations or problems of spatial configuration of patches including their size (opening size) and distribution, shape, adjacency or green-up delay, connectivity, proximity, and core area that make the conventional forest-management planning "spatial" powered by geographical information systems (GIS). Then, the paper explains various management approaches to conceptualize the spatial forest planning and analytical decision-making techniques, such as simulation, mathematical optimization and meta-heuristic techniques to solve the spatial forest management problem. It also provides information to measure the performance of various meta-heuristic techniques, when solving large-scale spatial problems. Also, some apparent new requirements, important needs for spatial forest planning, and important unresolved problems in spatial forest planning are identified. In conclusion, development of a hybrid-modeling technique, identification of target landscape structure, characterization of various forest values, such as biodiversity, water production, recreation, visual quality, erosion control, and an enthusiasm to implement the approach are identified important future development to spatial forest modeling.

Keywords: Forest management; Spatial planning; Modeling techniques; GIS; Spatial forest structure

Contents

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1. Introduction

Over the last few decades, environmental and public concerns about the impacts of forest-management operations on water pollution, erosion, landscape aesthetics, and biodiversity have been increasingly expanding. As a result, societies are faced with complex ecosystem management problems due to competing and complementary social values, and interactions between the social values and timber-production returns. Since ecological and environmental considerations are important for both, society and individual forest-owners or decision makers, there is an increasing need to analyze the development of spatial structure of forests and to develop means by which spatial objectives can be explicitly included in forest planning. Without tracking spatial detail, it is impossible to maintain a number of environmental and ecological conditions like maintaining biological diversity, limiting sediment loading in streams, limiting habitat disruption in an area, preventing a viewshed from being impacted too heavily, ensuring that open forage areas are provided for certain animals (Church et al., 1998; Baskent, 2001; Kurttila, 2001; Malchow-Moller et al., 2004).

Different management activities in any given planning unit may often influence adjacent units. For example, the clearcutting activity of one stand or harvest unit may expose a neighboring stand or stands to wind damage, bark injuries, drainage problems, and site class deterioration (Snyder and ReVelle, 1996; Tarp and Helles, 1997; Malchow-Moller et al., 2004). Furthermore, various types of damages or spatially uncontrolled management implementations result in decreased wood quality, habitat disruption, water pollution, increasing sediment quantities. For these reasons, spatial constraints are often imposed upon harvesting activities on adjacent forest stands or harvest units.

Importance of spatial harvest scheduling or planning has increased in recent years due to a number of factors. These factors include the recognition of the potential savings, when simultaneously scheduling harvesting operations and transportation projects, the realization of the importance of shape and arrangement of wildlife habitat, and the evaluation of the spatial effects of forest management on the output (Boston and Bettinger, 1999). Furthermore, spatial concerns arise immediately, when considering the management of stream-side riparian zones or scenic road corridors, the management of vegetative corridors through which migrating wildlife pass (Weintraub and Bare, 1996), national policies and international negotiations or certification.

Increasing pressure to meet various ecological and environmental goals, such as reducing the fragmentation of old forest, maintaining uncut borders around key habitats and creating corridors between valuable habitats (Öhman, 2001), evaluation of different management options for financial analysis, and examining the patterns and trends in the spatial development of forest ecosystems have stimulated interest in spatially evaluating different harvest strategies. In addition, the spatial pattern of forest-management activities must be integrated with temporal-management decisions, since together these decisions can greatly impact the quality and quantity of other resource uses of a national forest (Snyder and ReVelle, 1997). Consequently, socioeconomic and environmental or ecological goals often dictate its dispersion in time and space. Mea-