ELSEVIER

Ecological Modelling 127 (2000) 269–281

ECOLOGICAL MODELLING

www.elsevier.com/locate/ecolmodel

A target-oriented approach to forest ecosystem design — changing the rules of forest planning

Guoliang Liu [a,*], John D. Nelson [b], Chad W. Wardman [a]

[a] *Hugh Hamilton Limited, 850 West 15th Street, North Vancouver, BC, Canada V7P 1M6*

[b] *Faculty of Forestry, University of British Columbia, 2424 Main Mall, Vancouver, BC, Canada V6T 1Z4*

Accepted 19 October 1999

Abstract

This paper introduces several concepts which underlie the development of a spatially and temporally explicit forest ecosystem design model, forest simulation optimization system (FSOS). These concepts include: (1) two common landscape indicators — patch size and age class distributions — to quantify non-timber resource objectives; (2) dynamic cut block and patch building; (3) the integration of short- and long-term planning; and (4) target-oriented, adaptive forest ecosystem planning. FSOS uses a simulated annealing algorithm and a resource weighting approach to schedule harvest units to achieve a desired forest ecosystem state. We tested FSOS successfully on the data set from an 80 000 ha Tree Farm Licence in southwestern, British Columbia, Canada. Results of this analysis demonstrate the ability of FSOS to gradually change the landscape based on a desired future condition and differing resource priority schemes. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Adaptive management; Ecosystem planning; Forest harvest scheduling; Landscape design; Optimization; Simulated annealing; Target-oriented

1. Introduction

Forest conditions vary greatly, both spatially and temporally. Dispersed small patches and evenly distributed age classes may characterize one landscape while another may have large aggregated patches with unevenly distributed age classes. Forest management activities such as harvesting and other silvicultural treatments greatly affect forest landscape patterns. Forest planners and modelers have been searching for appropriate tools to modify landscapes to achieve and maintain desired forest conditions in complex ecosystems with conflicting resource objectives (Wardoyo and Jordan, 1996). Regardless of initial forest conditions or the complexity of resource interactions, a comprehensive approach is required which can modify the landscape from the current condition to the desired state.

Traditionally, forest management decision making tools have applied a set of 'rules' or 'constraints' to control harvest levels and spatial

* Corresponding author. Tel.: + 1-604-980-5061; fax: + 1-604-986-0361.

E-mail address: guoliang@hugh-hamilton.com (G. Liu)

0304-3800/00/$ - see front matter
PII: S0304-3800(99)00217-3

arrangements (O'Hara et al., 1989; Nelson and Finn, 1991; Nelson and Errico, 1993). With these approaches, a few repeatable solutions are produced by focusing on forest ecosystem modification processes. Researchers have begun to use other approaches which focus on achieving the desired forest ecosystem condition. This requires a more adaptive approach to forest ecosystem planning (Diaz and Bell, 1996; Wardoyo and Jordan, 1996; Crow and Gustafson, 1997); an approach which can incorporate spatial management strategies, set target levels to be achieved and maintained over time and measure the response of the forest to the management activities. This proactive approach is generally called 'adaptive' or 'target-oriented' ecosystem management.

The forest simulation optimization system (FSOS) is a landscape level forest ecosystem design tool which is designed to block and schedule forest treatments simultaneously under conflicting resources (e.g. biodiversity, habitat, water quality, visual quality, old-growth, etc.), incorporate tradeoffs between periods and resources, and derive forest ecological management solutions. Four main concepts underlie FSOS and give the model the required power and flexibility to address complex forest planning issues:

1. Patch and age class indicators — we have found that most non-timber objectives can be modelled using patch and age class distribution indicators as simple surrogates for ecosystem health and non-timber values.
2. Dynamic cut block and patch building — small resultant polygons are the basic model units, which can be combined to build blocks and patches.
3. Integrating short- and long-term planning scales — incorporating strategic and operational planning into one process strengthens the linkage between short- and long-term objectives and reduces planning costs.
4. Target-oriented approach — targets allow the user to achieve and maintain objectives through time and allow trade-offs over time and space, and between resources

The two main objectives of this paper are to: (1) demonstrate how these concepts are incorporated into a target-oriented forest ecosystem design model; and (2) show a practical application of these concepts with FSOS.

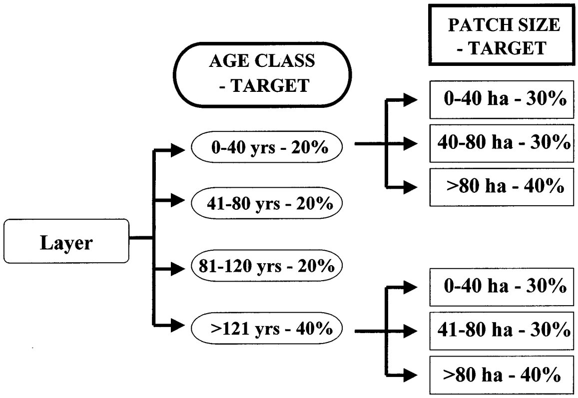

Fig. 1. Hierarchy of polygons, harvest units, openings and patches within the landscape.

2. Understanding the concepts

2.1. Patch and age class landscape indicators

Examples of non-timber forest ecosystem values include biodiversity, visual quality, and water quality and wildlife habitat. In order to quantify the response of these resource values to various spatial/temporal harvest configurations, common indicators are required to evaluate each resource and compare results between resources. Age class structure and patch size distributions are used to represent these values. Because it is the distribution of patch size within different age classes that creates biological and structural diversity at the landscape level (Ministry of Forests, 1995, 1998), it is essential that ecosystem management tools integrate patch and age class management strategies. Fig. 1 shows how this can be achieved by specifying the desired patch size distribution within each age class.

The desired forest conditions at the landscape level can be described by: (1) how much area in each age class in each resource layer; (2) how to distribute the stands of each age class (i.e. what patch distribution to create) in the resource layer; and (3) how long to maintain them.