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Application of texture mapping to generate and communicate the visual impacts of partial retention systems in boreal forests

M. Meitner *, R. Gandy, J. Nelson

Department of Forest Resources Management, Forest Sciences Centre, 2045-2424 Main Mall, University of British Columbia, Vancouver, BC, Canada V6T 1Z4

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Abstract

In this paper we describe the simulation and visualization of harvests over a 40 year period using large harvest units with a variable retention system where the amount and pattern of residual stems within the units is varied. We introduce the concept of texture mapping to control the spatial and temporal management of multiple stand strata within the bounds of a polygonal forest stand allowing for increased automation and flexibility of the visualization process without the need to modify the underlying data structure. This technique is demonstrated in a case study in north eastern British Columbia to show how the results can be used to address social concerns about large harvest units used in emulating natural disturbances. Our objective is to present a relatively fast and effective way to generate and communicate the visual impacts of complex harvesting patterns.
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1. Introduction

Sustainable forest management is based on maintaining environmental, social and economic values. Maintaining biodiversity is an important environmental criterion within sustainable forest management and one strategy for maintaining biodiversity is to plan harvests so that they mimic patterns of natural disturbances (Attiwill, 1994; Hunter, 1999). However, this may result in large harvest openings which conflicts with social values, especially visual impacts. Boreal forests are a case in point where fire is the most predominant stand-replacing disturbance agent (Johnson, 1992; Kurz and Apps, 1994). If harvests are to mimic fire disturbances, the size of harvest units needs to approximate the distribution of historic fire size and the pattern and quantity of residual forest left within these harvest units needs to approximate that found within naturally burned forests. This pattern can be created by retaining patches of forest or specific trees within a clearcut harvest unit using a method referred to as a variable retention silviculture system (Franklin et al., 1997).

Numerous methods of implementing variable retention in boreal mixedwood forests have been proposed for use in emulating patterns of natural disturbance (Lieffers and Beck, 1994; Lieffers et al., 1996; Bergeron and Harvey, 1997) but in all cases this requires significantly larger harvest units than those that have been used in the past. For example, DeLong (1998) described natural disturbance units for north eastern British Columbia that have patch size distributions that extend into tens of thousands of hectares. Forest management is intended to mimic the more frequent patch sizes within these distributions that range from hundreds to thousands of hectares. The very large (e.g. catastrophic fires) and very small (e.g. endemic windthrow) patch sizes within these distributions will likely occur naturally and need not be emulated by forest management.

Large harvest units have obvious economic benefits because operations can be concentrated, thus reducing moving and set-up costs as well as minimizing the total length of active road required. Concentrated harvests and fewer active roads provide environmental benefits such as fewer stream crossings, less sedimentation from roads, greater snag abundance and less fragmentation of habitat (DeLong et al., 2004; Seely et al., 2004). Concentrating harvests also allows other compartments in the forest to be closed for extended periods, providing better access control to portions of the forest where continuous human

* Corresponding author. Tel.: +1 604 822 0029; fax: +1 604 822 9106.
E-mail address: Mike.Meitner@ubc.ca (M. Meitner).

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presence is undesirable (e.g. Grizzly bear habitat). The conundrum for managers is that, while it is ecologically and economically desirable to mimic natural disturbances with large harvest units, this strategy is generally unpopular with many stakeholders and the public (Bradshaw, 1992; Daniel, 2001; McRae et al., 2001). If mimicking natural disturbances is to be an effective sustainable forest management strategy, then these social concerns must be addressed. This may prove easier than first imagined, as recent evidence suggests that the public is willing to accept larger, more aggregated harvest blocks relative to the status quo, especially if provided with information that stresses the benefits of that approach (Meitner et al., 2005a).

In this paper we describe the simulation and visualization of harvests over a 40 year period using large harvest units with a variable retention system where the amount and pattern of residual stems within the units is varied. We introduce the concept of texture mapping to control the placement of vegetation within the harvest units, which allows for the visualization of variable retention without the need to modify the underlying data structure. We use a case study in north eastern British Columbia to illustrate the application of the method and how the results can be used to address social concerns about large harvest units used in emulating natural disturbances. Our objective is to present a relatively fast and effective way to generate and communicate the visual impacts of complex harvesting patterns.

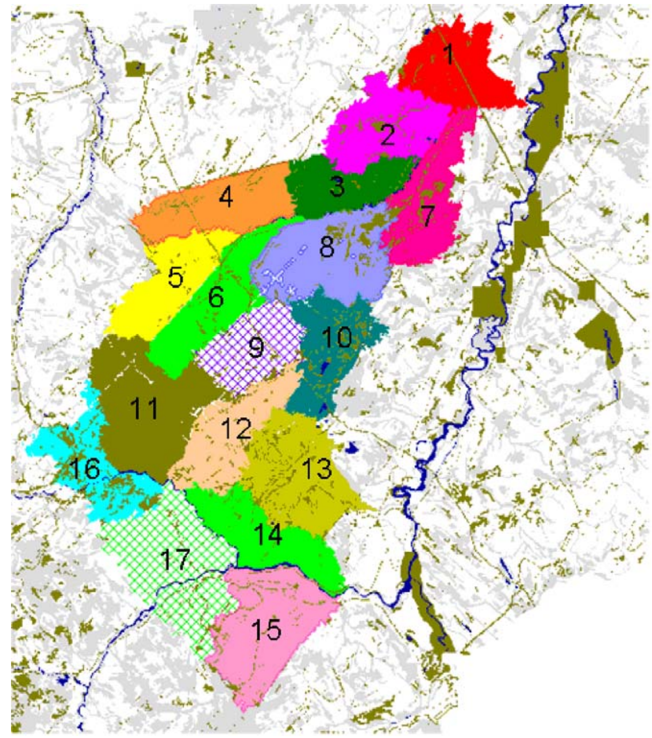

Fig. 1. Map showing the 17 harvest units designed for the Highhat Valley. Total area covered by the harvest units is approximately 36,000 ha.

2. Methods

We first describe the harvest schedule modeling, along with the study site and the procedures used to design the harvest units. We then describe the visualization modeling with a focus on the texture mapping procedures.

2.1. Harvest scheduling

Our study site is the Highhat Valley located within Tree Farm License 48 which is near the community of Chetwynd, British Columbia. The Highhat Valley covers approximately 36,500 ha, and is part of a larger unit known as Block 4 (288,000 ha). Seely et al. (2004) used Block 4 to compare dispersed and aggregated harvest patterns over long time horizons (250 years) on a host of criteria and indicators. The database contains polygons that represent individual forest stands along with attributes such as species, age, trees per hectare, site index, reserve status, minimum harvest age and economic operability. The database also contains a road network that is linked to the polygons and can be used to determine road construction schedules once the harvest schedule is generated. Growth and yield data for each polygon were generated with the FORECAST Ecosystem Simulation Program (Kimmins et al., 1999).

Large harvest units were manually designed for the Highhat Valley (Fig. 1) using forest cover and topography maps. When designing the units, we considered road access, economic operability and major topographic features such as ridge lines, streams, gullies and slope. The units range in size from approximately 1500 to 3000 ha, and correspond to the size of units currently being proposed in this region. The harvest units contain a range of stand types and stand ages. Some stands were recently harvested using approximately 40 ha harvest units (age < 15 years), some originate from relatively recent fires (age < 45 years) and the remainder range from 80 to 200 years (i.e. eligible for harvest within the next 40 years). Riparian zones, unstable terrain and other ecologically important areas within the harvest units are reserved and are not eligible for harvest. The intent was to completely cover the Highhat Valley with harvest units, regardless of age and reserve status, and to let the harvest scheduling model choose the timing and location of harvest accordingly.

For harvest scheduling, we used the FPS-ATLAS model (Nelson, 2003), which is a spatially explicit, forest-level simulation model designed for harvest scheduling. In a given time step, the model grows the forest for a specified period and then simulates a harvest. These steps are repeated until the desired planning horizon is reached. Polygons represent forest stands and are assigned to vegetation types which relate the age of the polygon to attributes such as harvest volume, and specify the age at which harvesting or other treatments can be applied. In general, stands over 80 years of age are eligible for harvest, provided they are not reserved.

For the Highhat Valley, we modeled a time horizon of 40 years with a 2 year time step because we wanted to capture visual detail from the time stands are harvested, through regeneration to the point where they are considered well established second-growth. The model was set to maximize the

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