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A method for landscape analysis of forestry guidelines using bird habitat models and the Habplan harvest scheduler

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Abstract

Wildlife-habitat relationship models have sometimes been linked with forest simulators to aid in evaluating outcomes of forest management alternatives. However, linking wildlife-habitat models with harvest scheduling software would provide a more direct method for assessing economic and ecological implications of alternative harvest schedules in commercial forest operations. We demonstrate an approach for frontier analyses of wildlife benefits using the Habplan harvest scheduler and spatially explicit wildlife response models in the context of operational forest planning. We used the Habplan harvest scheduler to plan commercial forest management over a 40-year horizon at a landscape scale under five scenarios: unmanaged, an unlimited block-size option both with and without riparian buffers, three cases with different block-size restrictions, and a set-asides scenario in which older stands were withheld from cutting. The potential benefit to wildlife was projected based on spatial models of bird guild richness and species probability of detection. Harvested wood volume provided a measure of scenario costs, which provides an indication of management feasibility. Of nine species and guilds, none appeared to benefit from 50 m riparian buffers, response to an unmanaged scenario was mixed and expensive, and block-size restrictions (maximum harvest unit size) provided no apparent benefit and in some cases were possibly detrimental to bird richness. A set-aside regime, however, appeared to provide significant benefits to all species and groups, probably through increased landscape heterogeneity and increased availability of older forest. Our approach shows promise for evaluating costs and benefits of forest management guidelines in commercial forest enterprises and improves upon the state of the art by utilizing an optimizing harvest scheduler as in commercial forest management, multiple measures of biodiversity (models for multiple species and guilds), and spatially explicit wildlife response models.

Keywords: Avian richness; Biodiversity; Extended rotations; Habitat model; Habplan; Harvest scheduler; Forest management; Riparian zone; Sustainable forestry initiative®

1. Introduction

The practice of forestry is increasingly guided by sustainable forestry concepts designed to protect environmental and aesthetic values (Loehle et al., 2002). Myriad guidelines and regulations developed to implement these concepts potentially affect management activities and the spatial structure of managed forest landscapes (e.g., rotation length, riparian buffer width, harvest method, regeneration method, retention patches, corridors, set-asides, cut-block size, green-up requirements), but they can sometimes have considerable economic cost (e.g., Barrett et al., 1998; Carter et al., 1997; Gustafson and Rasmussen, 2002; Hummel and Calkin, 2005; Kant, 2002; Nieuwenhuis and Tiernan, 2005; Ohman, 2000; Onal et al., 1998). The benefits of habitat features such as corridors are rarely known quantitatively (see Hannon and Schmiegelow,

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2002; Loehle et al., 2002). Thus, guidelines are sometimes based on surrogates of assumed ecological benefits (e.g., measures of fragmentation or edge) rather than on direct measures of wildlife or biodiversity response.

Forest managers commonly use computer software to schedule future silvicultural activities and identify harvest schedules that optimize (or nearly optimize) economic return. However, with the development of sustainable forestry certification programs, managers increasingly need to also consider environmental constraints as part of harvest scheduling exercises (Van Deusen, 1996). For example, the Sustainable Forestry Initiative® (SFI®; Sustainable Forestry Board, 2005) requires participants to "manage the quality and distribution of wildlife habitats and contribute to the conservation of biological diversity by developing and implementing stand- and landscape-level measures that promote habitat diversity." In this guidance, "quality" of habitats is not defined. A number of studies have incorporated spatial restrictions (e.g., limiting fragmentation) into planning problems as goals (Baskent and Jordan, 2002; Bertomeu and Romero, 2001; Liu et al., 2000; Nieuwenhuis and Tiernan, 2005; Rempel and Kaufmann, 2003) using tools such as simulated annealing or Tabu search, but usually without basing the objective on measures that directly correlate with wildlife benefits. Others (e.g., Larson et al., 2004) have spatially and temporally simulated the implications of forest management for selected components of biological diversity. However, using wildlife-habitat relationship models in concert with harvest scheduling software (Wigley et al., 2001) would allow managers to assess implications of alternative harvest schedules for biological diversity and the associated economic costs in commercial forest operations.

A wide range of techniques has been employed to estimate the future ecological benefits of managing forests in the context of protecting other resource values. The most tractable approach is stand-based and considers area in different categories to produce various ancillary (non-timber) benefits (e.g., Maness and Farrell, 2004; Wikstrom and Eriksson, 2000). However, most field studies relating wildlife response to forest structure have been performed at fine scales, generally at the level of the plot or forest stand. Relationships established at this scale rarely extrapolate well to broader landscape scales because processes driving the distribution of individual species (e.g., habitat selection, foraging and mating behaviors, population dynamics) may be taking place on much broader scales than those at which they are commonly studied (Maurer and Villard, 1994; Villard et al., 1995; Wiens, 1995). That is, wildlife benefits may not simply sum up as a function of acres in various age class/forest type categories.

A recent trend is the use of spatially explicit, landscape-scale wildlife suitability or response models (Arthaud and Rose, 1996; Calkin et al., 2002; Li et al., 2000; Larson et al., 2003; Mitchell et al., 2001) rather than models that rely exclusively on stand-level or patch-based information to predict wildlife responses to management. This is important because forest management activities play out over time to create landscapes with complex spatial patterns. Use of such models in concert with output from a harvest scheduler (e.g., Azevedo et al., 2005; Bettinger et al., 2003) would allow managers to evaluate tradeoffs (e.g., Zhou and Gong, 2005), particularly using production possibility frontier analysis (e.g., Arthaud and Rose, 1996; Calkin et al., 2002). This approach would help managers understand conflicts and tradeoffs between forest resources and values and make difficult decisions about alternative management strategies.

In this study, our objective was to evaluate and demonstrate an approach for frontier analyses of wildlife benefits using spatially explicit wildlife response models in the context of operational forest planning. We used the Habplan harvest scheduler (Van Deusen, 1996, 1999, 2001) to estimate the flow of wood under several types of forestry guidelines over a 40-year planning horizon for an industrial forest in South Carolina. To evaluate the potential biodiversity implications of the alternative forestry guidelines, we used the Habplan output with habitat-relationship models developed to predict overall bird richness, richness of several bird guilds, and presence of selected bird species on a regional scale, based on measures of habitat structure at multiple spatial scales (Mitchell et al., 2006).

2. Methods

2.1. Study site

Our study landscape comprised MeadWestvaco Corporation's Ashley-Edisto Districts located south of Summerville, South Carolina (Charleston, Colleton, and Dorchester counties, Fig. 1) in Bailey Province 232, the Outer Coastal Plain Mixed Province. The province is comprised of the flat and irregular Atlantic and Gulf Coastal Plains. Local relief is <90 m, and soils are mainly ultisols, spodosols, and entisols. Mean annual temperature ranges from 16 to 21 °C and average annual precipitation ranges from 102 to 153 cm. Regional vegetation is characterized by loblolly pine (*Pinus taeda*) forests on upland sites and interior swamps dominated by gum (*Nyssa* spp.) and bald cypress (*Taxodium* spp.). Many upland forests contain isolated depressional wetlands with hardwood and/or pine overstories.

Stand boundaries (polygons) and forest type/age were derived from operational inventory data provided by MeadWestvaco, including some GIS layers such as roads, streams, and elevation. There were 2788 polygons (stands) on the map. Classification errors were considered minor as only pine and hardwood types were used. Of the forested land on the landscape, 71% was pine and 29% was hardwood. These data do not reflect current conditions on the Ashley-Edisto Districts due to ongoing harvests, land transactions, and other changes. More detail on data collection and analysis can be found in Loehle et al. (2005) and Mitchell et al. (2006). The study area was virtually all farmed historically and then abandoned or planted to pine. Much of the area has been harvested several to many times. Thus, there is little old forest and no "old-growth," and logging operations on fairly short rotations keep the average age relatively young (Figs. 2 and 3).