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Predicting Impacts of Forest Management on Biological Diversity

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INTRODUCTION

Societal concern for biological diversity, likely driven by dramatic increases in global extinctions (Wilson 1988; Fenger *et al.* 1993), is evidenced by Canada's signing of the Convention on Biological Diversity. This concern greatly complicates forest management decisions (Bunnell 1976, 1990) because each action has potential repercussions for local flora and fauna. Single actions may have limited impacts, but cumulative effects over large regions and time horizons can reduce biodiversity.

Foresters must be able to assess the impacts of different management options on biological diversity. Since forest dynamics act over decades and centuries (Hunter 1990), such assessment requires prediction of future conditions, and consideration of cumulative effects. Field inventory of species gives a picture of current biodiversity (Pielou 1993) but cannot show how this picture will change over the long term in response to management. This memo describes how decision-support software (developed by the authors; see also Hansen *et al.* 1993) may be used as an alternative approach for assessing impacts of forest management on biological diversity. Note that management options are not generated; the timing, location, and type of treatment must be provided before assessment.

CONCEPTUAL APPROACH

Biodiversity (the variety of life and its processes) can be applied to genes, species, ecosystems, and landscapes (Noss 1990). The approach described in this memo focuses on the ecosystem level (where an ecosystem is an assemblage of species combined with its abiotic environment), but measures of biodiversity are extrapolated to the species and landscape levels. In British Columbia, the Biogeoclimatic Ecosystem Classification System (BEC) classifies land based on climate, soil properties, and composition of vegetation (Pojar *et al.* 1987). The approach outlined in this memo uses biogeoclimatic subzones from the BEC to describe climax ecosystem classes—a coarse measure of species diversity.

An ecosystem-level approach is appropriate for several reasons. First, ecosystems capture much of the abiotic variation, and hence plant composition, of land areas. Second, they are also correlated with vertebrate species distributions (since vertebrate abundance is correlated with both the abiotic environment and the vegetation). Third, because species composition varies with seral stage (with similar ecosystems following similar successional pathways), an ecosystem-level approach is the only way to account for this variation. Finally, ecosystems have the added benefit of being both simpler to use and broader in scope than species-level or gene-level approaches. While genetic diversity may best capture the intent of the term *biodiversity*, it is not easily observable. While species are observable, many remain unnamed (e.g., fungi; Chanway 1993), and most are not well enough understood to be managed reliably. Species management may be applied when a particular species is at risk and when relevant information is available.

Forest ecosystems are dynamic, changing in structure and composition in response to both the abiotic environment and the frequency and intensity of disturbance events (including management). Because species composition varies with seral stage, a static approach is inadequate. The length of time from any disturbance, coupled with ecosystem class, influences the plant composition of an area (Pojar *et al.* 1987). Hence, disturbance patterns and succession are also considered.

As well as ecosystem type and seral stage, a third factor, vegetation structure, is necessary for predicting vertebrate distributions (e.g., cavity-nesting birds require snags [Bunnell and Kremsater 1990; Hansen *et al.* 1991]). Knowing stand age alone is insufficient to predict structure because some structural features may be little altered by site disturbance. Thus, structural attributes of landscapes depend on disturbance intensity as well as ecosystem class and stand age. When examining managed forests, the intensity of disturbance is primarily dictated by the silvicultural system applied.

Biodiversity is considered at the species level by relating ecosystem and structural variety to requirements of individual species. A knowledge base of selected life history traits, including requirements for forest attributes, home range size, and dispersal ability, facilitates this comparison. Habitat models assess the quantity of resources and the pattern of resource distribution relative to life history.

MODEL DESCRIPTIONS, STRENGTHS, AND LIMITATIONS

To evaluate alternative management options, forest management and growth are simulated first to determine the distribution of seral stages and structural attributes on a landscape. Second, this variation is translated into measures of biodiversity. Two measures of biodiversity are generated. At the landscape level, the distribution of age classes on each ecosystem type highlights broad disparities in community diversity. At the species level, the distribution of suitable habitat shows impacts on selected species (e.g., keystone, indicator, or threatened) or habitat guilds (groups of species). Calculations of habitat suitability compare species requirements for structural attributes, home range size, and dispersal ability with the spatial distribution of these attributes on the landscape.

Although the model uses an ecosystem-level approach, it allows biodiversity to be viewed at the landscape and species levels. Also, it examines cumulative effects for periods of up to 300 years. Forest dynamics operate over decades and centuries; impacts of management can last as long. The flexible structure of the habitat suitability module allows examination of a wide range of species. The coarse resolution of the BEC information and the lack of life history information, however, preclude examination of nonvertebrates at present. Ideally, biodiversity assessments should incorporate millions of hectares. Currently, the model is limited to areas between 5000 and 50 000 hectares (approximately). Further development will attempt to address these limitations.

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