INTEGRATING GIS TECHNOLOGY WITH FOREST MANAGEMENT AND HABITAT ASSESSMENT EFFORTS ON OUR NATIONAL FORESTS

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ABSTRACT.—Research was conducted on a section of the Superior National Forest to develop and examine potential methods or approaches that may be used to integrate non-timber resources in multiple-use planning. An indicator species for old-growth conifer forests, pine marten (*Martes americana*), was chosen to examine potential conflicts between specific forest management practices and habitat values. This research explored an approach to combine spatially scheduled timber production and the impacts on marten habitat for a large area, examining simple management scenarios in the form of delayed harvesting. The results of the analysis indicate that clearcutting over the 50-year planning horizon had a significant impact on the marten habitat conditions of the study area only in specific management simulations.

INTRODUCTION

Within the past decade there has been growing awareness of the potentials as well as the importance of a quantitative understanding of natural resources, ecosystems, and the environment at various scales. Geographic Information Systems (GIS), with their capabilities for spatial analysis and modeling of diverse data sets, enhance the ability to address several natural resource and environmental issues that have a spatial component: e.g., biodiversity, land use planning, and wildlife habitat management. GIS facilitates the organization, manipulation and analysis of the myriad spatial and aspatial data often associated with these issues, and its data structures, and analytical techniques are being incorporated into a wide range of management and decision-making operations that pertain specifically to natural resources (Nichols et al. 1997).

Today, Geographic Information Systems (GIS) is thought of as an enabling technology for science because of the breadth of potential uses it has as a research tool. Developed and applied correctly, a GIS can provide forest resource managers with powerful information that will aid them in the development of management and planning decisions. Interfaced with predictive models, GIS technology can be extremely useful in resolving conflicts by presenting accurate data and alternatives as well as providing a potential user with the means to analyze and compare management alternatives.

Planning models that deal with integrated resource management concerns on national forests are now available to deal with vital spatial information. Advancements in GIS technology and natural resource modeling have made it possible to quantify various attributes so that a systematic examination and evaluation can be conducted for a given area. Use of a GIS can generate a level of spatial analysis that reflects the complex relationships represented within a given model and then incorporate these evaluations in the decision-making process. (Nichols et al. 1997).

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STUDY AREA

Located in northern Minnesota, the 490 km^2 study area represents 4 percent of the 12,140 km^2 Superior National Forest, encompassing portions of the Tofte and Kawishiwi Ranger Districts,. The landscape is covered with nearly continuous forest interspersed with wetlands. The forest vegetation includes both boreal and temperate components. The dominant upland coniferous tree species include black spruce, white pine, red pine, jack pine, white spruce, and balsam fir. The upland deciduous tree species include quaking aspen, bigtooth aspen, and paper birch. The dominant tree species found dispersed throughout the wetlands include black spruce, northern white cedar and black ash. Nearly 50 percent of the study area consists of spruce and fir stands. Peek et al. (1976) and Rogers (1987) provide a detailed description of the vegetation and landscape of the area.

Approximately 6,000 individual polygons were digitized by the National Ecology Research Center (U.S. Fish & Wildlife Service). Forest compartment/stand maps [1:15,840 (4" = 1 mile)] and stand exam data were obtained from each Ranger District.

RESEARCH OBJECTIVES

The overarching objective of this research was to evaluate the trade offs of managing a section of the Superior National Forest for timber and marten. There were four specific objectives:

(1) Create a habitat suitability index (HSI) model for marten to identify existing and potential marten habitat.

(2) Develop a spatial model of forest vegetation capable of estimating the impacts of forest management practices on marten habitat.

(3) Implement a number of simulation scenarios for analysis of the trade-offs between timber and marten habitat.

(4) Generate optimal management schedules for timber that can simultaneously meet specific requirements for marten habitat.

METHODS AND MODELS

In this study, a geographic information system (ARC/INFO) and a simulation model (DTRAN) (Hoganson et al. 1984) are used to compare the changes in pine marten habitat across time and space for a number of alternative timber harvest scenarios. Results are trade-offs between habitat carrying capacity and the Net Present Value (NPV) associated with timber harvesting on a section of the Superior National Forest. A habitat suitability index (HSI) model for pine marten was created to identify existing and potential marten habitat. The marten model is based on habitat use information that was collected from a literature review on marten and its habitat preferences.

The input for DTRAN was generated by RxWRITE (McDill 1994), a prescription writer for harvesting and forest management activities. The system provides a user-friendly interface to set up and simulate different stand management options, allowing users to specify the level of species aggregation, a range of products, potential harvest ages, thinning times, thinning intensities, and conversion options. DTRAN was used to simulate various forest development, harvest and silviculture scenarios over a 50 year planning horizon. The Net Present Values (NPVs) associated with various management scenarios were generated, using prices developed in the Minnesota Generic Environmental Impact Statement (GEIS) (Jakko Poyry 1992) for the Duluth market. In this model, the assumption was made that clearcuts occur at the beginning of each planning period. For each planning period, the HSI values were generated so that the impact of clearcuts occurring in any planning period can be examined in terms of habitat losses or gains. A real discount rate of 4 percent was used.

The information generated by the harvest scheduling model and the marten model was transferred to a geographic information system (ARC/INFO). This system generated a number of maps that were used to compare changes that occurred in habitat over time and space for a number of alternative timber harvest scenarios. The display of the optimal forest management schedules in a GIS environment facilitated the interpretation of the plans, highlighted resource conflicts, and supported operational planning. The sequencing of and linkages among analysis components used in this study are summarized in Figure 1.

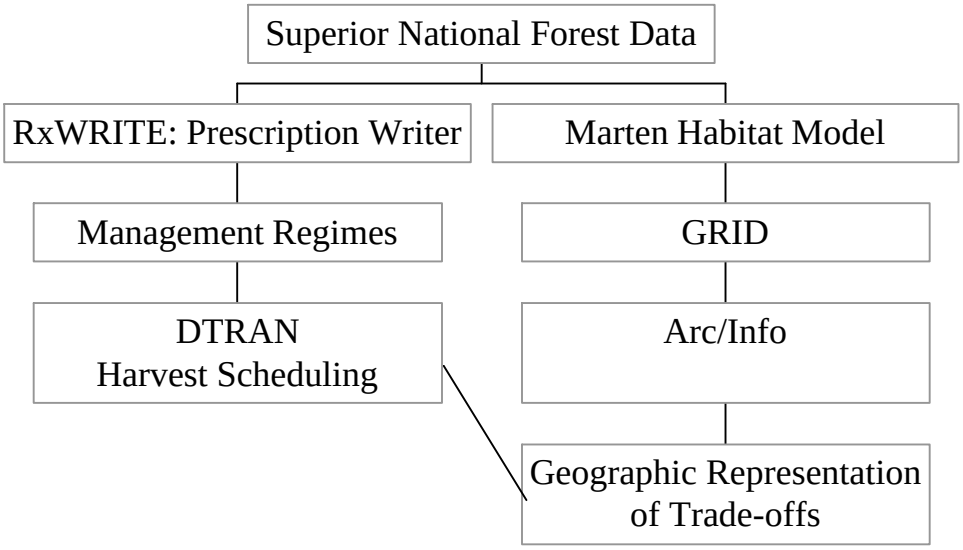

Figure 1.—Flow diagram of the analysis process

A MODEL OF PINE MARTEN HABITAT QUALITY

Marten (*Martes americana*) is a fur-bearing species associated with late-successional and old-growth forests across much of North America. Loss of viable marten habitat has accelerated over the past century, ultimately resulting in partial or complete depletion of marten populations in much of the Great Lakes region. In Minnesota, marten has not been observed outside the northeastern portion of the State since 1920, and the northeastern population remained essentially flat until the early 1970's (Gunderson 1965, Stenlund 1955, Mech and Rogers 1977).

Marten populations are sensitive to habitat change due to increased logging and silviculture practices, greater human access, and unrestricted trapping. Though the species prefers mature conifer or mixed forest stands with high stocking, there have been indications that it may be capable of adapting to a variety of forest habitats that consist of mixed deciduous and coniferous species. Changes in mature forested habitat can result in significant reductions in the marten population of a given area which could, under the most adverse circumstances, lead to the eventual loss of a viable habitat for marten. Marten typically avoid large forest openings such as clearcuts. An area

that is either cut or severely burned has no marten habitat value for at least 15 years, primarily because of the poor hunting conditions (Koehler and Hornocker 1977, Soutiere 1979). One researcher noted that the density of marten found in clearcut areas is one third of the marten densities observed in a partially cut or undisturbed mature forest (Soutiere 1979). Large openings in forest cover act as psychological barriers to marten. Marten tend to restrict themselves to the more dense areas of the forest, and are unlikely to travel more than 135m in the open.

Habitat quality for marten was calculated for a circular, 2.5 km^2 area which reflects its home range. Habitat quality was a function of the percentage of the home range covered by stands of different species types and ages. A program was developed using Arc Macro Language (AML) to represent the marten model in a GIS framework. The marten model was implemented in GRID and the trade-off analysis between timber production and marten habitat was conducted in ARC/INFO.

MANAGEMENT SCENARIOS

Three management scenarios were implemented in this study to assess the potential gains or losses in marten habitat or timber production as clearcutting was increasingly deferred over a 50 year planning horizon. Specific management scenarios were chosen primarily as case examples to examine the impact of constrained and unconstrained harvesting on marten habitat over time and space. The trade-off analysis operates on the HSI values derived for a given stand and the corresponding maximized NPV of timber associated with that stand.

An approach was explored to combine spatially scheduled timber production and the impacts on marten habitat for a large area in northern Minnesota, examining simple management scenarios in the form of delayed harvesting. The results of the analysis indicate that clearcutting over the planning horizon did not have a significant impact on the marten habitat conditions of the study area when the model is allowed to run unconstrained or clearcutting is deferred by ten years. But significant changes in the quality of marten habitat were observed when clearcutting was constrained in the first two planning periods (Nichols et al. 1997).

FINAL REMARKS

The merits of the spatial approaches used in this research are that the impacts of the proposed or simulated clearcuts can be observed across the entire study area without regard to forest stand boundaries. Marten habitat is assessed in a raster based GIS (GRID), relying on neighborhood analytical procedures to predict or determine the change in habitat values after clearcuts have occurred over time and space so that the analysis of a given area is based on an evaluation of the spatial habitat requirements of the marten without regard to arbitrary administrative delineations or boundaries. The availability of modeling capabilities in ARC/INFO enabled a level of spatial analysis used to examine the impacts of clearcutting on marten habitat.

As large tracts of contiguous old-growth forests vanish due to natural or man-made causes, there will be greater incentive to strengthen existing planning efforts to include wildlife resources in management evaluations of public lands. The use of technology as illustrated in this paper is becoming an integral part of the planning processes pursued on our national forests.

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