Linking Scenario Planning with GIS to Develop a Decision Support System for Multiple-Use Management in Mississippi[1]

by

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Abstract

Non-marketed forest outputs, such as clean air and water, recreation, and wildlife habitat, need to be measured quantitatively so projections can be made on the economic gains and losses associated with varying amounts of these outputs in relation to timber production. Of particular significance to the timber industry is the quantity and value of timber production forgone relative to varying amounts of wildlife habitat. Scenario planning methods linked with Geographic Information Systems (GIS) provide flexibility in assessing trade-offs between timber and non-timber outputs, thereby allowing spatially referenced land management regimes to be examined quickly. This approach will be used to estimate the potential economic gains or losses for Mississippi resulting from a manipulation of timber growing stock to produce more or less wildlife habitat. Current plot and tree level USDA Forest Service Forest Inventory and Analysis (FIA) data are used as a baseline vegetative set by which each management regime is assessed. This data set will be analyzed using the USDA Forest Service linear programming (LP) based forest-planning model, Spectrum, and the GIS software ArcView, to determine effects of management options for various suites of wildlife species in different physiographic regions of Mississippi. Through simulations of management regimes with even-flow and wildlife habitat constraints, the resulting quantitative measures can be used to evaluate tradeoffs inherent in multiple-use management, and potential impacts on both state and regional timber inventories and affected economies.

INTRODUCTION

Currently, commercial timber production in the South is stable, productive, and supplied by diverse landowner groups (Wear 1996). However, such stability is rarely permanent. Future shifts in demands for non-market forestland uses, such as wildlife habitat, may lead to changes in timber markets.

Non-marketed outputs such as clean air and water, recreation, and wildlife habitat are becoming increasingly important to the general public. These outputs need to be measured quantitatively, so projections can be made on the economic gains and losses associated with increasing or decreasing various combinations of these outputs.

Management objectives for private landowners, especially industrial landowners, tend to be less complicated than those on state and federal public lands. Nevertheless, public and private land managers increasingly must actively manage forestlands for the production and consumption of many products besides timber, that is, multiple-use forest management (Rohweder 2000). Multiple-use management requires tradeoffs between competing uses of the forest. Landowners generally invest in forests with the expectation of receiving returns on their investment (Wear 1996), and often they believe that the improvement of wildlife habitat will adversely affect timber production and, consequently, maximization of profit (McKee 1972). When given accurate information on the impacts of these management decisions, however, they may be willing to accept the tradeoffs of managing for multiple-uses that combine wildlife and timber outputs. In particular, landowners and policy makers need information on the impacts of alternative timber supply schedules, as outputs of other goods and services change. This information is extremely useful when developing land management plans, but to date there has been limited research in this area for the state of Mississippi.

This study takes the unique approach of combining forest inventory, wildlife habitat, and simulated timber harvest data to examine potential

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resulting economic returns for the state of Mississippi if the timber growing stock is manipulated to produce more or less wildlife habitat. The analysis is targeted to specific regions of the state, different landowner types, and various wildlife species so that landowners and policy makers are better able to understand ramifications of managing for multiple-uses. The objective of this paper will be to illustrate the methods required to perform this type of research.

METHODS

The goal of the pilot model described in this paper was to fine tune the methodology and understand the mechanics of the software used. Therefore, this initial model developed harvest schedules using linear programming for 40,000 hypothetical acres of mixed pine-hardwood and plantation loblolly pine (*Pinus teada*) located in a portion of the North Central Hills physiographic region that falls within the northern FIA region of Mississippi. Scenarios were simulated over a 50-year rotation period. Both the objectives of maximizing total timber volume produced for the region and maximizing optimum deer habitat were examined in this pilot model. The differences in the models, from a monetary standpoint, were the cost of wildlife management in terms of timber foregone or in delayed harvest. Prior to development of the model, the following process was used to class data in a useable format.

U.S.D.A. Forest Service Forest Inventory and Analysis (FIA) plot and tree level data from the 1994 survey was used as the baseline vegetation data for the state (Hansen et al. 1992). Resurveyed every five to seven years, it is the most current and complete set of forest inventory data for the state of Mississippi. Using a combination of the plot and tree level data, estimates of volume and acreage by ownership, tree species, and age class represented on each plot was extracted from the overall FIA data set. These tabular data were imported into a Geographic Information System (GIS) for analysis. Latitude and longitude of current FIA plots for Mississippi were also imported into the GIS. Plots were then segregated by FIA inventory region, and physiographic region of the state (Figure 1). Plots were segmented this way to aid in the representation of different management regimes.

To further subdivide these data, FIA plots were segregated by ownership. Non-industrial and industrial ownerships within the state were used to illustrate decision modeling at the management plan development stage of this project. This was done because landowners manage their land differently based on specific management objectives. For example timber product companies manage their property to maximize revenue, while in contrast, federal landowners such as the U. S. Fish and Wildlife Service enhance habitat to manage wildlife species.

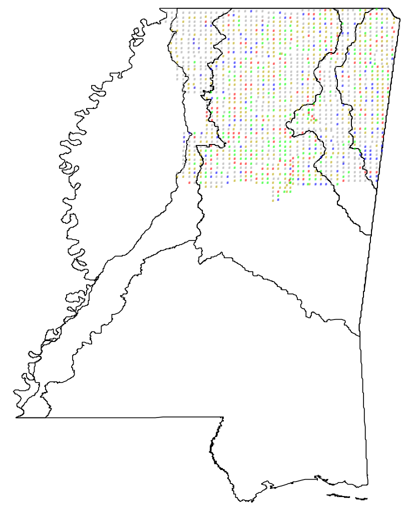

Figure 1. Northern Region FIA Plots and Physiographic Regions for Mississippi

Following the delineation of the FIA plots by vegetative and landowner types, they were then aggregated by different physiographic regions in Mississippi (Lowe 1915, MARIS 1999) using GIS. This was done so that key wildlife species could be identified for each physiographic region and/or timber type. Specific species within a region were chosen because of their economic value as game species for the state, because of threatened or endangered species status, or because they are indicator species for a particular habitat type. Habitat for white-tailed deer (*Odocoileus virginanus*), Northern bobwhite quail (*Colinus virginanus*), and eastern wild turkey (*Meleagris gallapavo*) were considered in this study.

Once current acreage distributions were mapped using GIS and key species determined, multiple decision modeling using linear programming was used to examine alternative management plans. This study employed the U. S. D. A. Forest Service forest planning model Spectrum, which aids in matrix development and generates optimized land allocation and management schedules among different analysis units over a given planning horizon (USFS 1999). Spectrum is readily available for download over the Internet, and allows the user to create objective functions that are adaptable to biodiversity and multiple use issues. This model includes Windows based data entry screens, matrix generator, and report generator. The commercial linear programming program C-Whiz (Ketron Management Science 2000) was used to solve the LP matrix of rows and columns generated by Spectrum.

As part of the matrix development process in Spectrum, timber volume estimates derived from aggregated FIA plot level data were input as analysis units, which were made up of comparable timber types of similar ages. The associated volumes were then projected across a 50-year planning horizon which was broken into 10, 5-year planning periods. A 50-year planning horizon was chosen to give 3 planning periods beyond the traditional 35-year rotation for loblolly pine, which is a prevalent, commercial timber species in the state. These additional 15 years provide the software greater flexibility in allocating management regimes through time. Analysis units were subjected to various timber harvesting regimes, such as one thin, two thin, and clear-cut harvests, over the 50-year planning horizon.

Wildlife habitat quality estimates for white-tailed deer, Northern bobwhite, and eastern wild turkey were input for each 5-year period, and were based on the estimated level of suitable habitat available during that period. Wildlife habitat constraints were measured on a scale in which habitat conditions were divided into three classes that ranged from low to high quality.

Monetary valuations of each regime were also assessed based on particular management activity inputs and timber and wildlife outputs for each forest type and analyzed using net present value (NPV). Future analysis will also include Benefit/Cost analysis and examine the monetary benefits for different ownership categories in each physiographic region of the state.

RESULTS AND DISCUSSION

In our example, the first scenario had the primary objective of maximizing the total volume of timber produced over the entire hypothetical 40,000 acres for both ownerships. The second scenario maximized optimum deer habitat for both ownerships. While total acres harvested remained fairly constant throughout the rotation, regardless of the objective, how those acres were allocated to different management emphases varied greatly.

When the objective was to maximize total timber produced over the entire 40,000 acres, over 70% of industry land was allocated to timber production. Although turkey management was not a primary objective in this first scenario, the model determined that the majority of the remaining acres were best allocated to be managed as high quality turkey habitat. Non-industry lands, or other timber (Figure 2), contributed to less than 25% of all lands managed for timber production. Instead, non-industry lands were allocated for management as high quality deer and turkey habitat. In this instance, no acres of industry or non-industry lands were allocated to Northern bobwhite quail habitat.

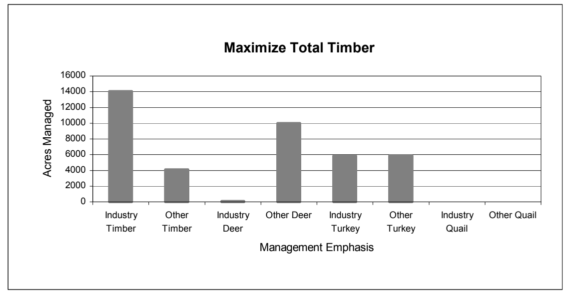

Figure 2. Acres Allocated Based on Management Emphasis When Total Timber Produced is Maximized

In comparison, when the objective was to maximize deer habitat the majority of industry lands (64%) was allocated to timber production (Figure 3). Acres allocated to deer management on industry lands increased significantly from the total timber scenario, while acres allocated to deer habitat on other lands decreased by almost 50%. Overall total acres managed for quality deer habitat in the North Central Hills Region increased by 934 acres over the timber maximization scenario. Again, although the production of turkey and quail habitat was not the primary focus of this scenario, quality habitat was still produced. Acres of quality turkey habitat decreased from the previous scenario by 5,700 acres while areas of suitable quail habitat increased by 5,978 acres.

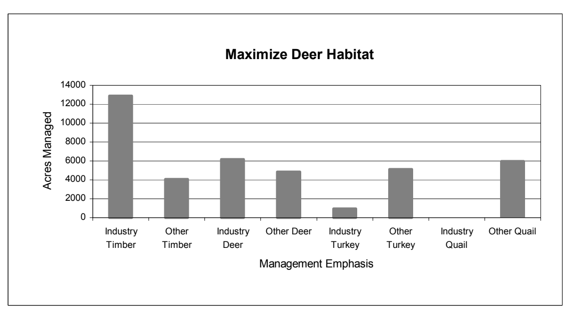

Figure 3. Acres Allocated Based on Management Emphasis When Deer Habitat is Maximized

Since it is difficult to ascribe monetary values to wildlife and wildlife habitat, these values must be derived from the comparable returns of harvesting forests with and without wildlife habitat constraints. The difference in values provides an opportunity cost of creating or conserving wildlife habitat. In this particular case, when the net present value, over the 50-year rotation, of the timber production and deer habitat scenarios are compared the value generated by the deer habitat scenario is only $2,401 less, in total, than the timber production scenario (Figure 4).

Although the results of this study are based on a hypothetical data set, it illustrates the usefulness of the information that can be derived from the model. There were several key points to be made from this pilot.

First, the results will be used to refine similar models for specific regions of the state for indicator species or species of concern such as gray squirrel (*Sciurus carolinensis*) and red cockaded woodpecker (*Picoides borealis*). Habitat generalists such as white-tailed deer often do not demonstrate significant preferences in habitat types from one 5-year period to the next, and may not be the best choice to model.

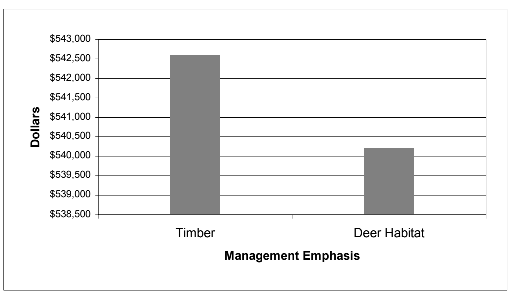

Figure 4. NPV Comparison of Timber Production and Deer Habitat Scenarios over a 50-year rotation

Second, in this model, habitat quality was ranked on a scale of 1-3 with 1 being the lowest and 3 the highest. Habitat quality ranking may be improved if it is on a scale of 1-5, which will better illustrate significant changes in habitat quality through the rotation.

Third, growth and yield models such as NatYield (Smith and Hafley 1986, Smith et al. 1989) and MSUGY (Matney 1996) will be used to project timber volumes to the end of the rotation. Current cost estimates of silvicultural activities such as site preparation, planting, and thinning will also be input into the model based on values found in the South (Dubois et al. 2001).

Finally, results will be combined using GIS software to spatially illustrate the impacts of various regimes for selected physiographic regions and ownerships. To date, few studies have used a GIS to depict and further analyze the results from linear programming models, and none have been completed for the state of Mississippi.

CONCLUSIONS

This research expands upon past studies that examined the tradeoffs between wildlife and timber management (McKee 1972, Brown et al. 1994) in several ways. First, management tradeoffs will be examined for the entire state of Mississippi through the use of forest inventory data specific to physiographic regions. Second, wildlife habitat quality will be measured rather than quantifying the number of individuals per acre for specific species. Finally, economic benefits to landowner types throughout the state will be derived. Rarely have studies been completed for Mississippi which quantify non-market benefits to landowners.

This current study will provide landowners and resource managers with a tool for making informed resource allocation decisions with regard to wildlife and timber management. Through the use of this model, they will be able to assess economic opportunities that may be created on forestland that is managed for both timber and wildlife habitat. For example, expanding wildlife habitat may provide opportunities for promoting fee-hunting programs. The resulting quantitative measures can also be used to evaluate the tradeoffs of multiple-use management, and impacts on both state and regional timber inventories and affected economies.

This unique approach of combining actual forest data and timber-wildlife habitat models and graphically depicting simulated levels of economic benefit will make the results more accessible to a diverse audience. Combining linear programming results in a GIS allows different scenarios to be mapped, therefore, landowners, resource managers and policy makers are likely to better understand the ramifications of managing for multiple outputs.

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