INTERDISCIPLINARY RESEARCH CAN PROVIDE INFORMATION FOR THE HARVESTING CHALLENGES OF THE 1990's

Chris B. LeDoux
Industrial Engineer and Project Leader

John E. Baumgras
Research Forest Product Technologist

Northeastern Forest Experiment Station
180 Canfield Street
P.O. Box 4360
Morgantown, West Virginia 26505
Telephone: 304-291-4488

ABSTRACT
Management of our complex forest ecosystems in the economic and political climate of the 1990's is a challenge for planners, managers, and loggers. A multifunctional approach --using the research results of other disciplines and considering all forest uses and values-- can improve the effectiveness of forest operations research. Since harvesting cost and revenue are closely related to changing stand attributes, harvest models must be linked with dynamic growth and yield models to accurately assess the impact of site and stand attributes on logging cost and stand management. Future harvesting plans must incorporate all forest values and uses as well as environmental impacts on soils, wildlife, and water quality. Future logging plans must bring together the volumes of research results from other disciplines in a decisionmaking model. The application of a model called MANAGE to integrate harvesting with the many uses of the forest is described.

Keywords:
Logging cost, wildlife, integration, models.

INTRODUCTION
The public has discovered that America's forests not only produce high-quality wood products but also are superb places in which to hike, hunt and fish, camp, and enjoy the outdoors. As public values change, so does the management of these forests. Changing values have resulted in new laws on land use and resource management. These new laws pose new challenges for forest planners, managers, and loggers, and will affect how millions of acres of commercially forested land will be managed.

The challenge for forest managers is to respond to and even anticipate changes in the social context for managing public forests while maintaining a sense of the long-term needs for wood products. To do this successfully requires comprehensive analyses that integrate logging technology, silvicultural treatments, economics, wildlife requirements, and other management considerations in the decisionmaking process. Rigorous financial analysis must be conducted so that tradeoff values of alternative forest management objectives are understood and planned for. Models such as TEAMS (Covington et al. 1988), FORPLAN (Sedjo 1987), and ECOSIM (Rogers et al. 1984) are examples of models that evaluate alternatives for large blocks of forested land.

Stand-growth simulators for forests in the Northeast include NE-TWIGS (Hilt and Teck 1988), SILVAH (Marquis 1986), OAKSIM (Hilt 1985a, b) FIBER (Solomon et al. 1987), and GRO2 (Sendak 1985). These models differ in forest-type application and in method of growth projection. Although some provide economic analysis for various silvicultural treatments, none have detailed logging-cost data and analysis options. MANAGE[1] (LeDoux 1986) is one of the few models applicable to forest conditions in the Northeast that estimates harvesting costs for cable and ground-based logging technology.

METHODS
In this paper we describe the use of the computer program MANAGE to evaluate the impact of four forest management scenarios on logging cost and net returns. Written in FORTRAN 77, MANAGE integrates harvesting technology, silvicultural treatments, market price, and economic concerns over the life of a stand. The simulation is a combination of discrete and stochastic subroutines. Individual subroutines model harvesting activities, silvicultural treatments, growth projections, market prices, and discounted present net-worth (PNW) economic analysis. The model can be used to evaluate alternative management strategies and to develop optimal management guidelines for eastern hardwoods.

Initial Conditions
The stand table used to initiate the simulations was published by Schnur (1937) for even-aged upland oak forests (Table 1). The table represents projected conditions by site index and age for a fully stocked upland oak stand. The initial tree list was input into MANAGE to project growth

[1] The computer program described in this publication is available on request with the understanding that the U.S. Department of Agriculture cannot assure its accuracy, completeness, reliability, or suitability for any other purpose than that reported. The recipient may not assert any proprietary rights thereto nor represent it to anyone as other than a government-produced computer program.

Table 1. Initial attributes of timber stand.

Site index	Mean dbh	Vol./ acre	Age	No. trees/ acre	Red maple	White ash	White oak	Red oak	Hickory
					species components				
	Inches	ft^3	years		---------- Percent ----------				
80	8.9	2612	50	249	5.0	6.0	38.0	46.0	6.0

and yield for each management scenario. The stand was assumed to be on moderate terrain and ground-based logging technology was used for both the thinnings and final harvests. The costs and benefits by management scenario were simulated and summarized on a discounted cash-flow basis.

LOGGING TECHNOLOGY

A skidder cost equation for a John Deere 540B[2] rubber-tired skidder was used to estimate skidding cost (LeDoux 1988). The 540B is a medium-size machine capable of skidding small and large logs (Figure 1). Skidding and other harvesting and transportation costs were estimated using EASTCOST (LeDoux 1988). EASTCOST is a microcomputer program that can estimate stump-to-mill costs of ground-based and cable logging systems for eastern hardwoods. The streams of costs and benefits were summarized by management objective. The delivered product prices used (Table 2) were obtained from Coastal Lumber Company, Hopwood, PA and from Forest Product Price Bulletins (Ohio Agric. Res. Serv., 1989; Penn State Univ., 1989; Tenn. Div. For., 1989).

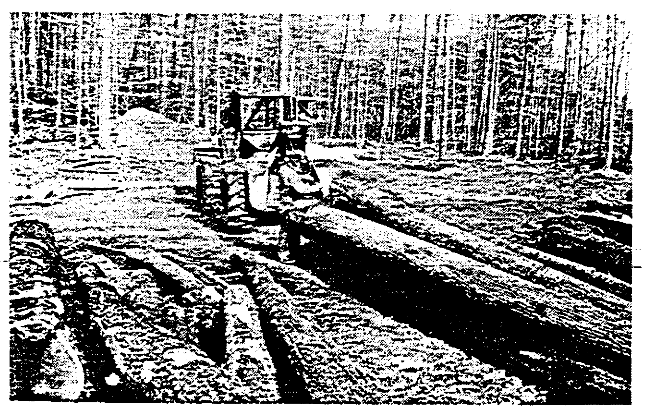

Figure 1. The John Deere 540B Skidder.

Management Objectives

For comparison purposes and to illustrate the use of an integrated model to evaluate alternative management objectives, we considered four scenarios. One was to not harvest the stand; the second was to harvest the stand using the culmination of mean annual increment as the decision criteria; the third was to provide substantial periodic volumes and cash flows through a combination of heavy thinnings and a delayed final harvest; and the fourth was to manage the stand to provide as much hard mast as possible for squirrels, turkey, deer, and bear, and to provide scenic beauty with large trees openly spaced within the stand (Ribe 1991) beginning at age 50.

In each case, the assumption is that the land owner or firm chose to manage the stand in this manner. Our intent is not to suggest the best management practices or guidelines, but to show the kinds of information that can be produced when evaluating or comparing scenarios. We report stand parameters such as dbh, volume yield, tree size, and present net worth so that tradeoffs can be visualized or computed and to show how the stands would develop for each scenario.

RESULTS

For management option 1, the stand was projected to its optimal economic rotation so that the maximum present net worth could be compared with other scenarios. This scenario would yield trees that average 14.2 inches dbh, yield a cubic-foot volume of 5,324/acre, have an average tree volume of 30 ft^3, and a present net worth of \$504/acre with an optimal economic rotation of 100 years.

[2] The use of trade, firm, or corporation names in this publication is for information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture or the Forest service of any product or service to the exclusion of others that may be suitable.

Table 2. Delivered prices for sawlogs and fuelwood/pulpwood by species (Doyle rule).

Species	Large high-quality sawlogs[a]	Medium-size quality sawlogs[b]	Small low-grade sawlogs[c]	Fuelwood/ pulpwood[d]
	----------	Dollars/Mbf	-------	Dollars/cord
Red maple	210	160	80	30
White ash	500	300	100	30
White oak	500	300	100	30
Red oak	600	350	100	30
Hickory	210	160	100	30

[a]Minimum small end diameter $\geq$ 13 inches; length $\geq$ 10 feet.
[b]Minimum small end diameter $\geq$ 11 inches; length $\geq$ 8 feet.
[c]Minimum small end diameter $\geq$ 10 inches; length $\geq$ 8 feet.
[d]89 ft^3/cord, minimum small end diameter $\geq$ 4.0 inches that will not make large, medium, or small sawlogs.

When using culmination of mean annual increment as the decision criteria, option 2, the stand would reach rotation age at 80 years (Figure 2), produce trees that average 12.18 inches dbh; yield a volume/acre of 4,482 ft^3, and have a present net worth of $365/acre. The average tree would contain about 21 ft^3.

Option 3, to provide periodic volume and cash flows through a series of thinnings, was accomplished by scheduling commercial thinnings at ages 65 and 100 with a final harvest at optimal rotation age of 150 years. This objective produced trees that averaged 13.89, 14.85, and 18.33 inches dbh at age 65, 100, and 150, respectively; volume yields were 2,000, 2,792, and 2,674 ft^3/acre at age 65, 100, and 150.

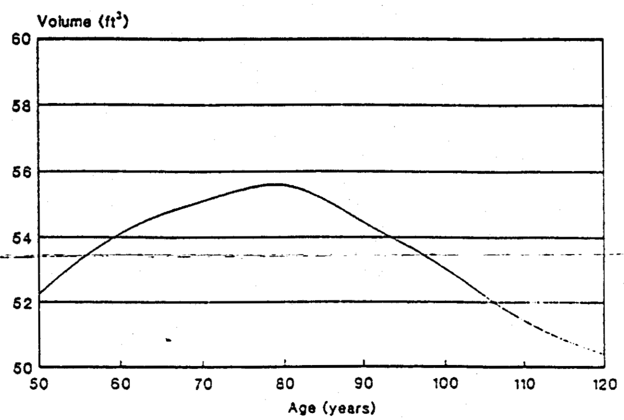

Figure 2. Mean annual increment for scenario 2.

Present net worths were $91.48 and $124.34, and $46.17/acre at ages 65, 100, and 150.

Option 4, to provide mast for wildlife and scenic beauty, was accomplished by removing smaller diameter trees in favor of those that would produce hard mast. The larger trees were left to increase and maintain the scenic beauty of the stand. The thinning at age 50 removed trees that averaged 6.63 inches dbh, leaving trees that averaged 10.53 inches dbh. The thinning at age 50 removed 613 ft^3/acre resulting in a present net worth of $-418.57/acre. The residual stand was projected to its optimal economic rotation for comparison purposes. The optimal rotation would be at age 100 years, yielding 4,955 ft^3/acre with trees that averaged 17.10 inches dbh. The average tree size would be 45 ft^3. However, trees that are 24 inches dbh and larger could be produced at a stand age of 165. The results for all management objectives are summarized in Figures 3-6.

CONSIDERATIONS FOR MANAGERS

Although the objective of management option 4 is partially to produce mast for squirrels, deer, turkey, and bear, there is no guarantee that mast will be produced or that the desired wildlife species will be present or even use the area: mast production or wildlife use are variables that cannot be accurately predicted. However, if through management we can provide healthy forests/ecosystems, then the chances of a given objective meeting with success are increased.

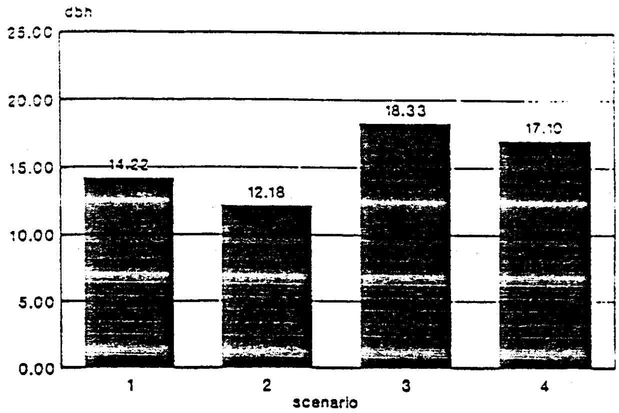

Figure 3. Average dbh at rotation age by management scenario.

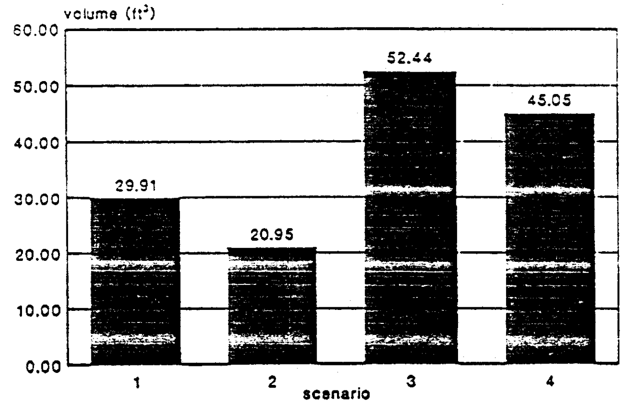

Figure 6. Average tree volume at rotation age by management scenario.

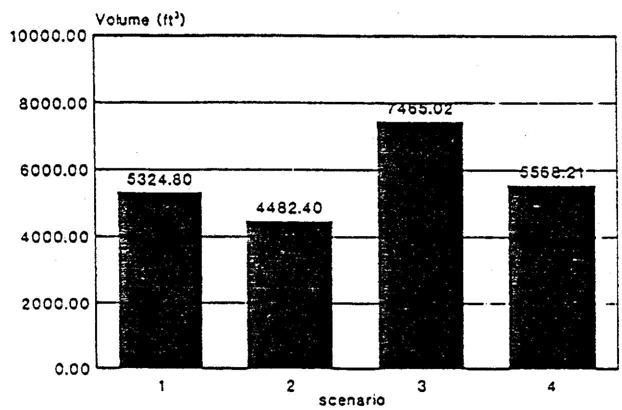

Figure 4. Total cubic-foot volume/acre at rotation age by management scenario.

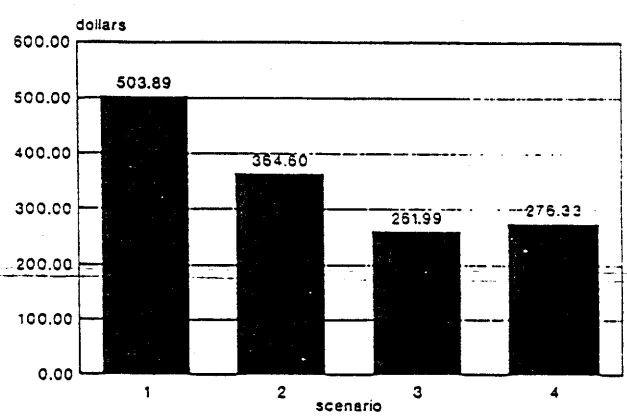

Figure 5. Cumulative present net worth by management scenario.

By evaluating alternative scenarios, loggers and logging planners can gain insight into the size and volume of wood flows created by various objectives. Analyses such as this also allow loggers to see project logging costs accurately. As forest-land owners and users specify management scenarios for whatever reasons that require logging, loggers and planners will need to know the types of products and values involved. Integrative models can provide them with information on tree and stand parameters necessary to harvest stands in the 1990's and beyond.

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