

9-8-2024

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Recommended Citation

Bettinger, P., Lee, T., Merry, K., & Drummond, D. (2024). A Forest Management Evaluation System for Small Private Forest Landowners. *The Journal of Extension*, 62(3), Article 19. <https://open.clemson.edu/joe/vol62/iss3/19>

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A Forest Management Evaluation System for Small Private Forest Landowners

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Abstract. When small private forest landowners have a need to address jointly economic and sustainability objectives, efficiency in both respects becomes important given limitations on the land, budget, time, and other resources that are available. The suite of forest management options available to a landowner may be vast and complex, therefore a tool to assist and inform their potential management activities can be of value. The eYield model was developed as an application (app) to assess forest management options on many different computing devices, from cellphones to desktop computers. Within eYield, a person can define a management situation, specify prices and costs for potential management actions, and receive economic, commodity production, and biological (tree volume, tree density) outcomes associated with different forest management scenarios.

INTRODUCTION

Of the 42% of the southern United States that is forested (Bettinger & Merry, 2019), about 86% is privately owned (Oswalt et al., 2019). Small, private landowners often own natural deciduous (hardwood) and coniferous (pine) forests. In the 1980s and 1990s, the Tennessee Valley Authority developed a Windows-based forest management model (Hepp, 1982, 1984) that helped Extension agents, consultants, and forest landowners assess management alternatives by describing forest growth, wood yields, and economic outcomes of potential future management activities. In the early 2000s, the developmental support for the Winyield model ended. In 2018, with support from the U.S. Department of Agriculture, developers began work on eYield (eyield.uga.edu). The eYield model is an Internet-based financial and biological growth model emulating the projections and outcomes of Winyield using a responsive design that facilitates its use by Extension agents on nearly any computing device: phones, tablets, laptops, and desktop computers. The eYield model projects the development of seven natural forest types common to the eastern United States: loblolly pine (*Pinus taeda*), slash pine (*P. elliottii*), shortleaf pine (*P. echinata*), longleaf pine (*P. palustris*), white pine (*P. strobus*), oak-hickory (*Quercus* spp. and *Carya* spp.), and yellow-poplar (*Liriodendron tulipifera*). These were the natural forest types included in the Winyield model.

The objective of this paper is to briefly describe the information required to use eYield and the types of outcomes that eYield can produce. While these efforts have an Extension agent in mind as the primary reader, many others (e. g., consultants, private landowners, and agency or company foresters) may benefit from an overview of the model.

INPUT INFORMATION FOR EYIELD

There are eight steps to design an eYield simulation. After accessing the eYield application and initiating a new scenario, the first step prompts the selection of desired reports (Figure 1). In step 2, an Extension agent identifies basic information about the analysis, such as which simulator to use, the stand name, and the narrative notes (Figure 2). In Step 3, the user identifies a reference or starting year, along with detail describing the initial forest condition (Figure 3), which may include basal area (ft² per acre, density of trees at 4.5 feet above ground) and

trees per acre, depending on the simulator. An Extension agent selects the log rule—the method for determining how many board feet (nominally 1 inch thick × 12 inches wide × 12 inches long) can be produced from a tree of a given size—which provides the flexibility to adjust to local or regional convention. In addition, the user identifies a minimum top diameter for pulpwood and a conversion rate that translates cubic feet of solid wood to cords (nominally, 128 ft³) of wood.

Step 4 requires a description of the tract’s site quality, or site index (Figure 4). A site index value represents the average height of the dominant and co-dominant (by crown class) trees in a forest at a given base age. For example, site index 75 (base age 25) suggests that the dominant and co-dominant trees in a forest will be 75 feet tall when they are 25 years old. In Step 5, an Extension agent specifies harvest regimes; this requires users to establish the age at which a thinning or a final harvest (clearcut) is desired, along with the residual basal area (ft² per acre) of trees that remain standing in the forest after the harvest activity is completed (Figure 5). Users can also specify an estimate of the expenses (as a percentage of the revenue) for the harvest activity. The user provides other economic factors in Step 6, such as the length of a planning horizon, the income tax rates (ordinary and capital gains), and the discount rate that will be used to calculate net present value and other economic metrics (Figure 6). In Step 7, the user can specify other types of financial transactions related to reforestation, hunting leases, and other important aspects of the management of the forest (Figure 7).

Finally, in Step 8, an Extension agent describes the forest products that may be generated during harvests (Figure 8). These products are diameter-based; in other words, the agent identifies a range of tree diameters for each product class. For example, pulpwood products may come from trees that are 5–9 in. in diameter at breast height, and sawtimber products may come from trees that are 10 or more in. in diameter at breast height. Two caveats are important here: (a) the diameter ranges cannot overlap, and (b) some pulpwood may be produced from the tops of sawtimber-sized trees, depending on the selected simulator.

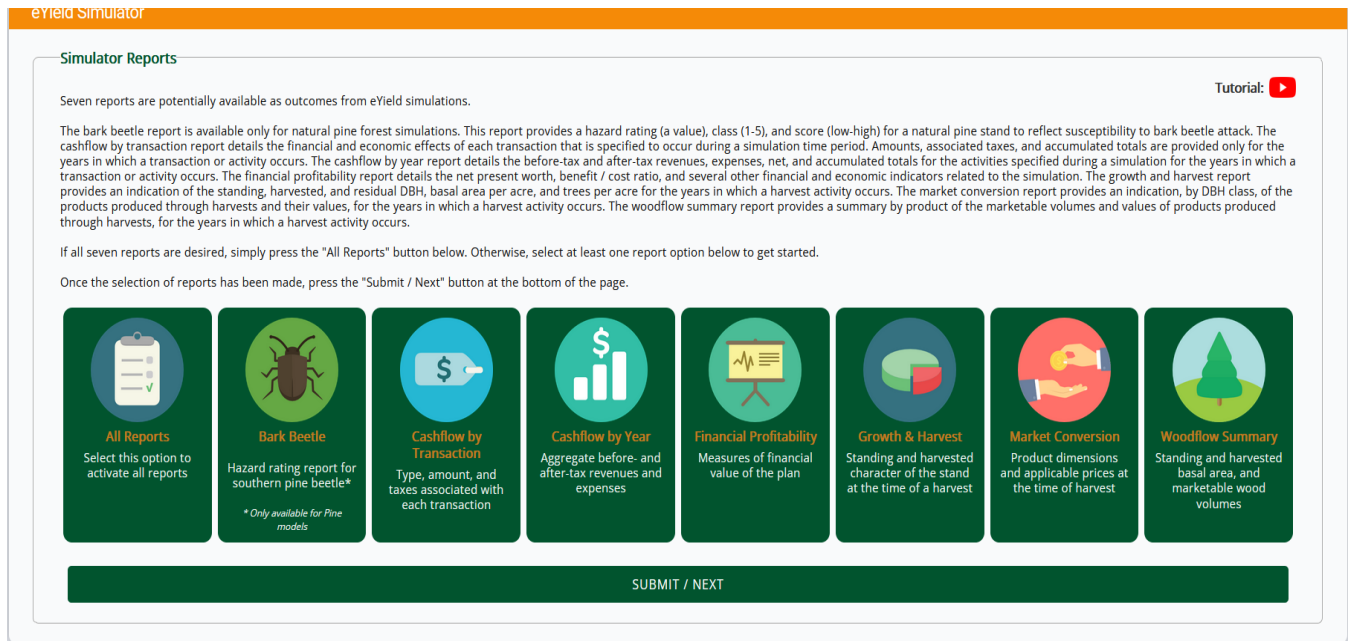


Figure 1. Step 1: Selecting the desired reports.

Evaluating Small Forests

The screenshot shows the 'eYield Simulator' interface. At the top, there is a navigation bar with tabs for 'STEP 1: Simulator Reports', 'STEP 2: Basic Information', 'STEP 3: Stand Parameters', 'STEP 4: Site Index', 'STEP 5: Harvest Regime', 'STEP 6: Financial Parameters', 'STEP 7: Financial Transactions', 'STEP 8: Market Stumpage Prices', and 'STEP 9: Results'. The 'Basic Information' tab is active. Below the navigation bar, there are buttons for 'Clear', 'Restart', 'Export', and 'Load'. The main content area is titled 'Basic Information' and contains a warning: 'Warning: Do NOT use your browser's BACK button. Use the buttons below or menu items to navigate the simulator.' There is a 'Tutorial' link with a play button icon. The 'Simulator:' section has a dropdown menu with 'Natural Loblolly Pine' selected. Below this, there is a paragraph of text explaining the simulator's capabilities and a link to 'Read more about the Natural Loblolly Pine Simulator Model...'. The 'Stand Name:' section has a text input field with the placeholder 'Enter any identifying name for the stand (30 characters or less)'. The 'Narrative Text:' section has a larger text input field with the placeholder 'Enter any miscellaneous comments about the scenario which should appear at the top of the report(s)'.

Figure 2. Step 2: Selecting the simulator and providing information about the stand.

The screenshot shows the 'eYield Simulator' interface, Step 3: Stand Parameters. The 'Simulator Model:' is 'Natural Loblolly Pine'. There are buttons for 'Clear', 'Restart', 'Export', and 'Load'. A 'Reports' section with several icons is visible. The main content area is titled 'Stand Parameters' and contains a warning: 'Warning: Do NOT use your browser's BACK button. Use the buttons below or menu items to navigate the simulator.' There is a 'Tutorial' link with a play button icon. The 'Number of Acres:' section has a text input field with '100' entered. The 'Reference Year:' section has a text input field with '2023' entered. The 'Pulpwood top diameter (inches):' section has a text input field with '2' entered. The 'Log Rule:' section has a dropdown menu with 'International' selected. The 'Stand Age:' section has a text input field with '20' entered. The 'Cubic feet per cord conversion equation:' section has a text input field with '77.1' entered, followed by a '+' sign, a text input field with '1.4' entered, followed by an 'x' sign, and 'DBH'. The 'Subject to a minimum of 50 cubic feet per cord and a maximum of:' section has a text input field with '110' entered. The 'Stocking Specifications:' section has a dropdown menu with 'Basal Area per Acre' selected. The 'Basal Area / Acre (ft²):' section has a text input field with '90' entered.

Figure 3. Step 3: Entering stand size, reference year, and basal area per acre; identifying the applicable log rule and conversion factor.

eYield Simulator

STEP 4: **Site Index**

Simulator Model: Natural Loblolly Pine Number of Acres: 100 Basal Area: 90 ft²

Site Index

Warning: Do NOT use your browser's BACK button. Use the buttons below or menu items to navigate the simulator.

Calculation Method: Manual Entry

Base Age: 25

Site Index (@25): 75

CANCEL / BACK SUBMIT / NEXT

Figure 4. Step 4: Selecting site index base age and entering site index value.

eYield Simulator

STEP 5: **Harvest Regime**

Simulator Model: Natural Loblolly Pine Number of Acres: 100 Basal Area: 90 ft² Site Index (@25): 75

Harvest Regime

Warning: Do NOT use your browser's BACK button. Use the buttons below or menu items to navigate the simulator.

You must include at least one harvest to move beyond this point.

Stand Age: *	Year:	Harvest Method: *	Residual BA/acre: *	% Expense: *
X 20	2023	Partial-cut - Low	70	10
X 20	2023	Partial-cut - Low	70	10
X 40	2043	Final harvest	0	10

+ Add 1 Row

CANCEL / BACK SUBMIT / NEXT

Figure 5. Step 5: Identifying planned harvest activities in eYield.

Evaluating Small Forests

eYield Simulator

[Simulator Reports](#)
[Basic Information](#)
[Stand Parameters](#)
[Site Index](#)
[Harvest Regime](#)
STEP 6: Financial Parameters
[STEP 7: Financial Transactions](#)
[STEP 8: Market Stumpage Prices](#)
[STEP 9: Results](#)

Simulator Model: Natural Loblolly Pine
Number of Acres: 100
Basal Area: 90 ft²
Site Index (@25): 75

Financial Parameters

Warning: Do NOT use your browser's BACK button. Use the buttons below or menu items to navigate the simulator.

Planning horizon minimum year: 2023
Planning horizon maximum year: 2043

Marginal federal income tax rate: 25
Capital gains tax rate: 25

Before-tax discount rate: 5
After-tax discount rate: 3.75

Figure 6. Step 6: Providing information concerning time horizon, tax rates, and discount rates of future revenues and costs.

eYield Simulator

[Simulator Reports](#)
[Basic Information](#)
[Stand Parameters](#)
[Site Index](#)
[Harvest Regime](#)
[Financial Parameters](#)
STEP 7: Financial Transactions
[STEP 8: Market Stumpage Prices](#)
[STEP 9: Results](#)

Simulator Model: Natural Loblolly Pine
Number of Acres: 100
Basal Area: 90 ft²
Site Index (@25): 75

Financial Transactions

Warning: Do NOT use your browser's BACK button. Use the buttons below or menu items to navigate the simulator.

Type	Description	First Year	Last Year	Repeat Every	\$ Amount	Per	Trees per Acre	% Inflation
X Reforestation Expense	Site preparation	2043	2043		130	Acre		1
X Reforestation Expense	Planting	2043	2043		55	Acre		1
X Income, Ordinary Taxable	Hunting lease	2023	2043	1	15	Acre		1

Figure 7. Step 7: Entering financial transaction information in eYield.

eYield Simulator

Simulator Reports Basic Information Stand Parameters Site Index Harvest Regime Financial Parameters Financial Transactions

STEP 8: Market Stumpage Prices STEP 9: Results

Clear Restart Export Load

Simulator Model: Natural Loblolly Pine Number of Acres: 100 Basal Area: 90 ft² Site Index (@25): 75

Reports: [Icons]

Market Stumpage Prices

Warning: Do NOT use your browser's BACK button. Use the buttons below or menu items to navigate the simulator. Tutorial: [Play]

Sawlog Products

Product Name:	Low-End DBH: *	High-End DBH: *	% Inflation: *	Price: *	Minimum Sale:
X Sawtimber	11	40	1	27 /Ton	0

+ Add 1 Product

Pulpwood Products

Product Name:	Low-End DBH: *	High-End DBH: *	% Inflation: *	Price: *	Minimum Sale:
X Pulpwood	5	9	1	7 /Ton	0

+ Add 1 Product

Other Products

Product Name:	Low-End DBH: *	High-End DBH: *	% Inflation: *	Price: *	Minimum Sale:
X Chip-n-saw	9	11	1	15 /Ton	0

+ Add 1 Product

CANCEL / BACK SUBMIT / NEXT

Figure 8. Step 8: Entering stumpage price information in eYield.

OUTCOMES INFORMATION FROM EYIELD

The outcomes produced by eYield include a report that details the financial profitability of the management regime that was specified for the simulated forest. Here, the report may provide a net present value (or worth), internal rate of return, benefit/cost ratio, and other financial metrics, depending on the simulator selected and the characteristics of the management regime. A report describing cashflow provides additional detail of the financial outcomes (before and after tax) each year of the planning horizon and the cashflow during the years where a transaction (harvest, reforestation expense, hunting lease income, etc.) occurred.

During years in which a harvest activity has been specified, a growth and harvest report describes the pre-harvest forest conditions (basal area and trees per acre by tree diameter class), the amounts of basal area and trees per acre scheduled for harvest, and the residual (standing) conditions after the harvest. This report informs a market conversion report, which details the types of products scheduled for harvest, the volume and weight of the products scheduled for harvest, and the value of these products. Finally, a woodflow summary report condenses the market conversion information into a simple description of the amount of each forest product projected for harvest, along with the per-acre value of these products (Figure 9).

CONCLUSION

As an alternative source of information for the management of small private forests in the eastern United States, eYield may provide Extension agents and forest landowners with insight into the economic potential of management practices. Periodically, forest landowners should assess options for the management of their forests to understand the economic trade-offs associated with both actions (such as harvests) and inactions (such as harvest deferment for carbon sequestration purposes). The time between assessments will certainly vary based on land-



WOODFLOW SUMMARY REPORT

STAND NAME:
ACREAGE: 100*

Management Plan:

This is a natural loblolly pine stand with a site index of 75 (base age 25).
 In 2023 a low-cut harvest was executed, leaving 70 square feet of residual basal area per acre.
 In 2023 a low-cut harvest was executed, leaving 70 square feet of residual basal area per acre.
 In 2043 a final-cut harvest is planned, leaving 0 square feet of residual basal area per acre.

Present year:	2024
Site index (base age 25):	75
Stand age (years):	21
Basal area (ft ² /acre):	90

	Standing		Harvested		Marketable				
	Age	Basal Area	Basal Area	TPA	Product	MBF	Cords	Tons	Value
2023	20	70	19.61	80.63	Pulpwood	-	5.56	12.15	\$84.20
2023	20	70	19.61	80.63	Pulpwood	-	5.56	12.15	\$84.20
2043	40	0	121.16	62.25	Sawtimber	23.44	-	160.42	\$5,232.64
			121.16	62.25	Pulpwood	-	4.93	5.38	\$45.48
						23.44	4.93	165.79	\$5,278.12

Figure 9. Example woodflow summary report from eYield.

owner concerns for future revenues, but practically speaking, these assessments might occur every 3–5 years as forests change in character. An Extension agent may also incorporate eYield into their programming and outreach efforts to illustrate forest management options to landowners who own naturally regenerated forests and who are interested in potential financial returns from these forests. Given the relatively accessible nature of eYield, short demonstrations of the projected outcomes from managing a stand of trees could be of interest to these landowners. The range of analyses is limited to natural forests, yet the analyses can be of value to the roughly 80% of private landowners who have yet to seek advice from others regarding the management of forests they own. The flexible approach in which an Extension agent can define a management problem facilitates some very refined analyses that allow exploration of options when costs and prices may be somewhat uncertain.

ACKNOWLEDGMENT

This work was supported by the U.S. Department of Agriculture, National Institute of Food and Agriculture (Award number 2018–68006–28095).

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