ECONHDWD:

A MODEL FOR THE ECONOMIC ASSESSMENT OF REDUCING HARDWOOD COMPETITION IN UNTHINNED LOBLOLLY PINE PLANTATIONS

by

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PREFACE

This bulletin presents a model to aid in making hardwood competition control decisions for unthinned loblolly pine plantations. The model is written for Windows 95, 98 or NT and is available for IBM compatible machines. Those wishing to obtain copies of the software should contact:

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To defer the cost of development, a charge of $60.00 will be made for the executable code. Checks should be made payable to the Department of Forestry, VPI.

Although the software presented here has been extensively tested and checked for accuracy and, to the best of our knowledge, contains no errors, neither Virginia Tech nor the authors claim any responsibility for any errors that do arise.

ABSTRACT

A model, called ECONHDWD, for assessing the economic consequences of vegetation management on the pine component of unthinned loblolly pine plantations was developed from the stand model (HDWD) of Burkhart and Sprinz (1984). Input requirements include stand information, utilization conversions and limits, costs, prices and discount rate. Stand and stock tables for the planted pine component are produced for stands with and without reduction in hardwood competition; users can also obtain an estimate of the volume in hardwood pulpwood. In addition, for a specified pulpwood or sawlog regime, an economic analysis can be obtained which includes net and gross harvest value, net present value, internal rate of return and the marginal rate of return on the hardwood reduction operation.

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Objective

Interest in vegetative management is increasing as the number of established pine plantations on cutover sites increases. Management decisions concerning the amount and timing of early reduction of hardwood competition require information regarding the biological and economic consequences of hardwood reduction on the residual stand over time. The objective of this bulletin is to present and describe a model for assessing the biological and economic consequences of reducing hardwood competition in unthinned loblolly pine (*Pinus taeda* L.) plantations.

Background

Burkhart and Sprinz (1984) presented a model for predicting the biological effects of hardwood competition on pine survival, growth and yield. Using that model as a base, ECONHDWD was developed to assess the economic feasibility of various vegetation management strategies.

ECONHDWD is an interactive program that provides yield and economic predictions for the planted component of unthinned loblolly pine plantations under various vegetative management strategies. Users can also obtain an estimate of hardwood pulpwood in these plantations.

Limitations in the use of ECONHDWD exist due to the data available, modeling methodology used and assumptions made with the underlying model. The limitations are as follows (Burkhart and Sprinz 1984):

1. The levels of hardwood competition cannot be related to specific treatments. The proportion of basal area in hardwoods must be input by the user based on past experience and judgment.

2. The model does not account for hardwood species composition. Differential effects from competing hardwood vegetation might result from variations in species composition.

3. The model applies only to unthinned stands. If thinnings are carried out, some of the assumptions of the model (such as a constant ratio of hardwood basal area to total stand basal area) may not be valid.

4. Only analyses of hardwood competition in the main canopy can be performed. The effects of controlling understory vegetation and of controlling grasses and herbs at the time of seedling establishment cannot be evaluated. (It may be possible to model these effects through a shift in stand age, but more data are needed before recommendations can be made.)

5. Release treatments cannot be evaluated unless they are performed early in the life of the stand so that stand development in the released stand can be assumed to be the same as in a plantation that has the same level of hardwood competition but has not been released. If the release treatment has a direct effect on the pine - such as causing mortality, a loss of a portion of a season's growth, or acting as a growth stimulant - then adjustment in the pine variables (trees surviving, age, site index) should be made to reflect these effects.

A range of analyses can be performed on reducing hardwood competition at the time of site preparation or after stand establishment. Analyses involving costs from site preparation techniques designed to reduce hardwood competition can be accomplished by assigning those costs to the cost of hardwood reduction. Similarly, analyses of reducing hardwood competition after stand establishment can be performed provided that stand development in the released stand can be assumed to be the same as in a plantation with the same level of hardwood competition that has not received the release treatment. Since hardwood reduction treatments occurring after age 9 may result in the release of pine, only hardwood reduction treatments occurring prior to age 10 can be evaluated using ECONHDWD.

In this bulletin, the inputs required, output obtained and program details for ECONHDWD are discussed. Information on the data and modeling methodology for the stand model (HDWD) can be found in Burkhart and Sprinz (1984).

Modifications to HDWD

Several modifications were made to the growth and yield model HDWD when structuring ECONHDWD. Since HDWD was developed and published, additional plot remeasurement data have been collected and used to reestimate the parameters in the site index equation. The updated parameter estimates, which follow, were incorporated into ECONHDWD:

$$\ln(H_d)=\ln(S)(25/A)^{-0.02205}\, e^{-2.83285(A^{-1}-25^{-1})}$$

where:

H_d = average height of dominant and codominant trees (ft)
S = site index (ft at base age 25 years)
A = age (years)
ln = logarithm base e

Subsequent to the release of HDWD, more appropriate individual tree volume and volume ratio equations from dominant, codominant and intermediate trees in

cutover, site-prepared loblolly pine plantations have been developed (Amateis and Burkhart 1987). These equations were incorporated into ECONHDWD.

Information developed recently (Burkhart and Bredenkamp 1989) on the proportion of trees by dbh class qualifying as sawtimber was also incorporated into ECONHDWD. For the sawtimber regime, a decreasing proportion of trees in the 8 to 15-inch dbh classes is designated as pulpwood material. This is an attempt to recognize that a varying proportion of trees in these dbh classes are not sawlog quality. The percentage of trees categorized as pulpwood in the sawtimber regime is as follows:

Dbh class (in.)	Percentage
≤7	100
8	51
9	27
10	16
11	10
12	6
13	4
14	3
≥15	0

An estimate of the volume in hardwood, in addition to the stand and stock tables for pine, was added to the growth and yield model. Assuming that hardwoods in cutover, site-plantations will be utilized for pulpwood, an estimate of the cubic-foot volume, outside bark, for all hardwood trees in the 5-inch dbh class and above to a 4-inch top diameter (ob) was desired. Volume for hardwoods was computed, by species group, using the equations from Bowling *et al.* (1989); volumes for volunteer pines were computed using the volume equations in Amateis and Burkhart (1987).

Data from a hardwood conversion/site preparation study at the Fayette Experimental Forest of the Auburn University Agricultural Experiment Station in Fayette County, Alabama, were used to develop an estimate of the basal area of the nonplanted pine component of plantations. We assumed that the basal area for old field loblolly pine plantations represents an upper limit of stand basal area and used the following equation (Burkhart and Sprinz 1984) to estimate this upper limit:

$$\log B = 0.38749 + 1.121332 \log H_d + 0.975619/A - 92.324443/T_s \quad (1)$$

where:

B = basal area (sq ft/ac) of loblolly pine plantations on old field sites
H_d = average height of dominants and codominants (ft)
A = plantation age (years)
T_s = number of trees/ac surviving
log= logarithm base 10

Then the following model was postulated:

$$Y = X_1 + ß_1 X_2 + e_i \quad (2)$$

where:

Y = upper limit of stand basal area (estimated from equation (1))
X_1 = observed basal area of pine (sq ft/ac)
X_2 = observed basal area of hardwood (sq ft/ac).
e_i = random error

Model (2) was fitted to the Fayette data using linear regression techniques and resulted in the following equation:

$$Y - X_1 = 1.5 X_2 \qquad (R^2) = 0.87 \quad (3)$$

Rearrangement leads to:

$$X_2 = \frac{Y - X_1}{1.5} \quad (4)$$

As an independent validation, basal area of hardwood was predicted with equation (4) for the 186 control plots in the VPI & SU Coop Thinning Study data set. In cases where predicted hardwood basal area was less than zero, the value was set equal to zero. Comparing predicted basal area of hardwood to the observed basal area of hardwood gave a mean residual (observed-predicted) of 1.59 square feet per acre. Plots of residuals versus age, site index (for pine), basal area of pine and basal area of hardwood revealed no strong patterns. Thus equation (4) was accepted and incorporated into ECONHDWD.

A stand volume function of the following form was desired:

$$V = ß_0 + ß_1(B_h)(H) + e_i \quad (5)$$

where:

V = cubic-foot volume per acre of hardwood
B_h = basal area of hardwood (sq ft/ac)
H = stand height (ft)
e_i = random error

Plotting average height of hardwood versus average height of dominant and codominant pines revealed a strong linear relationship. Since average height of dominant and codominant pines is an output of the stand model HDWD, it was used as the predictor variable in equation (5). Fitting equation (5) resulted in the following equation:

$$V = -20.86 + 0.2452(B_h)(H_d) \qquad (R^2 = 0.71) \qquad (6)$$

where:

V = cubic-foot volume per acre (ob) in the 5-inch dbh class and above to a 4-inch top (ob).

Equation (6) is used in ECONHDWD to predict volume per acre in hardwoods given basal area of hardwoods (B_h) in square feet per acre and average height of the dominant and codominant planted pines (H_d) in feet.

THE ECONHDWD ENVIRONMENT

The ECONHDWD software allows the user to quickly and easily setup, execute and analyze various decision scenarios. It can be run on any IBM compatible hardware with Windows 95 or newer operating system. Interaction with the model follows the usual Windows conventions. Output from the stand/stock table can be copied to the Windows clipboard and pasted into other applications for additional analyses.

INPUT PARAMETERS TO ECONHDWD

Input parameters to ECONHDWD supplied by the user are entered in the fields to the right of the labels. Parameters must be specified at the start of an ECONHDWD session and can be changed at any time. Saving an ECONHDWD session will save the last set of parameter estimates defined by the user. For details about entering data using the mouse or keyboard, see the online help under “Entering Input Data”. Below are brief descriptions of each input parameter.

STAND CONDITIONS

The six stand parameters are: (1) number of loblolly pine planted, (2) site index (base age 25), (3) stand age (age at which a yield prediction is desired and it is also used as the harvest age for the economic analysis), (4) Hardwood control (selecting NO produces only one stand/stock table which does not reflect controlling any hardwoods; selecting YES produces two stand and stock tables in the output. The first reflects no control and the second reflects the effect of controlling hardwoods by the percent of hardwood basal area removed due to control), (5) percent of the total stand basal area in hardwoods, (6) percent of the hardwood basal area reduced due to hardwood control, (7) age of hardwood control.

MERCHANTABILITY / CONVERSIONS

There are eight merchantability and conversion parameters for ECONHDWD. They are: (1) cubic feet (outside bark) per cord for pine, (2) cubic feet (outside bark) per cord for hardwood, (3) board feet per cubic foot (outside bark), (4) minimum dbh for total yield (inches), (5) minimum dbh for pulpwood (inches), (6) minimum dbh for sawtimber (inches), (7) minimum outside bark top diameter for pulpwood (inches), (8) minimum outside bark top diameter for sawtimber (inches).

ECONOMIC CHOICES

In the Options menu, selecting the "Include Economic Analysis" option displays the ECONOMIC CHOICES parameter list. This parameter list consists of two user defined variables. The first is Saw/Pulp analysis. This variable is for deciding whether the economic analysis will be performed for a pulpwood or sawtimber product objective. If pulpwood is selected, all merchantable volume is assumed to be pulpwood and only pulpwood prices and costs are applied. If sawtimber analysis is selected, the stand volume is merchandized into both solid wood products and pulpwood according to the specified dbh and top limits of each. Topwood from the sawtimber-sized trees is assumed to be merchandized as pulpwood and included in the pulpwood volume.

The second economic choice is to include or not include the pulpwood-sized value of hardwoods in the analysis. Selecting NO does not include the value of hardwoods. Selecting YES includes the value of hardwoods in the analysis.

COSTS

There are eight costs needed by the economic model:

- Site preparation costs ($/acre)
- Seedling costs ($/thousand).
- Planting costs ($/acre).
- Hardwood reduction costs ($/acre)
- Harvest costs for pine pulp ($/cord) - this is the harvesting and hauling costs associated with obtaining the pine pulpwood. If this cost is specified, then prices should be F.O.B. mill price. If this cost is set to zero, then prices should be stumpage prices.
- Harvest costs for hardwood pulp ($/cord) - this is the harvesting and hauling costs associated with obtaining the hardwood pulpwood. Again, prices should be F.O.B. mill price if this cost is specified as other than zero. If it is zero, then prices should be stumpage prices.
- Harvest costs for sawtimber ($/MBF) - this is the harvesting and hauling costs associated with obtaining the pine sawtimber. Prices should be F.O.B. mill price if this cost is specified as other than zero. If it is zero, then prices should be stumpage prices.

- Maintenance costs ($/acre/year) - this is the annual maintenance cost.

PRICES and RATES

There are three prices plus the discount rate needed by the economic model:

- Pine pulpwood price ($/cord) - if the harvest cost of pine pulpwood is other than zero, then this price is F.O.B. mill. Otherwise it is a stumpage price.
- Hardwood pulpwood price ($/cord) - if the harvest cost of hardwood pulpwood has been specified as other than zero, then this price is F.O.B. mill. Otherwise it is a stumpage price.
- Pine sawtimber price ($/MBF) - this is the price for pine sawlogs. Again, it is F.O.B. mill when the harvest/haul cost is not zero. If the harvest/haul cost for sawtimber is zero, then this price is a stumpage price. It should be noted that the price per MBF can be modified easily to account for different log rules.
- Discount rate (percent) - this should be the real rate when prices and costs are not adjusted for inflation. Otherwise, a nominal rate should be used.

GRAPHING OUTPUT

By selecting the "Include Diameter Graph" menu option the user can view graphically the results from the growth model. It is possible to view the distribution of number of trees, total height, total volume, pulpwood volume or sawtimber volume by dbh class. To view a comparison graph of the control versus the no control for the chosen distribution, select the overlay option.

Stand/stock table output

Stand and stock tables are displayed for unthinned pine stands without and with (if specified) reduction in hardwood competition. Stand summary information, including number of planted pine (trees/ac), site index, percent basal area in hardwood and stand age is presented at the top of the stand and stock table. Then stand and stock tables, using 1 in. dbh classes and totals where appropriate, are given with the following information:

Number of surviving pine (tree/ac)
Total height (ft)
Total basal area of pine (sq ft/ac)
Total yield of planted pine 1 in. dbh and greater (cu ft/ac)
For a pulpwood economic analysis regime, the pulpwood yield of planted pine according to the minimum dbh and maximum top diameter specified (cu ft/ac) is shown.

For a sawlog economic analysis regime, the merchantable yield (cu ft/ac) is divided between the sawlog and pulpwood (including topwood) portions to the minimum dbh and maximum top diameters specified.

Arithmetic mean dbh of all pine trees 1 in. dbh and greater (in.)

Hardwood pulpwood volume of all hardwood trees in the 5-inch dbh class and above to a 4-in. top diameter (cu ft/ac).

Stand/Economic summary table

Following the stand and stock tables, a table of stand and, if specified in the input, before-tax economic summary characteristics is displayed for the specified management regime. Values for the pine and hardwood component of stands without and with (if specified in the input) reduction in hardwood competition are given for the following:

Stand Characteristics

Arithmetic mean dbh of all trees 1 in. dbh and greater
Number of surviving pine (trees/ac)
Total basal area of pine (sq ft/ac)
Yield according to the management scenarios and limits specified (cu ft/ac)
Hardwood yield (pulpwood, cu ft/ac)

Economic Characteristics

Gross value at the time of harvest ($/ac) of the timber without consideration of harvesting and hauling costs
Net value at the time of harvest ($/ac) of the timber after harvesting and hauling costs have been deducted
Net present value of discounted net costs and revenues to age zero ($/ac)
Internal rate of return (%)
Rate of return (%) on the hardwood control operation

The economic analysis is based on a before-tax comparison of costs and prices associated with and without reducing hardwood competition. The discounted cash flow criteria (i.e., net present value and internal rate of return) are based on a year zero reference point. This means that the net present value of the treated stand is at the time of planting, or year zero. Both planting and site preparation are assumed to occur in year 0. The rate of return on the hardwood control operation is a calculated value based on incremental changes in costs and net value between the control and no control operations. It reflects the marginal rate of return of performing the hardwood reduction operation. All cash flows are on a pre-tax basis. Finally, it should be noted that the economic analysis is for one rotation (not infinite rotations).

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