Valuing Young Timber Scheduled for Future Harvest

by W. David Klemperer

There are often substantial differences in the price per unit volume of timber, depending on whether it is slated for immediate or future harvest. Value for immediate cutting purposes will be called “stumpage value” or “immediate harvest value” (IHV), while value for future harvesting will be called market value, or net present value (NPV) of future timber income. Previous articles have explained these differences for large inventories of old slowly growing timber.¹ In this article, the differences in price for rapidly growing young timber are explained, using present value analysis applied to models of southern pine forests.

The concepts reviewed have important implications for timber appraisal. A realistic market value, or most likely purchase price for timber held for future harvest, generally cannot be obtained by simply multiplying standing timber volumes by stumpage price per unit volume. Market values of forest tracts for deferred cutting may be below, above, or equal to current stumpage values. For rapidly growing immature timber, as opposed to old growth, market value is more likely to exceed stumpage value, although no rigid rules can be applied. In the absence of comparable sales, discounted cash flow (DCF) should be used to value timber held for future cutting.

IMMEDIATE HARVEST VALUE VERSUS MARKET VALUE

Figure 1 illustrates the difference between IHV and market value in rapidly growing even-aged timber. To demonstrate general principles, exact units on both axes are omitted. The solid “liquidation value” curve shows the net income per acre that could be derived by clear cutting and selling the bare land for $L (land value) per acre.

In Figure 1, R represents the economically optimal harvest age beyond which the annual percentage increase in forest liquidation value drops below the rate of return available on other investments of equal risk, or the discount rate. Taxes and other costs are temporarily ignored—ultimately, liquidation value must rise rapidly enough to cover taxes and other costs, plus the after-tax discount rate. Because of the nature of biological growth functions, even-aged forest liquidation values usually follow the shape of the solid curve in Figure 1. Timber buyers planning to postpone harvest until R, will tend to pay a market value equal to the NPV of future liquidation income.


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At ages less than $R$, forest market value exceeds current liquidation value because the liquidation value curve rises faster than the competitive discount rate used to compute present value of future income due at $R$. For example, in species such as loblolly pine, at certain ages merchantable volume growth can be 10% to 20% or more annually, and even greater in terms of value growth if timber quality and stumpage prices increase. Under competitive conditions, bid prices for immature forests often follow the shape of the broken curve for market value in Figure 1. The bid prices rise from land value ($L$) plus regeneration costs for newly reforested land, to the IHV plus $L$ at $R$.\(^2\) W.R. Sizemore,\(^3\) E.C. Frazer,\(^4\) and Bennett and Peters, Inc.,\(^5\) have recorded sale prices of timber in the South during the 1970s that exceed stumpage value on large tracts containing immature timber of various ages.

In contrast to the foregoing cases, consider a situation in which the harvest must be postponed beyond $R$ to age $R'$ in Figure 1 because of excess timber inventories. In such an instance, if stumpage value is growing slowly enough, market value could be below IHV, as shown by the dotted curve in Figure 1. Both the dotted and broken curves for market value in Figure 1 represent the present value of future liquidation income. Because of the nature of declining tree growth rates for any given species scheduled for future harvest and any given fixed rate of real stumpage price growth, the older the stand, the more likely it is that market value will he below IHV. Conversely, under the same constraints, the younger the stand, the more likely it is that market value will he above IHV. For any given aged timber, however, the higher the real discount rate and the lower the expected future stumpage prices, the more likely it is that market value will be below IHV, as has occurred in some recent sales of young southern pine timber.

**MULTIAGE CLASS FORESTS**

The above discussion focused on tracts of timber with a single age class, however, most large tracts contain several age classes. Figure 2 provides a simple model of a forest with one acre each in four age classes. The oldest class is rotation-aged and should be cut now; the others should be cut at intervals equal to one-fourth the rotation age. With a 36-year rotation, harvests should occur now and every nine years after, in perpetuity. Large tracts will often have more age classes, a more uneven age distribution, and yield more frequent harvests.

Assuming forestry is the highest and best use, a prospective buyer using NPV analysis to calculate a range of bid prices would capitalize the perpetual net after-tax income from the tract under various assumptions. Using the forest in Figure 2 as a model, hypothetical examples of present values are computed.

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FIGURE 1
Forest Value Relationships—Even-aged Timber, Constant Stumpage Price (not drawn to scale)

![Graph showing forest value relationships with different stages of timber age and value metrics like liquidation value, stumpage value, and market value.]

*Present value of future liquidation income occurring in year \( R \)*

FIGURE 2
Four-Acre, Four-Age-Class Forest, 36-Year Rotation, Even-aged management

<table>
<thead>
<tr>
<th>Current age</th>
<th>36 years</th>
<th>27 years</th>
<th>18 years</th>
<th>9 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut now and every 36 years thereafter</td>
<td>Cut in 9 years and every 36 years thereafter</td>
<td>Cut in 18 years and every 36 years thereafter</td>
<td>Cut in 27 years and every 36 years thereafter</td>
<td></td>
</tr>
</tbody>
</table>
NUMERICAL EXAMPLE

Assuming the forest in Figure 2 is composed of well-stocked loblolly pine on average sites in the Southeast, Table 1 shows pulpwood and sawtimber volumes and typical stumpage values for the Florida-Georgia-Alabama area in early 1984. Under these assumptions, if the four-acre forest were clearcut, gross IHV would be $3,936. However, if managed on a sustained yield basis, gross income would be $2,053 now and every nine years after.

Table 2 shows NPVs based on the above sustained yield income for several after-tax capitalization rates and rates of stumpage price growth. The forest values are the present value of a perpetual periodic income of $2,053 now and every nine years after, minus the present value of all future taxes and other costs, as computed using Equation 7 in the Appendix. Sample values for all calculations based on a 13% nominal interest rate (5.6% real) and a 10% nominal annual stumpage price growth rate (2.8% real) appear in brackets in the Appendix. The following additional assumptions were made, several of which are subsequently changed.

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**TABLE 1. Age Class Volumes and Immediate Harvest Values (IHVs) for Four-Acre, Four Age-Class Loblolly Pine Forest**

<table>
<thead>
<tr>
<th>Age (yrs)</th>
<th>Pulpwood</th>
<th></th>
<th></th>
<th>Sawtimber</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cords* /acre</td>
<td>IHV† $24/cord ($/acre)</td>
<td>MBF* /acre</td>
<td>IHV† $/MBF</td>
<td>IHV† ($/acre)</td>
</tr>
<tr>
<td>9</td>
<td>2.3</td>
<td>$ 55</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>19.2</td>
<td>$461</td>
<td>0.603</td>
<td>$160</td>
<td>$ 96</td>
</tr>
<tr>
<td>27</td>
<td>25.9</td>
<td>$622</td>
<td>3.866</td>
<td>168</td>
<td>649</td>
</tr>
<tr>
<td>36</td>
<td>23.6</td>
<td>$566</td>
<td>8.447</td>
<td>176</td>
<td>1,487</td>
</tr>
<tr>
<td>Total IHV =</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* MBF = thousand board Feet. Site index is 80 ft. (base-age, 50 year). Based on normal basal areas from the U.S. Forest Service (USFS)⁶ and yield equations in 5.11. Burkhart R.C. Parker, and R. S. Oderwald.⁷ Pulpwood to 4” lop, sawtimber to 6” top, international ¼” rule. Assumes full stocking.
† IHV or stumpage value. Based on January 1984 averages for Florida, Georgia, and Alabama from Timber Mart-South,⁸ computing slight increases in value for increasing percentage of peeler logs with greater stand age.
‡ Stumpage receipts if all four acres are clearcut immediately

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<table>
<thead>
<tr>
<th>Nominal Discount Rate (including 7% inflation)</th>
<th>11% (3.74)</th>
<th>13% (5.61)</th>
<th>15% (7.48)</th>
<th>20% (12.15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Real rates in parentheses)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nominal rate of stumpage increase</td>
<td>7% (0)</td>
<td>8.5 (1.40)</td>
<td>10 (2.80)</td>
<td>11.5 (4.21)</td>
</tr>
<tr>
<td>(real rate in parentheses)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forest Value†</td>
<td>$5,122</td>
<td>$6,580</td>
<td>$8,757</td>
<td>$12,033</td>
</tr>
<tr>
<td>Timber Value†</td>
<td>$3,922</td>
<td>$5,380</td>
<td>$7,557</td>
<td>$10,833</td>
</tr>
<tr>
<td>Valuation Factor</td>
<td>1.00</td>
<td>1.37</td>
<td>1.92</td>
<td>2.75</td>
</tr>
<tr>
<td>Forest Value†</td>
<td>$3,915</td>
<td>$4,663</td>
<td>$5,736</td>
<td>$7,295</td>
</tr>
<tr>
<td>Timber Value†</td>
<td>2,715</td>
<td>3,463</td>
<td>4,536</td>
<td>6,095</td>
</tr>
<tr>
<td>Valuation Factor</td>
<td>0.69</td>
<td>0.88</td>
<td>1.015</td>
<td>1.905</td>
</tr>
<tr>
<td>Forest Value†</td>
<td>$3,312</td>
<td>$3,757</td>
<td>$4,373</td>
<td>$5,236</td>
</tr>
<tr>
<td>Timber Value†</td>
<td>$2,112</td>
<td>$2,557</td>
<td>$3,173</td>
<td>$4,036</td>
</tr>
<tr>
<td>Valuation Factor</td>
<td>0.54</td>
<td>0.65</td>
<td>0.81</td>
<td>1.03</td>
</tr>
<tr>
<td>Forest Value†</td>
<td>$2,624</td>
<td>$2,795</td>
<td>$3,014</td>
<td>$3,300</td>
</tr>
<tr>
<td>Timber Value†</td>
<td>$1,424</td>
<td>$1,595</td>
<td>$1,814</td>
<td>$2,100</td>
</tr>
<tr>
<td>Valuation Factor</td>
<td>0.36</td>
<td>0.41</td>
<td>0.46</td>
<td>0.53</td>
</tr>
</tbody>
</table>

*Effective state and federal capital gain tax rate = 31%. Effective Management costs = $2/acre. Reforestation cost = $140/acre
†Net present value using equation 7 in Appendix
‡Assumes bare land value is $300/acre, or $1,200 in total
§Valuation factor, or timber value as a decimal percentage of the $3,936 IHV (timber value / IHV): Shaded areas show probable realistic ranges of valuation factors
1. Real stumpage price-increases, where relevant, continue for the first rotation only (36 years), and remain constant thereafter.
2. Reforestation costs at $140 per acre, based on extrapolations from R.W. Guldin, and J.E. Moak, W.F. Watson, and M.S. Watson. \(^9\)
3. Corporate buyer in early 1984, with combined effective federal and state capital gain tax rate of 31%. Currently higher tax rates would decrease valuation factors, but general relationships in Table 2 would still hold.
4. Effective costs for management and property taxes are $2 per acre per year, after tax savings from deductibility for ordinary income tax purposes.
5. Projected inflation is 7% annually. This is high for 1984, but is used to make a contrast with the 0% inflation in the sensitivity analysis. Slightly overestimating inflation causes capital gain taxes to be slightly higher and present values slightly lower. Real rates of stumpage price growth and real capitalization rates will be \((1 + n)/(1 + f) - 1\), where \(n\) is the relevant nominal rate and \(f\) is the inflation rate (all in decimals).
6. Bare land value is $300 per acre and all of one average site quality, based on extrapolations from A. Pleasonton and J.E. de Steiguer for rural southern timberlands.
7. There is no fertilization or thinning, and rotation length is 36 years, assuming management for sawlogs and peelers in addition to pulpwood. Economically optimal rotations are often shorter in loblolly pine, especially for pulpwood only, in which case they can be 25 years or less. \(^13\)
8. Forestry is the highest and best use, so that timber income is projected in perpetuity.
9. Timber is even-aged within each age class.

Under each interest rate in Table 2, the left-most column is the present value of gross forest revenue, minus present value of costs including taxes. The second column shows timber value as forest value minus land value (land value is 4 x $300 = $1,200). The last column under each interest rate is the “valuation factor,” or timber NPV as a decimal percentage of the $3,936 IHV.

If we consider the timber value columns in Table 2 as potential bid or market prices for timber, the valuation factor columns show that for several scenarios, prices paid for timber could exceed the IHV of $3,936. For example, given a nominal capitalization rate of 13% (5.61% real) and an annual stumpage price growth of 10% (2.8% real), the valuation factor is 1.15, which means timber value is 15% above IHV.

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It is beyond the scope of this article to make stumpage price projections or determine timber buyers’ discount rates. Thus, a wide range is shown for both variables. However, studies in the 1970s and early 1980s projected increases in southern softwood stumpage prices. For example, a widely cited report projected a real softwood stumpage price growth rate of about 2.6% annually in the Southeast between 1976 and 2020 for a composite of all timber products.\(^{14}\)

To put the Table 2 capitalization rates in perspective, a review of several studies before the mid-1970s shows average real rates of return on very low-risk investments to be less than 3% and average real returns to U.S. corporate capital, debt and equity combined, to be roughly in the 6% range—all after taxes.\(^{15}\) Depending on anticipated inflation, the above rates in nominal terms could be significantly higher. This does not say anything about actual capitalization rates used by timberland buyers, but it does suggest the relative risk levels associated with the capitalization rates shown in Table 2.

The upper-right and lower-left portions of Table 2 show unrealistic valuation factors based on the $300 per-acre land value (see assumption 6). For example, buyers of mixed-aged southern timber are not paying the 20 times IHV shown in Table 2 under a real after-tax hurdle rate of 3.74% and real annual stumpage price growth of 11.21%. Anyone using such a risky price projection is not likely to use such a low-risk interest rate. Likewise, no one in the South buys timber for the 36% of IHV shown under a 12.15% real after-tax hurdle rate and a 0% real stumpage price growth rate. The high-risk capitalization rate is too high for the low-risk price projection.

In general, the valuation factors along the upper-left, lower-right diagonal in Table 2 reflect the range of 5% to 25% premiums paid above current stumpage prices for large, young-growth southern pine tracts in the 1970s, as reported by E.C. Frazer,\(^{16}\) and Bennett and Peters, Inc.\(^{17}\) However, more recent sales of southern young growth timberlands (not for immediate harvesting) indicate that the prices paid are sometimes 10% to 20% below current stumpage values.\(^{18}\) This can be explained by higher real interest rates in the early 1980s and less optimistic views about future stumpage prices resulting from softer housing markets and increasing competition from Canadian lumber imports. This depressing effect on present value can be seen for the model tract in Table 2. Moving the diagonal in Table 2 to the right to higher discount rates and lower rates of stumpage price increase, valuation factors quickly fall below 1, indicating a market value below current stumpage price. Thus the historic range of valuation factors, the shaded areas in Table 2, for tracts of young timber can be readily explained by NPV analysis.

\(^{16}\) Fraser.
\(^{17}\) Bennett and Peters, Inc.
If NPV were below IHV for a tract as small (four acres) as the model in Figure 2, the most logical action financially would be to harvest those acres for which stumpage value growth percentage is less than the discount rate. However, for very large properties, such liquidation may not be feasible or practical.

SENSITIVITY ANALYSIS

The timber valuation factors in Table 2 are highly sensitive to assumed rates of stumpage price increase and capitalization rates. In addition, other factors can influence the valuation factor. For example, consider the 1.15 valuation factor for the 13% capitalization rate and 10% annual stumpage price growth as a benchmark. Table 3 shows how this factor will vary by changing only one variable and keeping all other inputs the same as in Tables 1 and 2 for the benchmark case.

Table 3 shows that the following variables could increase valuation factors above those shown in Table 2: lower reforestation costs; lower inflation projections, which would reduce capital gain taxes; lower land value; and shorter rotations. In addition, a greater concentration of volume in the very young, rapidly growing age classes could also increase valuation factors, as could increased value growth through fertilization, genetic improvement, thinning, higher site quality, or relatively higher values for sawlogs and veneer logs. Conversely, reversing the above variables could depress valuation factors below those in Table 2. The last row in Table 3 shows that valuation factors would be depressed by the increase in corporate capital gain taxes under the Tax Reform Act of 1986 (34% federal, plus an estimated 4% effective state taxes, assuming deductibility of an average 6% state income tax). However, this reduction in the valuation factor from 1.15 to 1.06 is exaggerated because land values that were held at $300 per acre would probably be lower under the higher tax rate, thus increasing the value allocation to timber.

CONCLUSIONS

Tables 2 and 3 illustrate selected conditions under which valuation factors are likely to reach certain levels. The tables do not predict valuation factors for southern loblolly pine tracts; rather they explain historic differences between stumpage prices and prices paid for timber held for future harvest. Although stumpage and land value data are for 1984, the valuation factors in Tables 2
and 3 can be applied in a general sense to a wide range of years and to many types of young, rapidly growing timber. The important point is that valuation factors for young timber can vary widely, depending primarily on real interest rates and future stumpage price expectations.

The value relationships shown for the four-acre forest model could also be shown for a larger forest. For example, a 100,000-acre forest in the Table 1 framework would have 250,000 acres in each age class, with the same relationships between present value and IHV. A large tract would generally have more than four age classes and yield harvests more often than the nine-year interval of the small model. In addition, site qualities and species would vary, and age-class distributions would usually be more uneven. In practice, the present values of forests would have to be computed by discounting separately actual projected net incomes, rather than using the equations in the Appendix, which apply only to the model in Figure 2.

Another way in which size is an important factor, other things being equal, is that the IHV on a large tract may sometimes be greater than that of a small tract because of lower logging costs and general management and procurement economies. However, the price paid for such a tract may be above, equal to, or below its IHV, for the same reasons discussed here.

The recent high real interest rates and less optimistic views about future stumpage prices have sometimes depressed bid prices for young timber below current stumpage prices when harvest is postponed. If real interest rates drop or anticipated stumpage prices should rise, prices paid for large tracts of young timber could easily rise above current stumpage prices, as has often been true in the past.

Market values of large, young timber tracts held for future harvest will not necessarily equal IHVs. The IHV of such tracts could be multiplied by an average valuation factor from comparable sales to determine market value. The valuation factor for a tract that has been sold is its timber sale price (excluding land value) divided by the stumpage value of standing timber. In the absence of comparable sales with respect to size, timber ages, location, species, and so forth, DCF should be used to value large tracts, using as many inputs from the market as possible.

APPENDIX

PRESENT VALUE OF A FOUR-AGE CLASS, FOUR-ACRE YOUNG-GROWTH FOREST

Notation

All values are per acre, where relevant. Rates are in decimal form.

\[ H = \text{stumpage value per acre of rotation-age timber in year 0; } H, \text{ refers to the } n^{\text{th}} \text{ harvest value in current dollars} \]

\[ R = \text{rotation age in years} \]

\[ l = \text{real annual growth rate of } H \text{ (in decimals), first } R \text{ years; thereafter, } H \text{ is constant in real terms} \]
I = average annual inflation rate (in decimals)

g = nominal annual growth rate in stumpage value of R-year-old timber, for first R years (in decimals) where \( g = (1 + I)(1 + 1) - i; \) thereafter, H increases at the inflation rate only capital gain tax rate (applied to harvest value, minus basis) annual cost per acre (includes administration and property taxes), after considering income tax savings from deductibility against ordinary income

\[
C = \text{reforestation cost per acre (also the value of newly reforested timber); increases at the inflation rate over time, constant in real terms}
\]

\[
B = \text{basis (or original purchase cost) for each harvest, for capital gain tax computation; subscripts refer to harvest number}
\]

\[
b = \text{rate of progression (in decimals) of market value from one-age-class acre (timber alone) to the next, at purchase date, given that the market value of newly reforested timber (age 0) is C and R-year-old timber is H. Thus } b = R \frac{H}{C} - 1. \text{ [E.g., 5-year-old timber is valued at C(1 + b)^5; 10-year-old is C(1 + b)^10; etc. These become the deductible basis values for capital gain tax calculations at harvest dates.}]
\]

\[
r = \text{real after-tax discount rate (in decimals)}
\]

\[
i = \text{nominal after-tax discount rate (in decimals) } i = (1 + r)(1 + f)\]

\[
L = \text{market value of bare land per acre}
\]

**Gross Harvest Incomes (Figures in brackets for g= .10 and I= .13 in Table 2)**

Harvest incomes occur in years 0, .25R, .5R, .75R, R, and every .25R years thereafter. (E.g., if R = 20, harvests occur now, in 5, 10, 15 years... n) Therefore, the first five gross harvest incomes in current dollars are

\[
\begin{align*}
H_1 &= H \quad [2,053] \\
H_2 &= H(1 + g)^{.25R} \quad [4,840.87] \\
H_3 &= H(1 + g)^{.5R} \quad [11,414.51] \\
H_4 &= H(1 + g)^{.75R} \quad [26,914.82] \\
H_5 &= H(1 + g)^R \quad [63,463.73]
\end{align*}
\]

After year R, harvests remain at H5 in constant dollars and rise at the inflation rate in current dollars.
Basis for Capital Gains (Figures in brackets for \( g = .10 \) and \( i = .13 \) in Table 2)

Given that timber age classes are initially valued as defined under \( b \) in “notation,” the deductible basis for each harvest’s taxable capital gain computation is

\[
\begin{align*}
B_2 &= C(1 + b)^{75R} \quad [1049.12, \text{ where } b = .00741] \\
B_3 &= C(1+b)^{5R} \quad [536.12] \\
B_4 &= C(1+b)^{25R} \quad [273.96]
\end{align*}
\]

For the fifth and all subsequent cuts, the original purchase cost becomes \( C \), remaining fixed in constant dollars of year zero. The first cut involves no capital gain, hence basis is not relevant.

It would be more precise to let initial forest age-class values (timber plus land) progress at some rate, \( j \), so that forest value in any year \( n \) would be \((L + C)(1 + j)^n\), and timber basis would be this value minus \( L \). The simpler basis calculation used here approximates the foregoing and is used to permit later assignment of different market values for land.

Net Present Value of Harvest Income (Figures in brackets for \( g = .10 \) and \( i = .13 \) in Table 2)

Present value of the first cut (in year 0) of \( R \)-year-old timber is

\[
H_1 - C \quad [1913] \quad (1)
\]

After-tax present value of the second cut is

\[
\frac{H_2 - t(H_2 - B_2) - C(1 + f)^{25R}}{(1 + i)^{25R}} \quad [1134.49] \quad (2)
\]

After-tax present value of the third cut is

\[
\frac{H_3 - t(H_3 - B_3) - C(1+1)^{5R}}{(1 + i)^{5R}} \quad [838.74] \quad (3)
\]

After-tax present value of the fourth cut is

\[
\frac{H_4 - t(H_4 - B_4) - C(1 + f)^{25R}}{(1 + i)^{25R}} \quad [656.09] \quad (4)
\]

After-tax present value of the fifth and all subsequent cuts every .25\( R \) years is

\[
\frac{H_5 - t(H_5 - C) - C(1 + f)^{75R}}{(1 + r)^{75R} - 1} \quad [1,336.01] \quad (5)
\]

where the first term is present value of the perpetual harvest series, computed in year .75\( R \), in constant dollars of year \( R \). The second term discounts the first to year zero, and the third term
deflates the year R dollars to year zero dollars. Present value of perpetual annual costs on four acres, calculated in real terms is

\[
\frac{4a}{r} \quad [142.67] \quad (6)
\]


Entire forest present value, four acres, is

Equations 1 + 2 + 3 + 4 + 5 — Equation 6 \quad [5,736] \quad (7)

Timber value is forest value minus market value for four acres of bare land:

Equation 7 - 4L \quad [4,536, for L=300] \quad (8)

For a forest of n acres in each age class, values in Equations 7 and 8 are multiplied by n.

The above equations apply only to a forest with four evenly distributed age classes. However, the same general DCF procedures are applied by many timber buyers to tracts of any size and number of age classes, species, and site qualities.