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Thomas J. Straka, PhD, and Steven H. Bullard, PhD

Land Expectation Value Calculation in Timberland Valuation

Appraisers often use discounted cash flow (DCF) techniques to value timber and timberland. Land expectation value (LEV) is a standard DCF technique applied to many timberland situations. LEV calculates the value of bare land in perpetual timber production and is often used to value even-aged pine plantations. However, it is also useful in the valuation of immature timber stands and uneven-aged timber stands cut periodically. These models have wide applicability in timberland appraisal situations.

Discounted cash flow (DCF) analysis derives the net present value (NPV) of the net income stream produced by a property. It is a relatively simple calculation, applicable to many timberland appraisal situations. Forestry and timberland investment analysts commonly use a specialized DCF technique to calculate the value of bare land in timber production. Land expectation value (LEV) is simply the value of a tract of land used for growing timber. It is the NPV of all revenues and costs associated with growing timber on the land in perpetuity (not just those associated with one “rotation of timber” or other time period). LEV is thus a special case of DCF where a perpetual stream of revenues and costs are considered. LEV can be interpreted as the maximum price possible for a tract of timberland if a rate of return equal to the discount rate used to calculate LEV is expected.

If the NPV of all cash flows expected from growing timber on a specific tract of land is estimated, the expected value of the land has been estimated (hence, the name “land expectation value”). The LEV criterion is also called “soil expectation value” and “bare Land value,” because many applications assume the cash flow stream begins with bare land. LEV also is sometimes called the Faustmann formula.” The technique was first published in 1849 by Martin Faustmann, a German appraiser who developed the formula to place values on bare forestland for tax purposes.

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While the calculation is not complex, it is not commonly used by appraisers. The formula does require judgments with respect to stumpage prices, reforestation costs, and forest yield. Evaluating a site with respect to these items may be beyond the expertise of many appraisers and will frequently require the assistance of a forester. Current stumpage-price information and cost-of-forest-practices data are available for most regions. A forester's expertise might be most necessary in establishing forest yield. Forest yield depends on site index (i.e., a measure of the land's ability to grow timber). The calculation is no more precise than the quality of the data used as input.

THE LEV CALCULATION

LEV simply calculates the value of bare land in perpetual timber production. It is based on the standard discounting formula for the present value of a perpetual periodic annuity:

$$PV = \frac{a}{(1+i)^t - 1} \quad (a)$$

where:

PV = Present value of a perpetual periodic annuity

a = Value received every t years in perpetuity

t = Years between annuity payments

i = Interest rate, expressed as a decimal

This is actually a standard DCF calculation, but with several critical assumptions:

1. The values of all costs and revenues are identical for all rotations. All costs and revenues are compounded to the end of the rotation to get the future value of one rotation. This value will be the amount received every t years.
2. The land will be forested in perpetuity.
3. The land requires regeneration costs at the beginning of the rotation.
4. Land value does not enter into the calculation. Land value is what you are calculating.

The value calculated is the present value (PV) for a perpetual series of rotations. Many timber companies and pension funds do not buy timberland with the intention of holding it to perpetuity. The LEV does give the value of bare land in permanent forest production, however, and is the standard forestry DCF calculation. Because it is a standard DCF calculation, it can be applied to single or multiple rotations on a consistent basis. For example, if the future value at the end of a single rotation is \$916.76 (see Table 1), LEV is \$408.65 at a 4% interest rate. The PV of the first rotation is $\$916.76 / (1.04)^{30} = \282.65 . This means that the PV of the remaining perpetual rotations must be $\$408.65 - \$282.65 = \$126.00$. The LEV at the end of year 30 must also be \$408.65, and if that value is discounted to today we obtain $\$408.65 / (1.04)^{30} = \126.00 . Thus, LEV does have practical applications to any situation where a forested tract will be in permanent timber production, but might change owners at different times.

The calculation is quite easy and involves two steps. First, each cost and revenue is compounded to the end of the first rotation. The net value at rotation represents the dollar amount available at the end of each rotation in perpetuity. Second, the PV of the dollar amount is calculated on a perpetual periodic basis using equation 1.

To calculate LEV for even-aged management (e.g., a pine plantation with all trees equally aged) on bare land, a simple three-step process is used:

TABLE 1 Revenues and Costs of a Typical Forestry Investment and Calculation of Net Future Value (i= 4%)

| Year | Item | Amount (per acre) | Compounding Formula | Future Value (year 30) |
|------|----------------------|-------------------|--------------------------------|------------------------|
| 0 | Site Preparation | (\$ 40.00) | $(1.04)^{30}$ | (\$129.74) |
| 0 | Tree Planting | (40.00) | $(1.04)^{30}$ | (129.74) |
| 18 | Thinning Income | 96.00 | $(1.04)^{12}$ | 153.70 |
| 25 | Thinning Income | 160.00 | $(1.04)^5$ | 194.66 |
| 30 | Final Harvest Income | 912.00 | | 912.00 |
| 1-30 | Annual Property Tax | (1.50) | $\frac{(1.04)^{30} - 1}{0.04}$ | (84.12) |
| | | | Net Future Value | \$916.76 |

1. Determine all of the costs and revenues associated with the first rotation. These values should include initial costs of planting, site preparation, and so on, as well as all subsequent costs and revenues.
2. Place the costs and revenues on a timeline and compound all of them to the end of the rotation. Subtract the costs from the revenues.
3. Use the PV of a perpetual periodic series formula to calculate the PV of an infinite series of identical rotations. (Divide by $(1 + i)^t - 1$ where t is the rotation length.)

Thus, the formula for LEV is simply:

$$LEV = \frac{NFV}{(1+i)^t - 1} \quad (b)$$

where:

LEV = Land expectation value

NFV = Net future value of one timber rotation

t = Length of timber rotation

i = Interest rate expressed as a decimal

Note that the LEV formula uses constant dollars and a real interest rate. The LEV calculation can include prices or costs adjusted for real price increases by using the formula for a geometric series of cash flows (cash flows that increase or decrease by a fixed percent from one time period to the

next). Of course, the annual percentage increase must be less than the discount rate or the LEV will tend towards infinity.

LEV is the theoretically correct criterion for valuing bare land in timber production, for evaluating the value of various forest management alternatives, or even for determining the age of final timber harvest (rotation age). It is so widely recognized as the standard criterion, appraisers certainly ought to include it in their “menu” of valuation techniques.

Sample Calculation for Even-Aged Management

Much timber is grown in plantations, or in stands of same-aged trees. This is called even-aged management. This is the ideal situation for the use of equation b. It should be remembered That we are dealing with bare land. In a typical appraisal situation such as this, there may be a cut-over tract of land, with remaining logging debris and a few scattered unmerchantable trees. A forester can “prescribe” the proper management regime (i.e., timing of management events over one rotation of trees). Assume in this case that site preparation and tree planting are required. The forester prescribes the proper timing of thinnings and the final harvest. The forester can specify the timber yields expected and should be knowledgeable on current prices of the expected timber yields. The appraiser will be required to project future timber prices, or will probably do a constant-dollar analysis and use a real interest rate as the discount rate. Timber prices have easily kept up with inflation since World War II, so a constant dollar analysis would be appropriate.

Assume the revenues and harvests exist as described in the first three columns of Table 1. A 30-year rotation is described for Southern Loblolly Pine and the real cost of capital is 4%. Site preparation and regeneration will occur in year 0 at a cost of \$80 per acre. Annual management costs and property taxes will be \$1.50 per acre. Thinnings will occur at ages 18 and 25 and will yield 6 and 10 cords per acre, respectively. Final harvest will yield 57 cords per acre. Pulpwood is worth \$16 per cord. If a buyer intends to follow this management sequence and wants to earn at least 4% on the investment, how much can the buyer afford to pay for the bare land?

All revenues and costs must be compounded to the end of rotation (year 30 in our example). The calculation for the net future value (NFV) of one rotation is:

$$NFV = \sum_{n=0}^t R_n(1+i)^{t-n} - \sum_{n=0}^t C_n(1+i)^{t-n} \quad (c)$$

where:

NFV = Net future value of one rotation at year t

R_n = Revenue received in year n

C_n = Cost incurred in year n

t = Rotation length in years

n = Year of a particular revenue or cost

i = Real discount rate, expressed as a decimal

Table 1 illustrates the use of equation c in determining the NFV of the example rotation. The NFV as calculated in equation c is substituted into equation b to determine LEV:

$$LEV = \frac{916.76}{(1+i)^t - 1} = \$408.65 \quad (d)$$

LEV represents the maximum amount that could be paid for a tract of land and still earn the required interest rate. A buyer could pay \$408.65 per acre for the tract and earn 4% on the investment, assuming that the land is used to grow timber according to the management schedule outlined.

This simple example does not include some common costs and revenues. For example, there is no provision for revenue from hunting leases. In the Southeast, income from hunting leases could be significant. These types of costs and revenues could easily be added to the calculations in Table 1 (e.g., for example, hunting lease revenue could be netted with the annual property tax). Also the LEV calculation applies to a forest with a predictable periodic timber yield. As a practical matter, unproductive land may have to be averaged into the expected yields, or its value calculated on a separated basis.

Valuing Immature Even-Aged Stands Using the LEV Criterion

Pre-commercial timber holdings pose a difficult valuation question. The stands of trees have value but, by definition, they have no current potential for conversion to timber products. The value is intrinsic and is equal to the DCF expected from future timber harvests. Pre-commercial timber's value changes with its temporal progression toward mature commercial timber. This value is affected by the sunk cost of stand establishment and the opportunity cost of holding land to grow trees.

Comparable sale information often does not reflect the value of immature timber. To value a parcel of land and immature timber at near bare land value, however, clearly does not make economic sense. Fortunately, a second method using LEV can clearly establish the value of immature timber.

Consider the same forestry investment described in Table 1. Assume the timber stand is 15 years old. A simple calculation can be used to estimate the value of this immature stand:

$$V_m = \frac{NVt + LEV}{(1+i)^t - m} - LEV \quad (e)$$

where:

V_m = Value of m -aged timber stand

m = Age of the immature stand

NV = Net value of the income and costs associated with the immature stand between year m and rotation age t

The value of this immature stand is calculated in Table 2. The value of the immature timber is \$501.41. Note that the value of the immature timber and the bare Land is \$910.06. The bottom of Table 2 shows how the \$910.06 was derived.

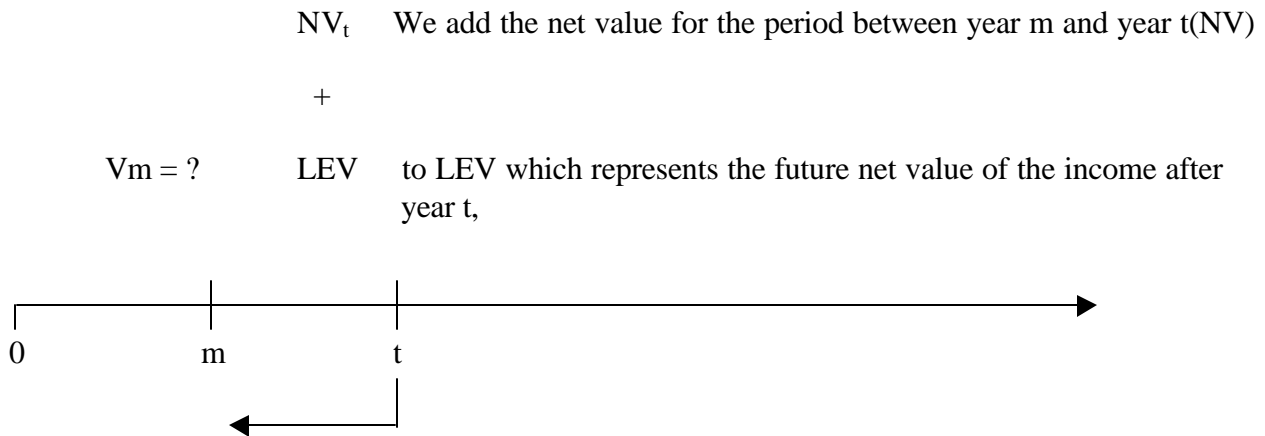
Why does this calculation work? If the interest rate and future management decisions are as originally assumed in the LEV calculation, the value of an immature stand has two components (see Figure 1):

TABLE 2 Calculation of Value of an Immature Even-Aged Timber Stand (Age = 15 years)

| Year | Item | Amount (per acre) | Compounding Formula | Future Value (year 30) |
|-------|----------------------|-------------------|--------------------------------|------------------------|
| 18 | Thinning Income | \$ 96.00 | $(1.04)^{12}$ | \$ 153.70 |
| 25 | Thinning Income | 160.00 | $(1.04)^5$ | 194.66 |
| 30 | Final Harvest Income | 912.00 | -- | 912.00 |
| 15-30 | Annual Property Tax | (1.50) | $\frac{(1.04)^{15} - 1}{0.04}$ | (30.04) |
| | | | Net Value at age 30 (NV_t) | \$1,230.32 |

$$V_m = \frac{\$1,230.32 + \$408.65}{(1.04)^{30-15}} - \$408.65 = \$910.06 - \$408.65 = \$501.41$$

FIGURE 1 Calculation of the Value of an Immature Timber Stand



This sum is then discounted to year m (the number of years is therefore $t - m$).

$$V_m = \frac{NV_t + LEV}{(1+i)^{t-m}} - LEV \quad \text{Why do we then subtract LEV to obtain } V_m?$$

With LEV included, we have the value of the land and timber. When we subtract LEV we have the value of the Immature stand of timber only.

1. The discounted net value of the income and costs associated directly with the existing, immature stand (NV).
2. The discounted LEV. LEV is also discounted for years because of the delay in harvesting subsequent stands. The LEV of all subsequent stands isn't realized until the existing stand is harvested in year t .

Valuing Uneven-Aged Timber Stands Using the LEV Criterion

Uneven-aged timber stands contain trees of various ages. Usually “mature” trees are selectively harvested on a cycle of some sort. The tract may be harvested annually, removing a small timber volume each year off each acre; or, perhaps, timber volume is removed every c years. In this case, the value of the land and timber must be estimated concurrently and one cannot be separated from the other. Unless all the trees are cut, bare land never exists under uneven-aged management. In effect, DCF is used to value a perpetual timber production “factory.”

The simplest case is when an annual income stream is produced. This is a perpetual annual annuity situation. The standard equation is

$$LEV = \frac{a}{i} \quad (f)$$

where:

LEV = Land expectation value

a = Net annual income generated

i = Interest rate, expressed as a decimal

Consider a 1,000-acre tract of timber that produces 1,500 cords of pulpwood annually. Pulpwood is worth \$35 per cord, so annual revenue is \$52,500. The tract costs \$3,000 annually to manage and property taxes are \$1.50 per acre per year. Annual costs, then, are \$4,500 and net annual revenue is \$48,000. Using a 4% discount rate, the LEV of this tract is:

$$LEV = \frac{\$48,000}{0.04} = \$1,200,000 \quad (g)$$

or \$1,200 per acre.

The other situation takes place when net timber revenue occurs on a periodic basis—say, every other year, or every five years. The standard LEV calculation is appropriate in this case. Such a forest is said to have “cutting cycles,” where a “reserve growing stock” is permanently maintained, and growth from this constant reserve is cut periodically. This is analogous to maintaining the principal in a savings account and periodically withdrawing interest. Note that annual management and property tax costs are subtracted from net timber revenue using the future value of a terminating annuity formula. LEV is calculated as:

$$LEV = \frac{NTR - \left[ax \frac{(1+i)^c - 1}{i} \right]}{(1+i)^c - 1} \quad (h)$$

where:

LEV = Land expectation value

NTR = Net timber revenue received every C years

a = Annual management and property tax costs

c = Number of years in the cutting cycle

i = Interest rate, expressed as a decimal

Consider a 1,000-acre forest that produces \$200 of net timber revenue per acre per year every five years, beginning in five years. Annual management and property taxes are \$2.50 per acre per year. LEV at a 4% interest rate is:

$$LEV = \frac{\$200 - \left[2.50x \frac{(1.04)^5 - 1}{0.04} \right]}{(1.04)^5 - 1} = \$860.64 \text{ per acre} \quad (i)$$

Note that land and timber cannot be separated in this case. Again, we are dealing with a timber production entity. In addition, the value of an off-cycle uneven-aged timber stand can be calculated. The same concepts used to develop equation e are necessary. The value of an uneven-aged stand between cutting cycles is given as:

$$V_u = \frac{NR_{c+m} : EV}{(1+i)^{c-m}} = \frac{NTR - a \left[\frac{(1+i)^{(c-k)-1}}{0.04} \right] + LEV}{(1+i)^{(c-k)}} \quad (j)$$

where:

V_u = Value of an uneven-aged stand between cutting cycles

NR_c = Net timber revenue at beginning of cutting cycle

LEV = Land expectation value, uneven-aged stand

c = Cutting cycle in years

k = Number of years since last harvest

i = Interest rate, expressed as a decimal

For example, the value of the 1,000-acre forest described previously, three years after a harvest is given by

$$V_u = \frac{\$200 - \$2.50 \left[\frac{(1.04)^2 - 1}{0.04} \right] + \$860.64}{(1.04)^2} = \frac{\$200 - \$5.10 + \$860.64}{1.0816} = \frac{1,055.54}{1.0816}$$

$$= \$975.91 \text{ per acre} \quad (k)$$

Notice equation j calculates the value of the timber stand immediately after a harvest ($k = 0$), which should equate to the results of equation h.

When $k = 0$, equation j gives a value of:

$$V_u = \frac{\$200 - \$2.50 \left[\frac{(1.04)^5 - 0 - 1}{0.04} \right] + \$860.64}{(1.04)^5 - 0} = \$860.64 \quad (l)$$

When $k = 5$, just prior to a harvest, the value of the timber stand is at a maximum:

$$V_u = \frac{\$200 - \$2.50 \left[\frac{(1.04)^5 - 5 - 1}{0.04} \right] + \$860.64}{(1.04)^5 - 5} = \$1,0664 \quad (m)$$

To reiterate a key point, the value of land and timber cannot be separated in the uneven-aged stand case. The two are intertwined to produce a single value.

CONCLUSION

A standard forestry DCF calculation is appropriate for most timberland valuation situations. In many cases the value of land and timber can be separated. The LEV model described assumes a cycle or rotation of growing trees. The standard assumption is that valuation takes place at the beginning of a cycle or rotation. The rigid assumptions of the model may make the formula inappropriate in some valuation situations, but it represents the standard forestry DCF valuation model.

The model can easily be adapted, however, to immature even-aged stands, uneven-aged stands, and uneven-aged stands between cutting cycles. Appraisers should find these techniques very useful in timberland valuation.

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