Forest Land Values and Return on Investment

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ABSTRACT. Increases in forest land value are occasionally viewed as returns separate from investment returns due to timber harvesting. When treated in this manner, the combined investment return appears to be greater than that obtained from the timber harvest alone. Future forest land values can increase only if timber price increases are anticipated beyond the first rotation. However, such anticipated price increases will be capitalized into higher present land values rather than increase the rate of return. Observed differences in land values over time are consistent with capitalized economic rent theory and cannot be correctly attributed as increases in investment returns. Land shifted to alternative nonforest uses in the future may also demand higher prices. If anticipated, however, such increases will also be reflected in higher present land values. FOREST SCI. 26:91–96.

ADDITIONAL KEY WORDS. Forest economics, rate of return, timber price increase, land use.

THE RELATIONSHIP between timber price expectations, present and future forest land values, and return on investment have been alluded to in recent articles by Pleasonton (1974), Miller and others (1978), and Klemperer (1977). However, none of the above undertook a detailed examination of these relationships. Other articles contained in the

financial maturity literature have also touched on certain of these relationships, e.g., Pearse (1967), Gaffney (1957), Bentley and Teeguarden (1965), Samuelson (1976), and Murphy and others (1977). Again, however, only passing attention is devoted to the relationship between timber price expectations, land value, and return on investment. Further, none of the above have discussed these relationships in a generalized framework. Standard textbooks such as Duerr (1960) and Gregory (1972) do not address these relationships. Although the relationship between timber value and land value is easy to grasp under static conditions, some authors (e.g., Pleasonton 1974) derive confusing and incorrect conclusions when changes in values over time are considered.

This analysis examines the role of future timber price expectations in determining both present and future forest land values and the relationship of price expectations to rate of return on investment. It is hypothesized that both present and future land values fully reflect anticipated changes in timber values. Forest land values do not change independently of changes in anticipated economic rents (timber values). Hence, observed changes in forest land values reflect anticipated changes in rents over time and do not constitute windfall increases in rates of return.

Four limiting cases, representing alternative sets of future price expectations, are developed, followed by empirical applications to illustrate the significance of each case. Finally, the conventional treatment of changes in land value separate from land use is critically reexamined.

PRESENT VALUE OF FOREST LANDS

If an acre of forest land is to be used solely for the continuous production of forest crops, the investment value at rotation start can be determined by calculating the present value of all future timber revenues net of all future timber costs that the property is expected to generate in perpetuity.

Case I.—Case I, the simplest situation, involves the assumption that the future harvest value (S_n), all costs of management, and the discount rate remain constant in perpetuity. Thus, we can write the per-acre net present value as

$$NPV = \frac{-c(1 + i)^n - L_0(1 + i)^n + L_n + S_n}{(1 + i)^n - 1} - \frac{a}{i} \tag{1a}$$

where

c	= reforestation costs/acre at time $t = 0$
a	= annual costs/acre of taxes, administration, etc.
L_0	= bare land value/acre at time $t = 0$
L_n	= bare land value/acre at time $t = n$
S_n	= harvest value/acre at rotation age n
i	= real discount rate in decimal form
n	= rotation age
NPV	= net present value of perpetual series of identical cash flows.

As a result of the assumption of constant inputs the land value remains constant over all succeeding rotations. Thus, an equivalent form of equation (1a) is

$$NPV = \frac{-c(1 + i)^n + S_n}{(1 + i)^n - 1} - L_0 - \frac{a}{i} . \tag{1b}$$

We are interested in determining the maximum amount, L_0, that we would be willing to spend to purchase an acre of bare land upon which we wish to grow continuous crops of timber in perpetuity. This is found by setting NPV in equation (1b) equal to zero and solving for L_0. Thus,

$$L_0 = \frac{-c(1 + i)^n + S_n}{(1 + i)^n - 1} - \frac{a}{i} . \tag{1c}$$

This is the familiar Faustmann (1849) formula where land is treated as a fixed factor of production and all economic rent is attributed to land. For a given management regime

and rotation age, we would be willing to spend no more than $\$L_0$/acre to purchase the bare land with a discount rate of i percent. These land values (L_0) are traditionally referred to as land expectation values by foresters.

Equation (1c) illustrates that L_0 is a function of the rotation (n), discount rate (i) and the net returns expected from timber growing. Thus, one way to increase L_0 is to increase expected revenue (S_n).

Case II.—We now relax our assumption of constant revenues over time while continuing to hold costs and technology constant. Specifically, we assume that the harvest value of mature timber is expected to increase at a real rate of p percent per year in perpetuity.[1] Under these conditions, equation (1c) becomes

$$L_0 = \frac{-c(1 + i)^n}{(1 + i)^n - 1} - \frac{a}{i} + S_0 \left[\frac{(1 + p)^n}{(1 + i)^n - (1 + p)^n} \right] \qquad (2)$$

where S_0 is the current harvest value/acre of rotation-aged timber which is expected to increase at an annual rate of p percent per year.[2] The bracketed term following S_0 is a special case of the general formula developed by Goforth and Mills (1975) for discounting a perpetual series subject to value increases when the number of years to the first future payment also equals the interval in years between subsequent future payments.

Case III.—We now assume costs and technology constant over time but allow harvest value to increase during the first rotation only. The present harvest value (S_0) is assumed to increase at an annual rate of p percent per year for n years and to remain constant thereafter. Under these conditions, equation (1c) becomes

$$L_0 = \frac{-c(1 + i)^n + S_0(1 + p)^n}{(1 + i)^n - 1} - \frac{a}{i} . \qquad (3)$$

Case IV.—The final case assumes a constant harvest value during the first rotation but with a perpetually increasing harvest value thereafter. Again, we hold all costs and technology constant. Under these assumptions, equation (1c) becomes

$$L_0 = \frac{-c(1 + i)^n}{(1 + i)^n - 1} - \frac{a}{i} + \frac{S_n}{(1 + i)^n} \left[1 + \frac{(1 + p)^n}{(1 + i)^n - (1 + p)^n} \right] . \qquad (4)$$

NUMERICAL EXAMPLE

To illustrate the practical significance of timber price expectations and forest land values, consider the following hypothetical example from western Washington. We assume an acre of medium site quality Douglas-fir forest land, which is managed on a 60-year rotation.[3] The reforestation expense at the beginning of each rotation is $100 per acre. Annual expenses are $3 per acre. The expected harvest volume is 34,000 board feet at age 60. The current value of 60-year-old stumpage is $130 per thousand board feet. The applicable real discount rate is 5 percent, and the real rate of increase in harvest value is 2 percent per year for applicable cases.

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[1] The harvest value is defined as the product of the timber volume per acre times the stumpage price. Hereafter, when an increase in future harvest value is discussed, it is implicitly the result of increasing stumpage (harvest) price per unit of timber and not from an increase in the harvest volume for a given rotation age.

[2] In Case I, p is assumed to be zero and $S_0 = S_n$. In Case II, $S_0 < S_n$ since $p > 0$. For analytical comparability, S_0 of Case I is equated to S_0 of Case II.

[3] For illustrative purposes, the rotation age is held constant for the alternative price expectations described in Cases I–IV. In reality, the optimal financial rotation age will vary in response to the set of economic assumptions used.

Case[a]	Land expectation value		Harvest value	
	L_0	L_{60}	S_0	S_{60}
	------------------------------ $/acre ------------------------			
I	84.36	84.36	4,420.00	4,420.00
II	776.16	2,924.46	4,420.00	14,502.16
III	654.64	654.64	4,420.00	14,502.16
IV	121.39	776.16	4,420.00	4,420.00

[a] Case I, constant harvest value; Case II, continuous increase in harvest value beginning in year zero; Case III, continuous increase in harvest value for n years only beginning in year zero; Case IV, continuous increase in harvest value beginning in year $n + 1$.

Substituting the above values in equations (1c) and (2–4) respectively, produces the set of expected harvest values and land expectation values for Cases I–IV shown in Table 1.

This simplified example illustrates that expectations concerning the future harvest value play a crucial role in determining today's bare land forest value. The present land value (L_0) under Case II is greater than L_0 for Case I with the anticipated increases in future harvest value capitalized into today's land value. The harvest value expectations of Case III give a present land value (L_0) greater than that derived for Case I but less than that found under Case II. The present land value (L_0) will be greater under Case IV than under Case I. However, this present land value will be less than that found for Case II for a given value of p. The reason, of course, is that one is obliged to wait until the end of the second rotation to first experience the expected rise in harvest value.

FUTURE FOREST LAND VALUES

The above example clearly leads to the recognition that present forest land values (L_0) are directly affected by expectations regarding future harvest value. Further, it is precisely these expectations which determine future forest land values when it is assumed that the land is to be devoted to continuous timber production. However, it is the relationship between L_0 and L_n under alternative sets of future harvest value assumptions that is critical to the correct interpretation of land value changes in investment analysis. These general relationships are summarized in Table 2 and numerical results for the Douglas-fir example are shown in Table 1. Of importance to this discussion is that only in Cases I and III does L_0 equal L_n. Furthermore, $L_n > L_0$ for Cases II and IV.

We conclude from this analysis that: (a) expected increases in harvest value affect today's forest land value (L_0), (b) land values will remain constant only if the harvest value is expected to remain constant (as under Case I) or increase during the first rotation only (as in Case III), (c) L_n is greater than L_0 if positive harvest value increases are anticipated beyond the end of the first rotation (Cases II and IV), and (d) such future price expectations influencing L_n are fully capitalized into a higher present land value (L_0).

IMPLICATIONS FOR RETURN ON INVESTMENT

Clearly, the rate of return on a forest land investment will remain constant when future harvest value increases are anticipated. The future expectations are simply capitalized into higher land values today.[4] For example, if a potential land purchaser believes that Case II assumptions will prevail in our Douglas-fir example, he will compute L_0 = \$776.16/acre and L_{60} = \$2,924.46/acre. The increase in land value of \$2,148.30/acre over the rotation does *not* represent an additional return over and above that realized from the timber

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[4] The reader may wish to verify this by solving for the rate of return (i) in equations (1c–4) with L_0 set to the values shown in Table 1.

TABLE 2. *Relationship between present and future forest land values.*

	Land expectation value[b]		
Case[a]	L_0 ($/acre)	L_n ($/acre)	Relationship
I	$\dfrac{x + S_n}{z}$	$\dfrac{x + S_{2n}}{z}$	$L_0 = L_n$
II	$\dfrac{x}{z} + S_0 y$	$\dfrac{x}{z} + S_n y$	$L_0 < L_n$
III	$\dfrac{x + S_0(1 + p)^n}{z}$	$\dfrac{x + S_{2n}}{z}$	$L_0 = L_n$
IV	$\dfrac{x}{z} + \dfrac{S_n}{(1 + i)^n}[1 + y]$	$\dfrac{x}{z} + \dfrac{S_{2n}}{(1 + i)^n}[1 + y]$	$L_0 < L_n$

[a] See Table 1 footnote a for definition of cases.
[b] We define the following variables. All terms are as defined in equations (1a) and (2).

$$x = -c(1 + i)^n - a\left[\frac{(1 + i)^n - 1}{i}\right]$$

$$y = \frac{(1 + p)^n}{(1 + i)^n - (1 + p)^n}$$

$$z = (1 + i)^n - 1.$$

income itself. While this conclusion follows from the preceding analysis it is nevertheless sometimes stated that such increasing land values do represent an additional return over that realized from the timber itself. This erroneous argument is often advanced as a factor to encourage landowners to engage in timber growing activities.[5]

AN ALTERNATIVE APPROACH

For clarification, assume that our hypothetical Douglas-fir acre will be devoted to continuous timber production. As discussed earlier for Case I, an acre of land valued at $84.36 that is capable of producing $4,420 every 60 years will only earn a 5.0 percent rate of return. This land will earn a larger rate of return only if it can be purchased today for less that $84.36/acre. In order to derive a larger return (while fixing $L_0 = $84.36), we must assume that the value of future harvests (S_n) will be substantially greater than $4,420.

In summary, a present bare land forest value of $84.36/acre is consistent with a return on investment greater than 5 percent *if* future harvest value increases are anticipated. If, however, land is presently valued at $84.36/acre *and* the harvest value is held constant at $4,420, a return on investment in excess of 5 percent must imply a future land use shift away from timber production. In order to derive a present bare land forest value of $L_0 = $84.36/acre in the presence of increasing timber prices it is necessary to *vary* the implicit annual percent increase in harvest value concomitantly with the timing of the assumed annual price rise such that the harvest value in year 60 equals $4,420/acre. Our earlier discussion, leading to equations (2–4), assumes a given annual percentage increase in harvest value (p) applicable over a variable number of years (Cases II–IV). As shown, L_0 does not remain constant (Table 1). Thus, constant land values today (L_0) *can* be contrived, but only if the assumed annual percent increase in harvest value is varied under each case.

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[5] For a recent statement of this view see the illustrated example presented by Pleasonton (1974).

SUMMARY

We have examined land value theory in detail in order to clarify the relationships between timber price expectations, present and future land values, and return on investment. One cannot arbitrarily assume increasing land value without making implicit assumptions about future land use and/or the value of the products derived from the land under these different uses. Land only has value as it is put to some use or as some potential use is ascribed to it. If land is devoted to timber production, then its forestry value is derived as the net present value of all future timber crops raised on the land. Accordingly, for forest use, land can only increase in value as timber becomes more valuable, other factors held constant.

If increasing future rents are anticipated, the prudent land buyer will bid more for land today. Expectations concerning the future are capitalized into higher land prices, not only in the future but also today. This is true both for land which remains under its current use (timber production) or for land subject to future changes in use.

Throughout our analysis we have assumed that land is devoted to continuous timber production. Clearly, if land is devoted to timber production and future harvest value increases are anticipated, these expectations are reflected in the present value of the land. Further, if a constant harvest value is assumed, an expected increase in future land value (L_n) must implicitly require a land-use shift away from timber production to some other higher valued use. When anticipated, both expectations influence L_0, the bare land value expressed at the present time. Only unanticipated changes in the future harvest value and/ or nontimber uses result in windfall gains and hence contribute to higher than anticipated rates of return. By definition, such events are unanticipated and cannot be legitimately introduced into *ex ante* investment analysis.

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