A FINANCIAL ANALYSIS OF THREE UPLAND OAK SITES IN SOUTHERN ILLINOIS[1/]

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Abstract.--This paper investigates the profitability of an even-aged upland hardwood management system under site and market conditions found in Illinois. Three unmanaged sites of varying quality and species composition were inventoried to provide the basis for simulating regenerated stands on sites possessing similar characteristics. Existing stand ages averaged 60 years with associated timber values ranging from $543 to $826 per acre. Based on maximization of land expectation value, optimal rotation ages for regenerated stands ranged from 60 to 100 years depending on site quality, price assumptions, and discount rate used in the analysis. In general, after stand age 70 or 80 is reached, it is better to plan harvests based on market expectations rather than a predetermined rotation age.

Keywords: hardwood management, land expectation value, present net worth

INTRODUCTION

Stumpage prices for white and red oak in Illinois have appreciated at an average rate exceeding general inflation for more than a decade[3/]. Based on USDA Forest Service (1982) forecasts of increased demand for high quality hardwoods, the increase in real stumpage prices for the oaks is likely to continue. Thus, an opportunity exists for Illinois timber producers to significantly increase the value of their woodlands through the production of high quality hardwoods. However, the opposite seems to be occurring. Much of Illinois' 4 million acres of forest land, over one-half of which is the upland oak-hickory type, are unmanaged and producing far below their potential (Herendeen and Rolfe 1983). In order to encourage the increased management of Illinois' forest lands for wood production, landowners must be presented with options for profitable management. The purpose of this paper is to assess the profitability of upland hardwood management in Illinois and to illustrate the impact of site selection, log-grade distribution, and species composition on the financial success of recommended forestry investments.

METHOD

Three typical upland oak forest stands of varying site quality and species composition were inventoried in southern Illinois (Pope County). A variable plot cruise using a 10 factor prism was employed; sample points were located on a systematic spacing of 2 x 5 chains. At least 13 points were sampled in every stand. Site indices for white oak ranged from 60 to 80 based on soil type (USDA Soil Conservation Service 1975), dominant or codominant trees, and site index curves developed by Carmean (1971). The average age of each stand was 60 years.

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[3/] Based on the "Illinois Timber Prices Survey" published by the Illinois Cooperative Crop Reporting Service and the Illinois Division of Forest Resources and Natural Heritage.

The even-aged management system presented in Table 1 was developed to maximize net return from the production of high quality oak and associated species. Land expectation value was chosen as the investment criterion. The management system is based on published literature and recommendations of professional foresters in Illinois. Management activities consist of an herbicide treatment of the existing stand to eradicate undesirable species followed, a year later, by a reproduction clear-cut. It is assumed that adequate advanced reproduction exists when the existing stand is harvested. Based on Sander (1977), two pre-commercial thinnings were planned for the regenerated stand at ages 10 and 20 years to develop the desired species composition shown in Table 2. Commercial thinnings were assumed to be feasible beginning at stand age 30 and proceeding, in 10-year intervals, to age 60. All thinnings are from below. Based on stocking graphs by Gingrich (1971) and predicted growth, 60 square feet of basal area is left after thinning at stand ages of 30 and 40 years. Seventy square feet is assumed to remain after thinning at 50 and 60 years. Rotation ages of 60, 70, 80, 90, and 100 are evaluated for the regenerated stand.

Management costs listed in Table 1 reflect several incentives available to qualifying landowners under the Illinois Forestry Development Act. Property taxes have been reduced by one-sixth (from $6.00 per acre), and cost-sharing is taken for site preparation and pre-commercial thinning. For example, the actual per acre cost of site preparation to the landowner is $60.00 minus the cost-share of $30.00. A four percent sawlog harvest fee is assessed by the state to cover the costs of this program.

Growth and yield estimates were obtained through use of a modified version of TWIGS (Belcher 1982). This model uses

Table 1.--An even-aged management system, and associated per acre costs, where the existing stand is harvested in year 0 and the regenerated stand is harvested at age 60, 70, 80, 90, or 100.

Year	Periodic Management Activities
-1	Site preparation; undesirable species are killed by herbicide treatment to reduce competition in new stand.
0	Existing stand harvested (assumes sufficient advanced reproduction of desirable species).
10 & 20	Pre-commercial thinnings to develop desired species composition. (All thinnings are from below.)
30 & 40	Commercial thinnings to 60 sq. ft. of basal area.
50 & 60	Commercial thinnings to 70 sq. ft. of basal area.
60, 70, 80, 90, or 100	Final harvest.

Costs	Dollars Per Acre	Cost Share Per Acre
Annual operation and maintenance	$ 2.00 1/	$ 0.00
Property taxes	1.00 2/	0.00
Site preparation	60.00	30.00 3/
Pre-commercial thin	60.00	33.00
Harvest fee (4 percent of sawlog harvest revenues)		
Sale fee (10 percent of final harvest revenue)		

1/ Includes transportation to site, fire break maintenance, and other miscellaneous expenses.
2/ Forest land was assessed at 1/6 the value of cropland with similar soil productivity.
3/ Represents state cost-sharing under the Illinois Forestry Development Act.

Table 2.--Species composition for regenerated stands in southern Illinois by site. Site index[1/] is based on white oak.

Poor Site - Site Index 60

Species	Year 0 Trees/A	Year 10 Trees/A	Year 20 Trees/A	Year 20 BA/Acre	Year 20 Avg DBH
White Oak	1,500	500	250	17.1	3.5
Red Oak	900	300	150	13.1	4.0
Hickory	300	100	50	2.5	3.0
Sugar Maple	150	75	40	2.0	3.0
Elm	150	25	10	0.6	3.5
Total	3,000	1,000	500	35.3	3.6

Medium Site - Site Index 70

Species	Year 0 Trees/A	Year 10 Trees/A	Year 20 Trees/A	Year 20 BA/Acre	Year 20 Avg DBH
White Oak	1,350	450	200	17.7	4.0
Red Oak	900	300	150	16.6	4.5
Sugar Maple	300	100	25	4.4	4.0
Hickory	300	50	50	1.2	3.0
White Ash	150	100	75	6.5	4.0
Total	3,000	1,000	500	46.5	4.1

Good Site - Site Index 80

Species	Year 0 Trees/A	Year 10 Trees/A	Year 20 Trees/A	Year 20 BA/Acre	Year 20 Avg DBH
White Oak	1,050	300	125	13.8	4.5
Red Oak	750	350	200	27.5	5.0
Sugar Maple	600	150	50	4.4	4.0
White Ash	300	150	100	11.1	4.5
Hickory	300	50	25	1.7	3.5
Total	3,000	1,000	500	58.4	4.6

1/ Base age 50.

an individual tree, distance-independent projection system for mortality and diameter growth. Timber volume estimates are divided into three size categories: sawtimber, pulpwood, and residues. For hardwoods, sawtimber represents growing stock greater than 11 inches (diameter at breast height) to a 9-inch top (diameter outside bark). Pulpwood consists of growing stock, excluding sawtimber, possessing diameters at breast height greater than 5 inches while residues comprise the remainder. One problem encountered with predicting yield was that of sawlog grade distribution. For the existing stands, the estimates shown below were based on private industry sawmill grade tallies taken over a one-year period classified according to Purdue log-grade definitions. These tallies were assumed to represent the distribution of log-grades obtainable from unmanaged stands.

Since less information is available for managed stands, obtaining grade distributions for the regenerated stands was more difficult. Trimble (1965) produced

Log-grade distribution for existing stands[1/].

Veneer	2 percent
Prime	8 percent
No. 1	25 percent
No. 2	55 percent
No. 3	10 percent

1/ For non-veneer species, veneer grade was classed as prime. Since the existing stands were unmanaged with respect to grade, this distribution was held constant regardless of age.

estimates of butt-log-grade distributions for various species. These estimates, along with those above for unmanaged stands, served as a starting point in determining grade distributions for the regenerated stands (Table 3).

Timber harvest yields and associated stumpage prices are given in Table 4. It is assumed that pulpwood will be sold as firewood and that sawlog stumpage at final harvest is sold through competitive bidding in favorable markets. The base year for all costs and prices is 1984.

A discounted cash flow procedure was used to evaluate alternative management regimes based on maximization of land expectation value (LEV). LEV reflects the algebraic sum of all relevant discounted cash flows, and assumes an infinite number of timber rotations, each based on the initial regenerated stand. For each management regime considered, LEVs were determined on a before- and an after-tax basis.

Table 3.--Log-grade distributions for regenerated stands by quality response to management, adapted from Trimble (1965).

High Quality Response

Age	Veneer	Prime	No. 1	No. 2	No. 3
(years)	(%)	(%)	(%)	(%)	(%)
60	0	0	40	45	15
70	2	23	33	32	10
80	3	42	25	25	5
90	4	56	17	18	5
100	4	71	10	10	5

Medium Quality Response

Age	Veneer	Prime	No. 1	No. 2	No. 3
(years)	(%)	(%)	(%)	(%)	(%)
60	0	0	35	50	15
70	1	19	30	40	10
80	2	33	25	35	5
90	3	47	20	25	5
100	3	62	15	15	5

Low Quality Response

Age	Veneer	Prime	No. 1	No. 2	No. 3
(years)	(%)	(%)	(%)	(%)	(%)
60	0	0	30	55	15
70	1	14	27	48	10
80	1	24	25	45	5
90	2	33	22	38	5
100	2	43	20	30	5

Table 4.--Per acre timber harvest yields, and associated stumpage values, for commercial thinnings and final harvests ranging from 70 to 100 years.

Site Index 60

Year	Fire-wood (Cds.)	Residues (Tons)	Year	Fire-wood (Cds.)	Residues (Tons)	White Oak (Bd.Ft.)	Red Oak (Bd.Ft.)
30	0	3.5	70	6.1	27.8	60.6	4,950.3
40	5.3	6.7	80	8.2	35.4	89.5	7,156.0
50	3.0	3.6	90	10.3	42.5	120.9	9,167.3
60	5.3	6.3	100	12.2	48.3	136.6	10,985.9

Site Index 70

Year	Fire-wood (Cds.)	Residues (Tons)	Year	Fire-wood (Cds.)	Residues (Tons)	White Ash (Bd.Ft.)	Red Oak (Bd.Ft.)
30	1.8	8.6	70	7.1	28.3	196.2	5,401.2
40	6.1	6.3	80	9.3	35.6	262.3	7,447.3
50	3.4	3.8	90	11.5	42.2	306.5	9,352.0
60	1.3	5.9	100	13.3	47.3	333.2	11,013.8

(Thinning at age 60 includes 989.8 Bd.Ft. sold as woods run.)

Site Index 80

Year	Fire-wood (Cds.)	Residues (Tons)	Year	Fire-wood (Cds.)	Residues (Tons)	White Ash (Bd.Ft.)	Red Oak (Bd.Ft.)
30	6.0	8.8	70	8.0	28.9	305.9	5,674.4
40	6.7	6.8	80	10.3	35.7	404.8	7,528.1
50	3.4	3.8	90	12.3	41.5	470.0	9,238.2
60	1.6	6.4	100	13.8	45.8	509.6	10,620.8

(Thinning at age 60 includes 988.7 Bd.Ft. sold as woods run.)

Base Year Stumpage Prices (Doyle) by Species and Grade[1/]

Species	Veneer ($/MBF)	Prime ($/MBF)	No. 1 ($/MBF)	No. 2 ($/MBF)	No. 3 ($/MBF)
White Ash		327	239	99	28
Cherry		316	233	98	24
White Elm		69	50	27	19
Hickory		64	47	20	22
Sugar Maple	460	159	107	48	19
White Oak	1,200	278	193	84	26
Red Oak	500	347	249	117	30
Black Walnut	2,000	550	390	231	109

Woods Run: $72.00/MBF
Firewood: 3.00/Cord
Residues: 1.50/Ton

1/ Sawtimber stumpage prices are from Bulletin No. 176, Purdue University, Department of Forestry and Natural Resources, May 8, 1984.

Federal income tax considerations included a 10 percent investment tax credit[1/], seven-year amortization of establishment costs, expensing of annual maintenance costs[2/] and property taxes, and timber depletion. These incentives were used to adjust nominal cash flows and discount rates for use in determining the after-tax LEVs. The tax adjusted discount rate assumes that the best

1/ If the 10 percent investment tax credit is claimed, half of this amount must be subtracted from the timber cost basis or amount amortized.

2/ This may mean selling the timber under I.R.S. Section 631.

available alternative is taxed at ordinary rates and is set equal to the nominal before-tax rate times one minus the landowner's marginal income tax bracket. Inflation was set at 4 percent and was based on the GNP Implicit Price Deflator averaged over the three most recent years[3/]. Assuming a marginal income tax bracket of 15 percent, the equivalent real before-tax and nominal after-tax discount rates are 4 and 6.94 percent, 5 and 7.82 percent, and 6 and 8.7 percent, respectively.

The average landowner was assumed to be in the 15 percent marginal tax bracket except for the years of the last commercial thinning and final harvest. For these years, the landowner's marginal tax bracket was set at 28 and 33 percent, respectively. The latter rate includes the additional 5 percent tax.

RESULTS

Existing Stands

Present before-tax timber values for existing stands ranged from $543 per acre for the poor site (SI 60) to $826 per acre for the good site (SI 80). For the medium site (SI 70), present timber value was $685 per acre. In almost all cases it did not pay to delay harvest of the unmanaged existing stands. That is, the before-tax present net value of these stands was greatest at the current age of 60 years. The only case where it was more profitable to delay harvest was for the poor site at a real before-tax discount rate of 4 percent. On this site and at this discount rate, before-tax present net value was greatest at age 80.

Regenerated Stands

Based on the management system presented earlier and a log-grade distribution represented by a medium quality response to management, regenerated stands were simulated for each site and evaluated at rotation ages of 60, 70, 80, 90, and 100 years. Before- and after-tax LEVs, representing the maximum amount which an investor could pay for an acre of bare land and still earn a return equal to the discount rate used, are shown in Table 5. Optimal before-tax LEVs range from -$86 per acre for the poor site to $410 per acre for the good site, depending on the discount rate and price assumption. For the medium site, at a real discount rate of 5 percent and assuming stumpage values appreciate at an average rate of one percent per year, the land expectation value is -$22 per acre at an optimal harvest age of 80 years.

For the after-tax case, optimal LEVs range from -$69 per acre for the poor site to $1,555 per acre for the medium site, again depending on the specified discount rate and price assumption. For the medium site, assuming a 5 percent real discount rate and one percent stumpage price appreciation, the optimal land expectation value equals $69 per acre at a harvest age of 90 years.

After-tax LEVs are higher for this investment because of the disproportionate effect of taxation on revenues and costs. That is, costs are adjusted annually, whereas adjustments to revenues occur infrequently. The reduction in the discount rate by the landowner's marginal tax bracket has the largest impact on land expectation value. The lower after-tax discount rate also increases the optimal rotation age based on maximization of land expectation value.

Sensitivity Analysis

The sensitivity of financial maturity (i.e., maximum LEV) and investment profitability to changes in site, discount rate, log-grade distribution, price assumption, and species composition is presented below. The analysis is based on after-tax LEVs under the same management and tax conditions as previously discussed.

Figure 1 shows the optimal rotation age to be 90 years for all sites at a discount rate of 5 percent and one percent stumpage price appreciation. Note, however, that the rotation decision becomes less critical once stand age 80 is reached. That is, once the stand reaches 80 years, the landowner should harvest based on market expectations as opposed to any predetermined rotation age. There is little to gain by waiting to harvest between ages 80 and 90, and little to lose between ages 90 and 100, however, there is much to gain by proper market timing. In figure 2, it is seen that as the discount rate increases, the range over which market timing is applicable, also increases.

The effect of changes in log-grade distribution for the medium site is illustrated in figure 3. Within the range studied, profitability is not affected to any significant degree except at the lower discount rates. This result can be explained by the small percentage of ve-

[3/] Based on the same index, inflation averaged an annual rate of 3.55 percent from 1929 to 1984.

Table 5.--Per acre before- and after-tax land expectation values by site, discount rate, and assumptions regarding the real rate of stumpage price appreciation. For after-tax LEVs, inflation was set at 4 percent. The optimal rotation ages (in years) are indicated by the numbers in parentheses.

Relative Stumpage Price Change (%)	Land Expectation Values[1/]								
	Real Discount Rate								
	4 Percent			5 Percent			6 Percent		
	SI60 ($)	SI70 ($)	SI80 ($)	SI60 ($)	SI70 ($)	SI80 ($)	SI60 ($)	SI70 ($)	SI80 ($)
	------- Before-tax -------								
0	-60 (80)	-45 (80)	-38 (80)	-81 (80)	-72 (70)	-66 (70)	-86 (70)	-80 (70)	-76 (60)
1	47 (90)	70 (90)	79 (80)	-37 (80)	-22 (80)	-15 (80)	-66 (80)	-56 (70)	-51 (70)
2	370 (100)	409 (100)	410 (90)	71 (90)	95 (90)	104 (80)	-21 (80)	-6 (80)	1 (80)
	------- After-tax[2/] -------								
0	-5 (90)	14 (90)	21 (90)	-53 (80)	-40 (80)	-34 (80)	-69 (80)	-61 (80)	-56 (70)
1	262 (100)	295 (100)	297 (100)	47 (90)	69 (90)	76 (90)	-25 (90)	-11 (80)	-4 (80)
2	1,461 (100)	1,555 (100)	1,544 (100)	375 (100)	413 (100)	414 (100)	95 (100)	118 (90)	126 (90)

1/ All LEVs reflect the optimal harvest age (60, 70, 80, 90, or 100 years), cost-sharing, and the costs specified in Table 1.
2/ For the after-tax case, an income tax rate of 15 percent is assumed except for the years of the last commercial thinning and final harvest where the tax rates are 28 and 33 percent, respectively. After-tax cash flows are discounted at rates equivalent to the above real discount rates (6.94, 7.82, and 8.7 percent, respectively). Timber establishment costs, which remain after cost-sharing is applied, are amortized over the first seven years. A 10 percent investment tax credit is taken.

neer logs, the small percentage reductions in prime logs as quality response diminishes, and in the price differential between prime and No. 1 logs.

Figure 4 shows the impact of the stumpage price assumption on after-tax land expectation values over a range of discount rates. As seen, LEV is very sensitive, especially at the lower discount rates. The reason is that future (appreciated) timber values are discounted less heavily. At the higher rates of discount, the price assumption becomes less critical.

Percentage oak was varied from 20 to 80 percent (based on live trees/acre at age 20) for the medium site to test investment sensitivity to species composition (fig. 5). Except for the lowest discount rate, LEV was affected little by changes in percentage oak. The reason for this lies in the large proportion of white ash present (at low oak percentages) and the small percentage of veneer logs assumed. This is because the stumpage price for white ash was equivalent to that for oak and increasing amounts of oak veneer did not significantly increase the value of the timber stand. Thus, unless the landowner or manager is exceptionally good at producing veneer quality logs, management should stress quality hardwoods in general rather than spend the time and money to specifically increase the percentage of oak on an upland site.

If it is assumed that the investor already owns the land and that property taxes will be paid regardless of land

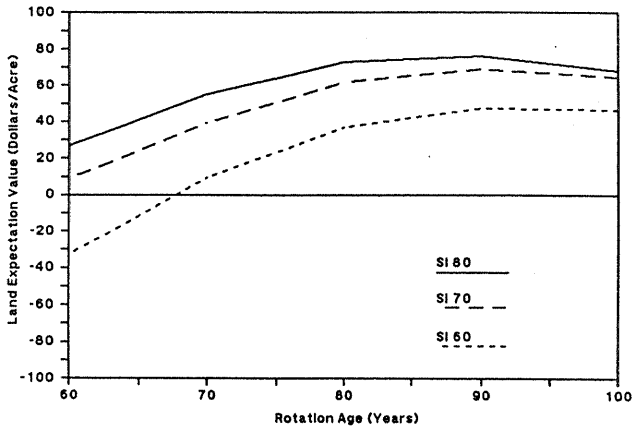

Figure 1.--After-tax LEVs for regenerated hardwood stands by rotation age and site quality. A 5 percent real before-tax discount rate, medium log quality response to management, and an 1 percent real annual stumpage price change are assumed. Discounting reflects 4 percent inflation and a 15 percent marginal income tax bracket.

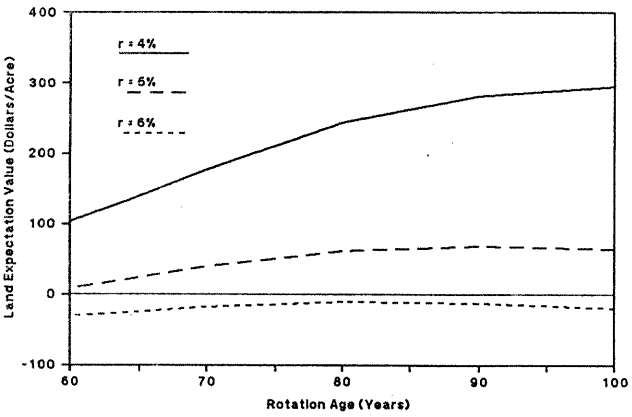

Figure 2.--After-tax LEVs for a regenerated hardwood stand by rotation age and discount rate. A medium site, medium log quality response to management, and an 1 percent real annual stumpage price change are assumed. Discounting reflects 4 percent inflation and a 15 percent marginal income tax bracket.

use, then these taxes can be excluded from the analysis. Figure 6 presents the real before-tax rate of return expected from the specified investment. The $5.00 property tax reduction, due to the Illinois Forestry Development Act, is treated as a benefit. Real before-tax rates of return exceed 10 percent for each site.

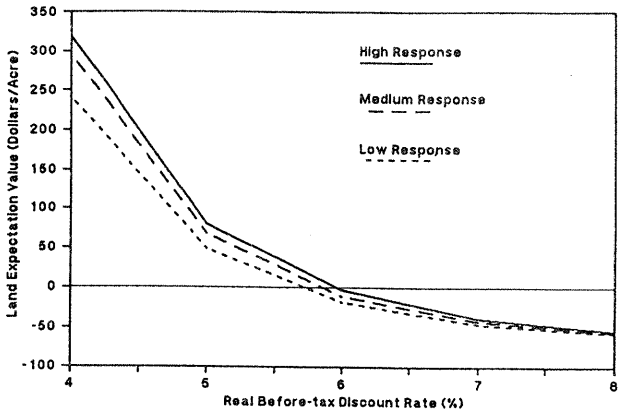

Figure 3.--After-tax LEVs for a regenerated hardwood stand by discount rate and log quality response to management. A medium site and an 1 percent real annual stumpage price change are assumed. Discounting reflects 4 percent inflation and a 15 percent marginal income tax bracket. The optimal rotation age varies along the curve.

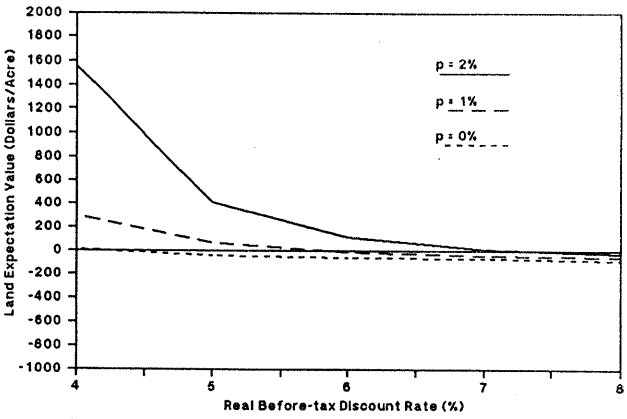

Figure 4.--After-tax LEVs for a regenerated hardwood stand by discount rate and real annual stumpage price change (p). A medium site and medium log quality response to management are assumed. Discounting reflects 4 percent inflation and a 15 percent marginal income tax bracket. The optimal rotation age varies along the curve.

CONCLUSIONS

Based on the even-aged management system described above, all sites inventoried were generally at or past financial maturity based on maximization of present net value. Only at the lowest discount rate considered did it pay to delay harvest of the existing stand. While tax adjustments did increase the number of cases where waiting to harvest

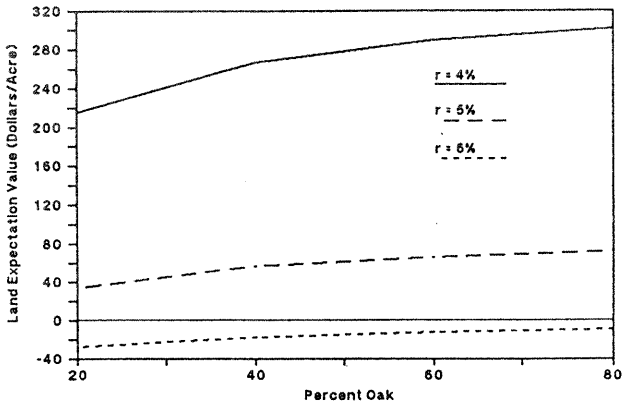

Figure 5.--After-tax LEVs for a regenerated hardwood stand by percent oak and discount rate. A medium site, medium log quality response to management, and an 1 percent real annual stumpage price change are assumed. Discounting reflects 4 percent inflation and a 15 percent marginal income tax bracket. The optimal rotation age varies along the curve.

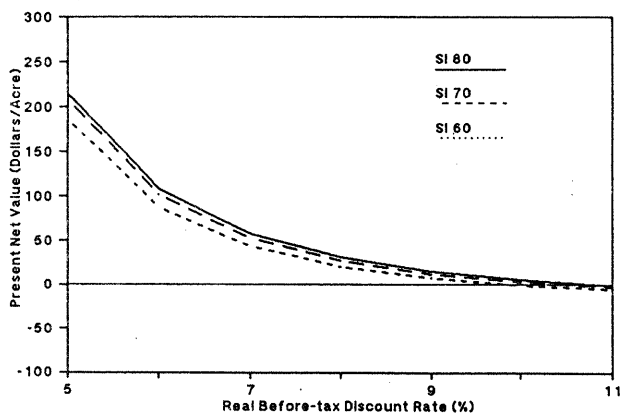

Figure 6.--After-tax present net values for regenerated hardwood stands by discount rate and site quality. A real property tax savings of $5.00 per acre per year, medium log quality response to management, and an 1 percent real annual stumpage price change are assumed. Discounting reflects 4 percent inflation and a 15 percent marginal income tax bracket. The optimal rotation age varies along the curve.

was profitable, most management decisions were unaffected. The recommendation is to regenerate the stands as soon as sufficient advanced reproduction occurs.

State forestry incentives and federal income tax adjustments proved important in increasing profitability for the regenerated stands. However, even with preferential treatment, the investment was not very desirable at discount rates equal to or greater than 6 percent on all sites. This 6 percent is a real before-tax rate and corresponds to a market interest rate of 10.24 percent assuming inflation is equal to 4 percent.

Land expectation value was very sensitive to the discount rate. Optimal rotation ages ranged from 60 years to 100 years depending on investment assumptions. At a real before-tax discount rate of 5 percent for example, the optimal rotation age is 90 years, assuming after-tax treatment and one percent stumpage price appreciation. However, because of the flatness of the LEV curve, once stand age 80 is reached, it is better to harvest based on market expectations rather than a predetermined rotation age.

There seems to be some room for error in estimating log-grade distribution and species composition before management decisions are affected. Within the range studied, profitability and land expectation value were not very sensitive to changes in log-grade distribution or changes in percentage oak. The importance of these factors in influencing investment performance rests on the magnitude of change and the relative value of the other timber species in the stand.

If property taxes are not treated as a timber investment cost, then real before-tax rates of return can be expected to exceed 10 percent for the Illinois forestry investment conditions considered in this study.

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