Economics of Red Pine Management for Utility Pole Timber[1]

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ABSTRACT. Including utility poles in red pine management regimes leads to distinctly different management recommendations. Where utility pole markets exist, managing for poles will maximize net returns. To do so, plantations should be planted with a minimum of 890 trees/ac. Residual thinning densities should be maintained above 110 ft²/ac, higher than usually recommended. In Michigan's northern Lower Peninsula, approximately 195,000 ac of established stands were suitable for utility pole management in 1980. Landowners can increase the soil expectation value (4% discount rate) on their investment from $4.00/ac to $104/ac by managing for poles along with pulpwood and sawtimber on site index 75, well-stocked stands.

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Management guidelines are based on assumptions subject to varying degrees of uncertainty, including: biological growth, biological response to management activities, site productivity, current and future costs and markets, relevant discount rate, and landowner objectives. However, guidelines still serve an important operational role.

Management guidelines are often derived to maximize the financial return to the landowner and need to be redetermined when conditions change. Financial returns to forest management are determined from estimates of product prices, management costs, and the volume, size, and quality of each product. Generally only pulpwood or sawtimber, or both, have been considered as end products in the Lake States. This can be a significant error in forest types that could yield other, high value, products such as utility poles. This paper shows how landowner revenue can be increased by modifying red pine management guidelines to include utility pole production.

MANAGEMENT GUIDELINES FOR LAKE STATES RED PINE

Many red pine management guidelines assume that the landowner's objective is to maximize revenue, and that a price premium exists for sawtimber. Other assumptions vary, but recommended initial thinnings generally leave 70 to 90 ft² of basal area per acre (Lundgren 1965, Benzie 1977, Lothner and Bradley 1984, de Naurois and Buongiorno 1986). The timing and intensity of this initial thinning limit the number of potential utility poles that a stand can produce. Rudolph et al. (1984) provides an exception and recommends maintaining stand densities between 110 and 130 ft² of basal area per acre to maximize value. Recommendations designed to maximize cubic-foot production, regardless of products, call for maintaining high densities (Lundgren 1983, Rose et al. 1981). We conducted a study of red pine management to determine if guidelines for producing pulpwood, sawtimber, and utility poles could increase landowner revenue.

PRODUCING RED PINE UTILITY POLES

Evaluating the production of red pine utility poles is important for four reasons. First, a large sustainable market exists for red pine utility poles in Minnesota, Iowa, Illinois, Michigan, and Wisconsin (Harms et al. 1988). Second, substantial stumpage premiums are being paid for red pine utility poles (Table 1). Third, the timing, density, and types of management activity directly affect the product mix possible from a red pine stand. Fourth, stringent standards affect the acceptability of individual trees as utility poles (Table 2).

The proportion of potential utility poles increases with stand density but rarely exceeds 45% of the number of trees (Guilkey 1958, Jennett 1987). This is primarily due to the number and size of branches in lower density stands. The proportion of potential utility poles rejected for excessive limbs increases greatly when basal area drops below 110 ft²/ac (Guilkey 1958, Jennett 1987). Laidly and Barse (1979) and Stiell (1984) found that spacings greater than 7 by 7 ft (890 trees/ac) led to stands with excessive knot surfaces and reduced the percentage of utility poles in the stand.

THE RED PINE RESOURCE IN THE LAKE STATES

Of the 1.5 million acres of red pine forests and plantations in the Lake States (Smith and Hahn 1989, Smith and Hahn 1986, Hahn and Smith 1987), approximately 699,000 are suitable for management to produce utility poles (based on data from the most recent USDA Forest Service surveys: Minnesota in 1977, Michigan in 1980, Wisconsin in 1983). Unsuitable stands were those thinned to less than 110 ft²/ac or established at densities lower than 890 trees/ac. In Michigan's northern Lower Peninsula (NLP), approximately 195,000 acres were suitable for utility pole management in 1980.

SIMULATING MANAGEMENT ALTERNATIVES

We simulated management alternatives for common Lake States practices in high site index red pine plantations. Thinning strategy, thinning technique, stocking, rotation length, and

Table 1. Red pine product prices, 1987, for Michigan's Northern Lower Peninsula.

Product	Unit	$/Unit[a]	ft³/unit[b]	$/100 ft³
Pulpwood	cords	7.25	80	9.06
Sawtimber	mbf	81.50	160	50.94
30 ft Pole	pole	5.00	7	70.88
35 ft Pole	pole	9.00	9	105.32
40 ft Pole	pole	13.00	11	122.68
45 ft Pole	pole	18.00	14	126.24
50 ft Pole	pole	24.00	22	108.44

[a] Mich. Dep. Nat. Resour., For. Manage. Div. 1988a.
[b] Cubic foot volume for the poles is estimated from Ek, Birdsall, and Spears (1984).

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Table 2. Red pine pole class specifictions for minimum top and minimum butt diameters, outside bark, by lengths.[a]

Class	Minimum top dob	Minimum butt diameters by length 31′	36′	41′	46′	51′	56′
		(in.)					
1	8.8			14.7	15.3	16.0	16.5
2	8.1	12.2	12.8	13.7	14.3	15.0	15.5
3	7.5	11.3	12.0	12.7	13.3	14.0•	14.5•
4	6.8	10.5	11.2	11.8	12.3		
5	6.2	9.7	10.3	11.0	11.5•		
6	5.5	9.0	9.5	10.2•			

[a] Based upon American National Standards Institute (1979) with a bark correction factor from Fowler and Damschroder (1988). A 1-ft stump is assumed. Additional specifications include: no short crooks, minimal sweep, 2-in. maximum knot size in lower half of tree, 4-in. maximum knot size in upper half of tree, and the sum of diameters of all knots greater than 0.5 in. cannot exceed 8 in. in any 1-ft section. Individual buyers may have their own specifications.
• Pole classes and lengths used in the evaluation.

product mix were also used to define management alternatives (Table 3).

Thinning strategies consisted of light thinnings every 10 years, heavy thinnings every 10 years, and heavy thinnings every 15 years (Table 4). In all cases the first thinning was a row thinning to improve access to the stand. Two types of subsequent thinning techniques were simulated. The first assumed that all thinnings were from below, and the second assumed that one thinning was from above and the remainder were from below. Silvicultural evidence suggests that thinning from above instead of from below will have little impact on total cubic-foot volume produced from red pine plantations (Buckman and Wambach 1966).

The 10-year light thinning strategy maintains basal areas high enough to encourage self-pruning and to produce utility poles. It corresponds to the recommendations of Rudolph et al. (1984). The 10-year heavy thinning strategy corresponds to the minimum stocking level shown by Benzie (1977) and simulated by de Naurois and Buongiorno (1986). The 15-year heavy thinning strategy was recommended by de Naurois and Buongiorno (1986) as the best scenario to maximize financial return on site indices 60 and 75.

ESTIMATING GROWTH AND YIELD

The Lake States TWIGS 3.0 model (Miner et al. 1989) was used to predict the growth and yield of pulpwood and sawtimber in red pine plantations. TWIGS is an individual tree model that "grows" trees based on an individual tree diameter distribution. The accuracy of TWIGS has been validated for red pine by Brand and Holdaway (1989), Miner et al. (1989), and de Naurois and Buongiorno (1986). The equations were derived from stands with a minimum age of 15 years. The initial mean dbh was estimated as a function of site index, age (15 years), and established trees per acre (Benzie 1977). The initial diameter distribution used in this study was observed by Stiell and Berry (1973) on the Petawawa Forest in Ontario.

We estimated pole production as a percentage of the living trees before the harvest at 45 years. The number and class of potential utility poles were estimated by a five step process:

1. Pole production was evaluated only if the initial number of established trees per acre was 890 and stand densities were maintained above 110 ft^2/ac.
2. The number of utility poles per rotation was estimated by using 10, 20, or 30% of the remaining trees at 45 years (Table 5). Ten to 20% can be considered a conservative estimate of the number of utility poles produced from high density stands (Uttech and Stier 1986).
3. Individual tree heights to the minimum acceptable top diameter for each pole class were estimated as a function of tree diameter, site index, and stand basal area (Ek et al. 1984). This tree height equation causes a reduction in the height after thinning since basal area is reduced. Stand basal areas were, therefore, constrained not to fall below their 45-year levels.
4. Each tree was evaluated to determine the highest pole class for which it could qualify: Class 6 was the lowest class.
5. Utility poles were harvested either by thinning from above or by a final clear cut. The largest utility poles were harvested first.

EVALUATING MANAGEMENT ALTERNATIVES

Soil expectation values (SEV) and internal rates of return (IRR) were calculated using a forestry investment analysis program, QUICKSILVER 3.1PC (Vasievich and Wiethe 1986). The IRR is the interest rate that equates the present value of returns and costs for one rotation. Although it is commonly used, it does not provide a measure of absolute magnitude, and it can lead to a suboptimal ranking of alternatives. The SEV is the net present value, discounted revenue minus discounted cost, of an infinite number of rotations starting with the bare land. When projects are mutually exclusive, the net present value for equal time horizons will indicate the optimal management scenario (Rose et al. 1988, Davis and Johnson 1987).

Soil expectation values were calculated with real discount rates of 3 and 4%. Naurois and Buongiorno (1986) found that the average real return on moderately risky Aaa corporate bonds was 2.5%, and Row et al. (1981) recommended 4% for the Forest Service.

Stumpage prices used are in Table 1. Although real changes in stumpage prices over time are difficult to predict, their effect can be substantial. By altering the magnitude of financial returns, real stumpage price changes can change recommended management strategies. Although past trends may not hold for the future, they can provide information about general conditions.

We examined the trend in red pine stumpage prices for the NLP by transforming the real prices to their natural logarithms and regressing these transformed prices on a time trend. Real prices were determined by deflating nominal prices by the Producer Price Index for all commodities (US Dep. Labor, Bur. Labor Stat. 1988). Real prices remained constant for pulpwood, and increased at 2.7% per year for sawtimber between 1967 and 1987 (significant at $\alpha = .05$). A recent study that analyzed future stumpage predic-

Table 3. List of parameters and values used to define management scenarios.[a]

Site index:	60; 75.
Thinning strategy:	light at 10-yr intervals; heavy at 10-yr intervals; heavy at 15-yr intervals.
Thinning technique:	All thinnings from below; one thinning per rotation from above.
Initial trees/ac:	680; 890.
Rotation length:	45; 55; 60; 65; 75.
Product:	Pulpwood and sawtimber; pulpwood, sawtimber, and utility poles (10, 20, and 30%).
Pricing scenario:	All products remain constant in real terms; sawtimber and pole prices increase at 2.5% per year.
Economic criterion:	Internal rate of return; soil expectation value with a 3% discount rate; soil expectation value with a 4% discount rate.

[a] There are 984 total combinations.

Table 4. Thinning treatments by management scenario.[a]

Age in years	10-year interval Light thinning	10-year interval Heavy thinning	15-year interval heavy thinning
25		thin every 3rd row	
30			thin every 2nd row
35	thin every 3rd row	thin to 70 ft²[b]	
45	thin to 110 ft²	thin to 80 ft²	thin to 80 ft²[b]
55	thin to 120 ft²	thin to 90 ft²	
60			thin to 80 ft²
65	thin to 130 ft²	thin to 110 ft²	

[a] One thinning per rotation was from above at ages 45 and greater. For example, the 15-year heavy thinning treatment required six simulations per site index and initial density: a 75-year rotation with a thinning from above at 45 years; a 75-year rotation with a thinning from above at 60 years; a 60-year rotation with a thinning from above at 45 years; a 75-year rotation with all thinnings from below; a 60-year rotation with all thinnings from below; and a 45-year rotation with all thinnings from below.
[b] For site index 75, the residual basal area was 85 ft² to avoid thinning more than 50% of the stand.

Table 5. Estimated percentage of poles per acre, and number of poles per acre, by site index.[a]

Site index	% Poles at age 45	% Poles at age 0	Total poles per acre over the rotation
75	10	6.6	58
	20	13.1	117
	30	19.7	175
60	10	6.5	57
	20	12.9	115
	30	19.3	172

[a] Based on 890 established trees/ac and a light thinning regime.

Table 6. Summary of optimal management strategies for site index 75.

Total poles per acre (%)	Real increase	Initial stocking per acre	Thinning[a] strategy	Rotation year	SEV[b] per acre	Increase over two-product manage.
0 (0%)	0.0%	680	HEAVY @ 15-YRS	60	$ 4	n/a
58 (10%)	0.0%	890	LIGHT @ 10-YRS	55	($ 13)	($ 17)
117 (20%)	0.0%	890	LIGHT @ 10-YRS	55	$ 27	$ 23
175 (30%)	0.0%	890	LIGHT @ 10-YRS	55	$ 104	$100
0 (0%)	2.5%	680	HEAVY @ 15-YRS	75	$ 668	n/a
58 (10%)	2.5%	890	LIGHT @ 10-YRS	75	$ 696	$ 28
117 (20%)	2.5%	890	LIGHT @ 10-YRS	75	$ 809	$141
175 (30%)	2.5%	890	LIGHT @ 10-YRS	75	$1028	$360

[a] All optimal thinning strategies for site index 75 include a thinning from above at 45 years.
[b] Calculated with 4% as the discount rate.

tions for southern pine sawtimber stumpage, a red pine substitute, concluded that a sustained price increase trend of about 2% can be expected (Binkley and Vincent 1988).

Two price outlook scenarios were used. The first assumed that real prices would remain constant for all products. The second assumed that real pulpwood prices would remain constant and real sawtimber and pole prices would increase at 2.5% per year. Establishment costs were typical costs and practices experienced in Michigan in 1987 (USDA 1988).

- Site preparation: $90/ac
- Seedlings: $90/thousand trees
- Planting: $50/ac
- Chemical release: $50/ac when the stand is 3 years old

For this study, management costs were assumed to be equal to 10% of sale value. It was assumed that the land is enrolled in Michigan's Commercial Forest Act (Mich. Dep. Nat. Resour., For. Manage. Div. 1988b). The Act establishes the ad valorem tax rate as $0.30/ac/yr and requires 10% of the stumpage to be paid as a yield tax.

RESULTS

For constant prices, the ranking of management regimes was consistent over all financial criteria used in the analysis (3% SEV, 4% SEV, and IRR). With increasing prices, the IRR criterion suggested slightly shorter rotations and earlier thinnings from above than the SEV criterion. However, because all criteria lead to similar conclusions, only the results for the 4% SEV economic criterion are presented. Optimal management returns are presented in Tables 6 and 7.

Pulpwood and Sawtimber Only

Without real price increases, returns on site index 75 ranged from a $167 loss to a $4 gain in SEV for pulpwood and sawtimber only. The 15-year heavy thinning strategy with 680 initial trees/ac, a thinning from above at 45 years and a rotation age of 60 years was the only strategy to yield a positive SEV without real price increases. With real price increases, the optimal rotation age extended to 75 years (SEV = $668).

Without real price increases, returns on site index 60 ranged from a $199 loss to a $77 loss. The 10-year light thinning strategy with 680 initial trees/ac, a thinning from above at 45 years, and a rotation age of 60 years was the best SEV without real price increases. With real price increases, the optimal rotation age extended to 75 years (SEV = $479).

Pulpwood, Sawtimber, and Poles

Without real price increases, optimal returns on site index 75 ranged from a $13 loss with 10% poles to a $104 gain in SEV with 30% poles. A 55-year rotation with a thinning from above at 45 years produced the best returns with 10% and 20% utility poles. The rotation extended to 65 years with 30% utility poles. With real price increases, the optimal returns ranged from $696 to $1,028 SEVs. Rotation ages extended to 75 years for 10% and 20% utility poles. A 65-year rotation provided the best return with 30% poles.

Without real price increases, optimal returns on site index 60 ranged from a $83 loss in SEV with 10% poles to a $58 loss with 30% poles. A 65-year rotation with a thinning from above at 45 years produced the best returns. With real price increases, the optimal returns ranged from $479 to $725 SEV. Rotation ages extended to 75 years.

SCREENING THE OPTIONS FOR EXISTING STANDS

Figure 1 can be used to evaluate existing stands for their potential to produce utility poles. Then, if pole production is an option, Tables 6 and 7 can be used to determine the recommended management strategy for an existing stand. The steps involved are:

1. Select the table for site index 75 (Table 6) or site index 60 (Table 7).
2. Work from left to right. Choose the approximate number of potential utility poles from the first column (use 0 if utility pole production is not an option or 175 for seedling/sapling stands and young pole stands).
3. Use the desired real price increase assumption, 0% or 2.5%.
4. Find the initial stocking per acre in the third column, 680 or 890.
5. The preferred management regime then appears to the right.
6. The last column, labeled "Increase over two product mgt," shows the net difference associated with managing for utility poles.

As an example, for an existing stand with site index 75, 175 potential utility poles per acre, and a 0.0% expected

Table 7. Summary of optimal management strategies for site index 60.

Total poles per acre (%)	Real increase	Initial stocking per acre	Thinning[a] strategy	Rotation year	SEV[b] per acre	Increase over two-product manage.
0 (0%)	0.0%	680	LIGHT @ 10-YRS*	65	($ 77)	n/a
57 (10%)	0.0%	890	LIGHT @ 10-YRS*	65	($ 83)	($ 6)
115 (20%)	0.0%	890	LIGHT @ 10-YRS*	65	($ 72)	$ 5
172 (30%)	0.0%	890	LIGHT @ 10-YRS*	65	($ 58)	$ 19
0 (0%)	2.5%	680	LIGHT @ 10-YRS*	75	$479	n/a
57 (10%)	2.5%	890	LIGHT @ 10-YRS*	75	$503	$ 24
115 (20%)	2.5%	890	LIGHT @ 10-YRS**	75	$578	$ 99
172 (30%)	2.5%	890	LIGHT @ 10-YRS**	75	$725	$246

[a] Calculated with 4% as the discount rate.
* Includes a thinning from above at 45 years.
** Includes a thinning from above at 55 years.

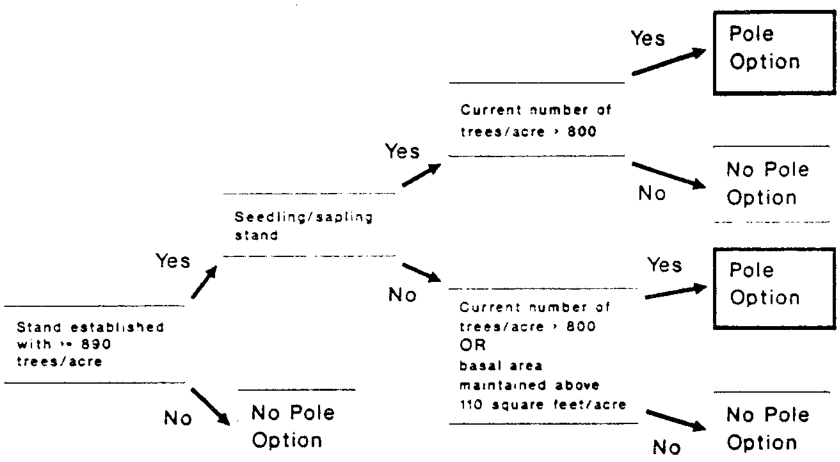

Fig. 1. Determination of silvicultural conditions suitable for production of utility poles.

real price increase, landowners can increase the SEV (4% discount rate) by $100/ac if they manage for utility poles plus pulpwood and sawtimber. The indicated management would be a 10-year light thinning strategy, thinning from above at 45 years, and clear cutting at 55 years.

RECOMMENDATIONS

Landowners can maximize their returns from red pine management on site index 60 and 75 sites by managing for utility poles where markets exist. To accomplish this, initial densities should be at least 890 trees/ac, thinnings should be light at 10-year increments (minimum of 110 ft^2 residual basal area per acre), and a thinning from above should be done when the stand is 45 years old.

If landowners estimate 30% of the stand to be poles at age 45, the SEV (4% discount rate) will increase by $19/ac on site index 60 and $100/ac on site index 75. If real price increases in sawtimber and poles are expected, returns will increase by $246/ac on site index 60 and $360/ac on site index 75. □

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