Economic and Management Models for Cottonwood in Central Oklahoma

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Abstract

Production in thinned and unthinned cottonwood stands in central Oklahoma was studied over a 22-year period. Volumes per tree were obtained with a local volume table constructed for the study area. Values per tree were assigned by two schedules, one at a fixed rate per cubic foot, the second at a sliding scale of value per cubic foot. Volumes and values for the stands by years were obtained. Average acre stand, stock, and value tables for rotations 5 years to 22 years were constructed. Allowance was made for the usual first year costs and annual expenses in growing the timber. The net discounted soil value theorem was used to identify optimum rotations.

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The recent increase in demand for cottonwood stumpage in Oklahoma makes evident the need for obtaining more information on the production and management of the species. In a recent bulletin (Walker, 7) is described the growth and yield obtained from cottonwood over a 22 year period on a Port silt-loam soil in Central Oklahoma. From the same data, economic and management models are developed in this report.

Sustained-yield models for forests composed of even-aged stands have been developed by many writers. Meyer (4) has been largely responsible for adapting the DeLiocourt principle of the sustained yield model for uneven-aged stands for use in this country. The use of marginal analysis to determine financial maturity was described by Duerr and Bond (1), and the use of the discounted net soil value has been described by many foresters and economists. Gaffney (2) has compared the several methods of estimating financial maturity, and has clearly demonstrated the superiority of the Faustmann approach (discounted soil value). Walker (6) has developed value schedules for trees of different diameters, using local volume tables for the species involved.

Procedure

Data on production and mortality were collected from a seed-origin stand of cottonwood in west-central Lincoln County, Oklahoma, over a 22-year period. This study was reported by Walker (7) in 1967. In the present study, the same production information is used as a basis for formulating economic and management models for the species under local conditions.

Stand tables showing the number of trees per acre by diameter classes have been prepared. A table was made for each of the 22 years of the study. Figure 1-a, b, c, and d depict graphically the tables for ages 5, 10, 15 and 22.

A local volume table (volumes based upon diameter breast high measurements only) was constructed, using measurements from trees felled over the several years the study was in progress. The final volume table was obtained by smoothing the raw field data with a logarithmic

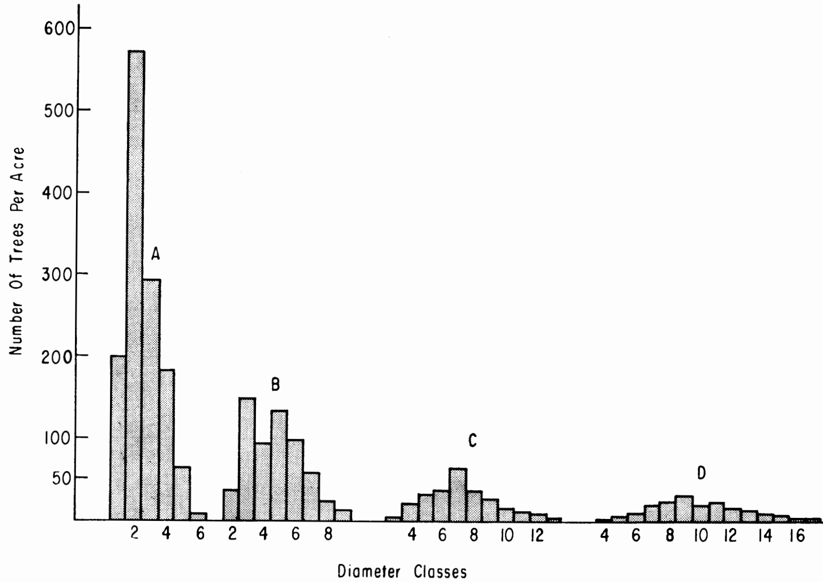

Figure 1. Trees peracre in individual stands at 5 years (A), 10 years (B), 15 years (C), and 22 years (D). Cottonwood, central Oklahoma.

volume curve. The volumes per tree by diameter classes used throughout this report are given in Table 1.

Two value schedules were adopted. In schedule #1 a stumpage value of $1.00 was used for a 12-inch tree and a constant value of $0.048 per cubic foot, regardless of tree size, was applied. Schedule #2 represents a sliding scale of stumpage value per unit of volume, from $0.03 per cubic foot for 6-inch trees to $0.088 per cubic foot for 17-inch trees. Trees in 4- and 5-inch classes are assigned slightly larger than $0.03 value per cubic foot, on the premise that trees in these diameter classes might find a post market, or some special product market other than pulpwood. Value schedules are given in Table 2.

Sustained yield models were prepared by subjecting both the volume and value data to summation procedures. The summation technique is described in all standard texts on forest management (5). For example, summation of volume for a 10-year rotation requires that the volume on each of 10 acres, with succeeding age classes 1 to 10 occupying equal areas of one acre, be added together, with the last term (volume at age 10) over the denominator 2. (The last operation is a requirement of the arithmetic progression). The result is an estimate of the volume on 10 acres required to produce a 1-acre clearcut per year yielding the vol-

Table 1: Local Volume Table for Cottonwood in North Central Oklahoma.

Diameter at breast height inches	Volumes per tree cubic feet
4*	1.02
5	1.85
6	3.05
7	4.75
8	6.9
9	9.5
10	12.8
11	16.5
12	21.0
13	26.0
14	32.0
15	38.5
16	46.0
17	54.0

*The smallest merchantable tree was considered to be 4". Therefore, all volumes and values given in the study are for trees 4" and larger.

Table 2: Value schedules for cottonwood trees.

Diameter class inches	Schedule 1* dollars	Schedule 2** dollars
4	.05	.05
5	.09	.06
6	.15	.09
7	.23	.17
8	.33	.27
9	.45	.42
10	.61	.60
11	.79	.84
12	1.00	1.25
13	1.24	1.67
14	1.52	2.24
15	1.83	2.94
16	2.19	3.75
17	2.57	4.75

* Based on the constant value of $0.048 per cubic foot regardless of tree size.
**Based on a sliding scale of values per cubic foot, from $0.03 for 6" trees to $0.088 for 17" trees.

ume of a 10-year stand. If the owner actually has 10 acres in cottonwood with age classes 1 year to 10 years equally represented, then he should be able to perpetuate the harvest of 1 acre of 10-year old stock each year. Similarly if the ownership is 5 acres, the annual harvest would be ½ acre, and in general, the clearcut area would be 1/10 of the plantation area. A 20-year rotation requires 1/20 of the plantation area in age class 1 year to 20 years to support an annual clearcut of 20-year timber on 1/20 of the area. Average acre data are derived from the summations by dividing by the number of years (or acres) in the rotation.

Average acre stand tables are depicted to best advantage on a semi-logarithmic graph (X-axis arithmetic, Y-axis logarithmic). Figure 2 illustrates the average acre stand tables for rotations 5, 10, 15, and 22.

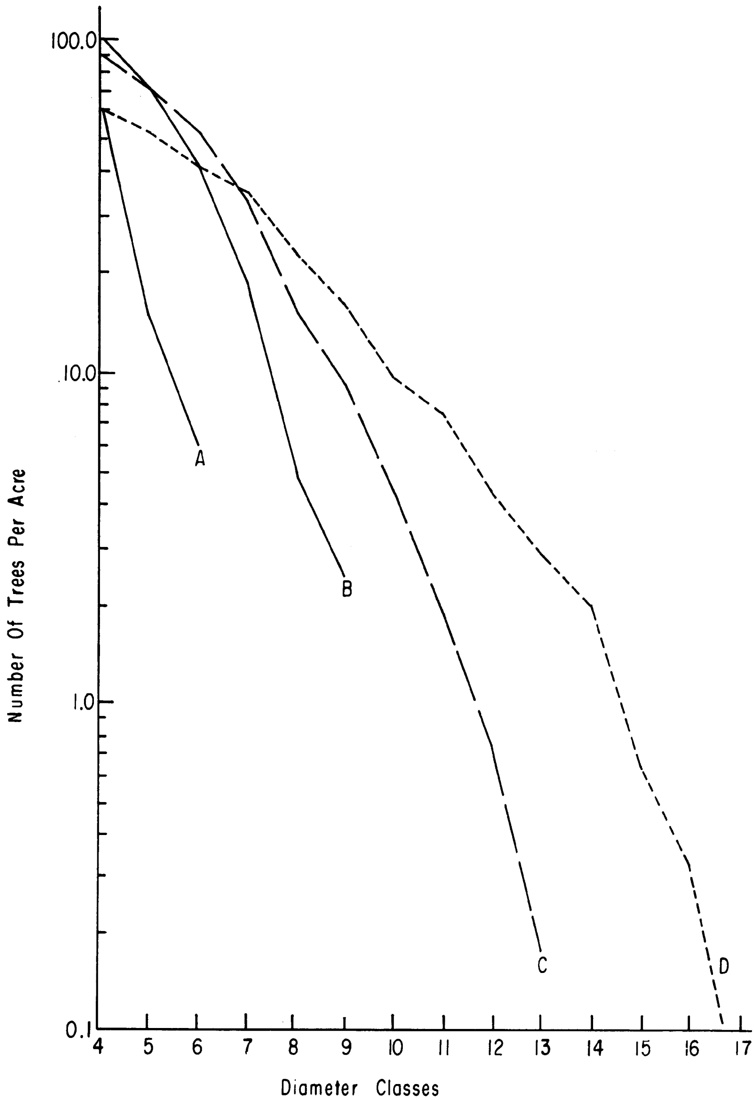

Figure 2. Number of trees per average acre by diameter classes for rotation 5 years (A), rotation 10 years (B), rotation 15 years (C), and rotation 22 years (D). Cottonwood, central Oklahoma.

The summations of stand values, and the identification of yield values provide the bases for constructing the economic models for different rotations. In this study, all rotations from 5 years to 22 years were analyzed. When net stumpage values are used, harvesting and marketing costs may be ignored, but the costs involved in growing the timber must be considered. Therefore, cost schedules have been developed for such necessary expenses as site preparation, planting, cultivation, cleaning, ad valorem taxes and administration. Net discounted soil values are used to identify optimum rotations.

Results and Discussion

Stand Structure

Stand structure refers to the distribution of trees by diameter classes, and to the spatial relationships of the tree stems. For an even-aged stand, the usual form of the distribution of trees per unit area over diameter classes is a normal curve, slightly skewed right, with the mean falling to the right of the mode diameter class. The very young stand is characterized by a narrow range of diameter classes and a high mode. With the passing of time, the mode declines rapidly and moves to the right, and the spread of diameter classes increases. Skewness also tends to increase. These characteristics are illustrated in the present case in Figures 1-a, b, c, and d.

Thinnings and Mortality

A thinning from below at age 12 has the effect of reducing the number of small trees, increasing the diameter of the tree of average basal area, and increasing the volume-basal area ratio in the stand. Within a few years following the thinning, however, the significant differences in average diameter and volume-basal area ratio have disappeared, indicating that the untreated stand loses by natural competition the trees that normally would have been removed in a thinning from below (Walker, 7). Annual losses by competition in an unthinned stand may therefore be used as a measure of the volume available annually in a repetitive thinning program.

In general, natural mortality in both volume and value declines gradually after age 12. If a thinning is performed at age 12, mortality is practically eliminated in the 13th year. For this reason. the volume and value removed in thinning in the 12th year was distributed about equally for ages 12 and 13 in order to give a closer estimate of the loss by competition that would have occurred in the absence of the thinning. Dollar values for mortality from age 12 to 22 were computed by each of the value schedules. The cubic equations used to balance the results are:

Schedule 1: $\hat{Y} = .4972 + 2.5461X - .5210X^2 + .0274X^3$
2: $\hat{Y} = .7783 + 1.8002X - .3846X^2 + .0206X^3$

The equations are valid only from X = 12 years to X = 22 years. The mortality curve for schedule 1 is shown in Fig. 3.

Growing Stock Volumes and Values

Net residual growing stock at age 22 tends to be the same for both thinned and unthinned stands (Walker, 7). Cumulative mortality in the unthinned stand and the cumulative thinning plus cumulative mortality in the thinned stand, when added to the net residual growing stock, give comparable gross production figures. Mortality therefore is a measure of the difference between net and gross production.

Stand tables of the residual growing stock from age 1 to age 22 have been prepared. Four of these tables (at ages 5, 10, 15, 22) are depicted by bar graphs (Figures 1-a, b, c, d). Each stand table was converted to dollar value with each of the value schedules. The results were smoothed by the cubic equations:

Schedule 1: $\hat{Y} = -45.6125 + 16.8820X - .8871X^2 + .0212X^3$
2: $\hat{Y} = -26.5796 + 10.6254X - .5867X^2 + .0210X^3$

The equations are valid only from X = 3 years to X = 22 years. Gross production is obtained by adding the curved cumulative mortality values to the curved residual growing stock values. Figure 4, using data from value schedule #1, exemplifies the value curves.

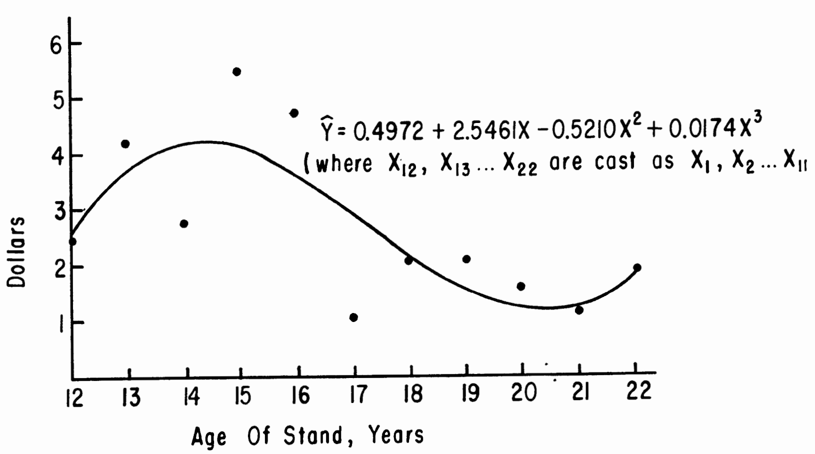

Figure 3. Value of mortality (or thinnings available) from age 12 to age 22 in cottonwood stands, central Oklahoma. (Value schedule # 1).

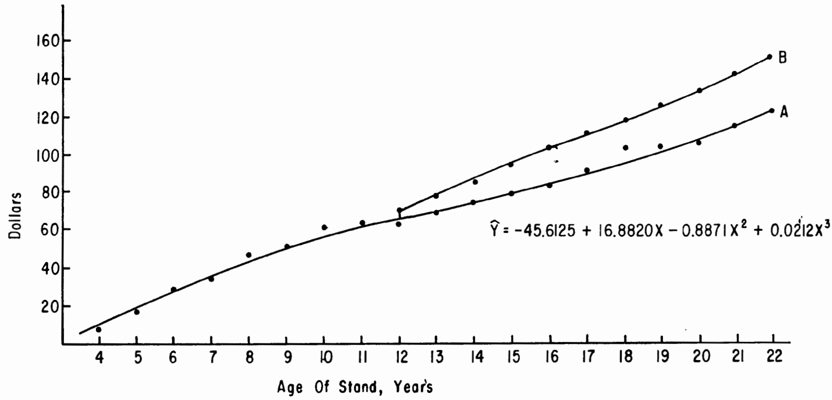

Figure 4. Net growing stock value (A) and gross production value (B) per acre for cottonwood stands in central Oklahoma. (Value schedule #1).

Table 3: Residual cottonwood growing stock volume and value for different rotations, Central Oklahoma.

Rotation (R)	Stock on R Acre*	Stock on Avg. Acre	Value of Stock Avg. Acre (Sch. 1)	Value of Stock Avg. Acre (Sch. 2)
years	cu. ft.	cu. ft.	dollars	dollars
5	327	65	3.20	3.14
10	4399	440	21.44	15.95
15	11052	737	36.64	29.29
20	20880	1044	50.55	45.32
22	25674	1167	56.34	53.26

*Growing stock volumes obtained by summation

The net residual growing stock required for different rotations is given in Table 3. Volume is expressed in terms of the total on a number of acres equal to the number of years in the rotation, with succeeding age classes on each acre. Average acre volumes are also given.

Net and Gross Yields

Net yield is that volume or value available for clearcut at any given stand age, no thinnings or mortality calculated. Gross yield at a given age is that volume or value available for clearcutting at that age plus the accumulated volume or value of the previous thinnings, or mortality, or both, up to that time. Table 4 gives the information on net and gross production for stand ages 5, 10, 15, 20, and 22.

For the short pulpwood rotations considered in this report, the increase of gross production over net production is not large. The increase,

Table 4: Net and Gross Yields of Cottonwood at different ages, Central Oklahoma.

	Net Yield			Gross Yield		
Age	Volume	Schedule 1 Value	Schedule 2 Value	Volume	Schedule 1 Value	Schedule 2 Value
years	cu. ft.	dollars	dollars	cu. ft.	dollars	dollars
5	330	19.26	14.50	—	—	—
10	1257	55.69	42.00	—	—	—
15	1636	83.64	74.81	1943	94.10	84.78
20	2225	107.97	120.09	2745	132.82	140.83
22	2530	124.09	148.28	3112	151.39	170.78

expressed in revenue dollars, amounts to 12.5 percent at 15 years and 23 percent for 20 years. With longer rotations, such as would be required for the production of sawlogs and veneer stock, the increase of gross over net production could be expected to be much larger.

Financial Aspects of Cottonwood Management

In this report, net discounted soil value is used in the analysis of the economic aspects of cottonwood management. Both net production without thinning and gross production with thinnings are considered. Two value schedules are used. The chosen discount rate is 5 percent.

Values used in this study apply to standing trees, therefore harvesting costs and marketing costs and returns are disregarded. Costs of growing the timber needed to be accounted for, so that proper deductions from gross stumpage value may be made.

The application of the soil value theory requires that all the estimated future harvest values, based upon present product prices, be discounted to the present. From this amount is deducted the sum of all the discounted future costs, based on current cost schedules. The resulting net residual is termed the net discounted present worth of the enterprise. It represents the capital amount, which, if deposited at compound interest at the rate used in the discounting process, would yield each revenue on schedule and would allow for each cost item when due. This capital value would remain unchanged at the end of each succeeding rotation, and may therefore be thought of as a residual value applying to bare land. Variations in the capital value of land are caused by variations in net income. An increased discount rate causes the capital value to decline. Different rotations also affect the capital value, due to the fact that the relationship between gross returns and costs vary. Commonly, the rotation which results in the maximum net discounted value is the rotation adopted, because the use of this particular rotation maximizes the rate of return on the actual investment.

Evaluation of Costs

Costs involved in growing cottonwood timber may be classified into 3 major categories:

(1) First year costs

(2) Costs occurring at times between initial establishment and final harvest of the crop, usually in designated years of the rotation.

(3) Annual expenses

First year costs are those occurring only once each rotation, in the year of establishment of the crop, immediately following the final harvest, by clearcutting, of the previous crop. Included are such expenses as site preparation (disking or plowing), planting or seeding, or initial weed or brush control. The capital value of such costs is established as

$$V_0 = C + \frac{C}{(1+p)^r - 1}$$

where V_0 is the present discount value of a perpetual series of these costs, C = the cost, p = the discount rate (as .05 for 5%), and r = years in the rotation. In the above equation, C evaluates the first installment, due immediately, and therefore unaffected by discount, and

$$\frac{C}{(1+p)^r - 1}$$

evaluates all future installments, the first due r years from now. In the case of cottonwood culture, a certain amount of brush and grass removal is usually needed, and the cost of obtaining and planting cuttings should

Table 5: Soil value computation at 5 percent discount, for an unthinned cottonwood stand, Central Oklahoma. (Value schedule #1 is used).

	Rotations (years)				
	5	10	15	20	22
Value of final harvest (Yr)	19.26	55.69	83.64	107.97	124.09
$\frac{Yr}{(1.05)^r - 1}$	69.71	88.55	77.52	65.31	64.45
Value of first year cost (C)*	46.19	25.90	19.27	16.05	15.19
Value of annual expense ($\frac{e}{p}$)**	15.00	15.00	15.00	15.00	15.00
Net soil value	8.52	47.65***	43.25	34.26	34.26

* Value = $\$10 + \frac{\$10}{(1.05)^r - 1}$

** Value = $\frac{0.75}{.05}$

***The culmination occurs at age 12 with a soil value of $48.38.

Table 6: Soil value computation at 5 percent discount for an unthinned cottonwood stand, central Oklahoma. (Value schedule #2).

	Rotations (years)				
	5	10	15	20	22
Value of final harvest (Yr)	14.50	42.00	74.81	120.09	148.28
$\frac{Yr}{(1.05)^r - 1}$	52.48	66.78	69.34	72.64	77.02
Value of first year cost (C)	46.19	25.90	19.27	16.05	15.19
Value of annual expense ($\frac{e}{p}$)	15.00	15.00	15.00	15.00	15.00
Net soil value	-8.71	25.88	35.07	41.59	46.83*

*The culmination of soil value occurs after age 22.

be included. If site preparation cost is $5 and the planting cost is $5 per acre, with a discount rate 5 percent and a rotation of 20 years, the present worth of this series of operations is

$$V_o = \$10 + \frac{\$10}{(1.05)^{20} - 1} = \$10 + \frac{\$10}{2.6533 - 1} = \$16.05^*$$

*$(1+p)^n$ values are read from a table of compound interest

It should be noted that longer rotations would show smaller capital values for this expense. For a 30-year rotation, the same expense is evaluated as

$$V_o = \$10 + \frac{\$10}{4.3219 - 1} = \$13.01$$

For a very short rotation, such as 5 years, the negative value of a first year cost would be an important limiting factor in the production of wood fiber:

$$V_o = \$10 + \frac{\$10}{1.2763 - 1} = \$46.19$$

Costs occurring during the rotation may be exemplified with a weeding or cleaning, in the fifth year of a 20-year rotation, designed to remove excess trees in a natural stand, or perhaps to remove unwanted species or brush in a planted stand. If the cost of performing this work is $7 per acre, the present net capital value of the infinite series is:

$$V_o = \frac{W (1.05)^{20-5}}{(1.05)^{20} - 1} = \frac{\$7 (2.0789)}{2.6533 - 1} = \$8.80$$

The capital value of this expense could be reduced either by delaying the work until after the fifth year, or by lengthening the rotation. Delaying the work, however, might result either in incurring more actual cost, or in reducing crop production. The advantages of the delay would in either case be lost. In planted stands, cleaning might be needed on some acres but not on others, whereas natural stands always need attention of this kind in the early years of the rotation. No allowance for weeding cost has been made in the financial analysis in this study.

Annual expenses usually consist of ad valorem taxes, and any administrative or fire protection costs. If such an expense amounts to \$.75 per acre, the present value of the infinite series is established simply as

$$V_o = \frac{e}{p} = \frac{.75}{.05} = \$15.00$$

Control of expenditures is a most important factor governing the profitability in a timber production enterprise. Annual expenses are the most critical type of cost, since they are directly deductible from annual income, or are capitalized with e/p as a negative value against land. Delayed returns are adversely affected by the mounting carrying costs of annual expenditures. This factor explains why an item such as the ad valorem tax is of such concern in timber production. First year costs are also restrictive, particularly in the short rotations considered here. For a 1-year rotation, the first year expense would, of course, be an annual expense. At 5 percent discount, a \$10 cost would capitalize at

$$\frac{\$10}{.05} = \$200$$

as a negative value against land. The same \$10 per acre cost capitalizes at \$25.90 for a 10-year rotation, \$16.05 for a 20-year rotation, \$13.01 for a 30-year rotation, and \$11.66 for a 40-year sawlog or veneer log rotation.

Evaluation of Stumpage Returns

The returns from the sale of products on the stump are of two general types: (1) The final harvest which terminates the rotation and sets the stage for a succeeding rotation, and (2) intermediate revenue-producing partial cuttings in the form of thinnings.

Evaluating all the future final harvests at a point in time when the land is bare requires discounting the series, with the first return due a rotation's period in the future. This discount is accomplished with the equation

$$V_o = \frac{Yr}{(1+p)^r - 1}$$

where Yr = selling price of the stumpage at rotation. If the stumpage return expected from a clearcut at age 20 is $150, and the discount rate is 5 percent, then the present worth of the infinite series is

$$V_o = \frac{\$150}{2.6533-1} = \$90.73$$

Revenue produced at any time during the rotation is treated in exactly the same way as are costs incurred during the rotation. If a thinning at age 12 is expected to yield $5 worth of products, then the series, with the recurring thinnings in the 12th year of each rotation, is evaluated as

$$V_o = \frac{T\,(1.05)^{20-12}}{(1.05)^{20}-1} = \frac{\$5\,(1.4775)}{2.6533-1} = \$4.47$$

The value (S_o) assigned to land may be identified as the difference between the present value of future revenues and the present value of future costs:

$$S_o = 90.73 + 4.47 - 15.00 - 16.05 - 8.80 = \$55.35$$

The capital value of land, $55.35, may be annualized as a land "rental" figure, $55.35 (.05) = $2.77, which is an imputed annual cost of ownership, or a possible "fair rental" figure under a lease agreement.

When a number of thinnings are considered in the rotation, the net revenue from each one must be carried at p percent interest from the year in which it is made until end of rotation. Accrued values are then summed and discounted. In the present case, mortality losses from age 12 onward are considered as volumes available for thinning year by year, and each net thinning stumpage value carried to rotation at 5 percent interest. For a 13-year rotation, the computation is:

$$V_o = \frac{T_{12}\,(1.05)^{13-12}}{(1.05)^{13}-1}$$

and for a 22-year rotation, the computation becomes:

$$V_o = \frac{T_{12}\,(1.05)^{22-12} + T_{13}\,(1.05)^{22-13} + \ldots\ldots + T_{21}\,(1.05)^{22-21}}{(1.05)^{22}-1}$$

The computational procedure is simplified as shown in Tables 7 and 8 which evaluates rotations 5 and 10, 15, 20, and 22 for thinned stands. The underlined figures on the diagonal represent the final harvest values at rotation age, while the columns above each underlined figure represent the accrued values (at 5 percent) of thinnings made prior to the clearcut at rotation age. The column sums are discounted over the denominator

Table 7: Soil value computation, at 5 percent discount, for a thinned cottonwood stand, central Oklahoma. Values of thinnings and/or mortality are carried at 5 percent compound interest from year of occurrence to rotation age. (Value schedule #1).

Age	Value of thinning or mortality	Rotations (years) 5	10	15	20	22
	dollars	—dollars—				
5	—	19.26*				
10	—		55.69			
12	2.55			2.95	3.77	4.15
13	3.72			4.10	5.23	5.77
14	4.19			4.40	5.62	6.19
15	4.08			83.64	5.21	5.74
16	3.63				4.41	4.86
17	2.94				3.40	3.75
18	2.19				2.41	2.66
19	1.55				1.63	1.79
20	1.19				107.97	1.31
21	1.26					1.32
22	1.93					124.09
Sums		19.26	55.69	95.09	139.65	161.63
$\frac{\text{Sum}}{(1.05)^r - 1}$		69.71	88.55	88.14	84.47	83.95
Value of first yr. Cost		46.19	25.90	19.27	16.05	15.19
Value of annual expense		15.00	15.00	15.00	15.00	15.00
Net soil value		8.52	47.65	53.87**	53.42	53.76

* Underlined figures are final harvest values. Other figures are the thinning or mortality values extended from year of occurrence to end of rotation by 5 percent compound interest.
**The culmination occurs at age 17 with a soil value of $54.74.

$(1.05)^r - 1$, which gives the present value of all expected future gross revenue. From this value are deducted, one by one, the present values of all future estimated costs. The final result is the net soil value for each of the considered rotations.

Desired Rotation Length

From the financial standpoint, the optimum rotation is identified by the highest net discounted soil value. Use of this rotation results in maximizing the rate of return on the actual investment, regardless of whether that actual investment is less than, more than, or equal to, the computed soil value.

The factors which determine the rotation at which the soil value will culminate are as follows:

1) Thinned versus unthinned stands. The application of thinning to a stand has the effect of increasing the net recovery of volume and hence of value, making it possible to harvest more nearly the gross production

Table 8: Soil value computation at 5 percent discount, for a thinned cottonwood stand, central Oklahoma. Values of thinnings and/or mortality are carried at 5 percent compound interest from year of occurrence to rotation age. (Value schedule #2).

Age	Value of thinning or mortality	Rotations (years) 5	10	15	20	22
years	dollars			—dollars—		
5	—	14.50				
10	—		42.00			
12	2.21			2.56	3.26	3.60
13	4.49			4.95	6.32	6.96
14	3.27			3.43	4.38	4.83
15	3.14			74.81	4.01	4.42
16	2.74				3.33	3.67
17	2.18				2.52	2.78
18	1.60				1.76	1.95
19	1.11				1.17	1.29
20	0.84				120.09	.93
21	0.92					.97
22	1.46					148.28
Sums		14.50	42.00	85.75	146.84	179.68
$\frac{\text{Sum}}{(1.05)^r-1}$		52.48	66.78	79.48	88.82	93.33
Value of first year cost (C)		46.19	25.90	19.27	16.05	15.19
Value of annual expense $(\frac{e}{p})$		15.00	15.00	15.00	15.00	15.00
Net soil value		-8.71	25.88	45.21	57.77	63.14*

*The culmination of soil value occurs after age 22.

of the stand. These intermediate returns also have the effect of cancelling out some of the mounting carrying costs (costs of overhead, administration, interest on investment). In every case, the availability of net revenue during the rotation has the effect of delaying the financial rotation. In the present study, the analysis using value schedule #1 indicates a 5-year lengthening of the financial rotation when thinnings are applied.

2) Value per unit of wood produced. If the value per cubic foot in a large tree is no greater than that in a small tree (i.e., if a flat rate per cubic foot or per cord is paid for stumpage) the financial rotation tends to occur early in the life of a stand. If, however, wood is sold by weight, or if there is a recognized quality differential due to tree size, then a premium is attached to large trees, and it pays to hold them longer before applying the final clearcut. In this study, the financial rotation for both thinned and unthinned stands occurs before age 18 when value schedule #1 is used. However, use of value schedule #2, in which schedule consideration is given to increasing stumpage values per cubic foot with increasing tree size, net soil values continue to rise to age 22, and the financial rotation remains unidentified. In choosing a rotation to maximize profits, the timber grower will do well to consider very carefully the basis for stumpage payments.

3) Nature of the costs encountered in growing the timber. High first year costs practically rule out the use of very short rotations. If such rotations are desired, ways must be found to reduce expenditures in site preparation and regeneration to a minimum.

Annual expenses do not influence length of the financial rotations, although they are highly important in determining whether the timber-growing enterprise may be profitable. Regardless of rotation length, annual expenses carry the capital value e/p.

4) The discount rate. An increasing discount rate has a major influence upon capitalized values, causing them to decline. The effect upon rotation length, however, is a minor one. Increasing the rate tends to shorten the rotation. In this study, the use of 8 percent discount with value schedule #2 failed to bring the rotation of maximum soil value into the identifiable range (i.e., below 22 years). However, the use of 8 percent discount with value schedule #1 reduced the optimum rotation from 17 years to 15 years.

Summary

Stand tables have been prepared for individual age classes 1 to 22 years in a seed-origin cottonwood stand in central Oklahoma. Average acre stand tables for rotations 5, 10, 15, and 22 years were obtained by summation procedure. Stand tables were converted to stock tables with the use of a local cubic-foot volume table developed in the study area. Stock tables were converted to value tables by using two prepared value schedules. Average acre values for different rotations were obtained by summation in the same way that stock tables were derived.

Average-acre growing stock volume increased from 65 cubic feet for a 5-year rotation to 1167 cubic feet for a 22-year rotation.

Values of the growing stock increase in proportion to volume if a schedule of constant value per unit of measure is used; disproportionately to volume if a sliding value scale is used.

Allowance was made for first year costs of $10 per acre, and annual expenses of $0.75 per acre. Soil values were computed under both net production and gross production regimes. The discount rate used was 5 percent.

Optimum rotations were identified with maximum net discounted soil value. For the unthinned stand the optimum rotation was 12 years

when value schedule #1 was used, but more than 22 years when value schedule #2 was employed. For the thinned stand the optimum rotation was 17 years by value schedule #1, but beyond 22 years by value schedule #2.

Use of an 8 percent discount rate and value schedule #1 in the thinned stand reduced the optimum rotation from 17 years to 15 years. However, use of the 8 percent rate and value schedule #2 in the thinned stand failed to bring soil value culmination within an identifiable range.

It may be concluded that variation in the discount rate has only minor effects upon optimum rotation length, but increasing value per unit of volume in larger trees is a major factor in lengthening the rotation.

The effect of adding thinning volumes or mortality volumes to the net stand production (i.e. gross production) is one of lengthening the rotation of maximum soil value. With the use of value schedule #1, this lengthening amounted to 5 years. With schedule #2, the increase is unidentified because both unthinned and thinned stand optimum rotations occur after 22 years. It is logical to assume, however, that the lengthening would be greater than 5 years due to increased production of large trees to which premium values are assigned.

Annual expenses and first year costs are critical factors to be evaluated in a cottonwood-producing enterprise. They need to be kept at the lowest level consistent with satisfactory production conditions. For rotations of less than 20 years, and particularly for rotations shorter than 10 years, first year costs can become prohibitive. Ways must be found to reduce or bypass the usual site preparation and planting expenses if such rotations are to be considered.

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