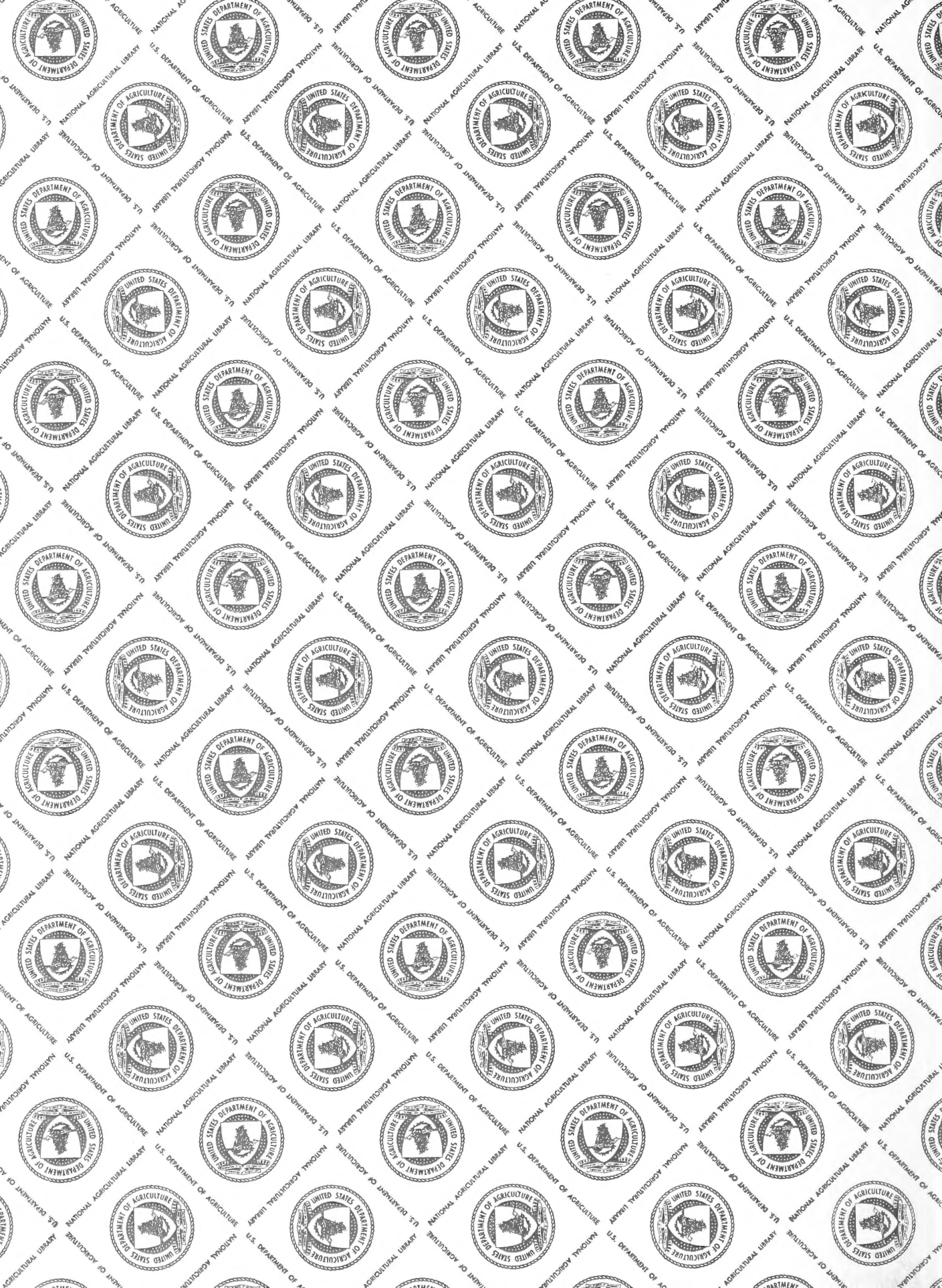
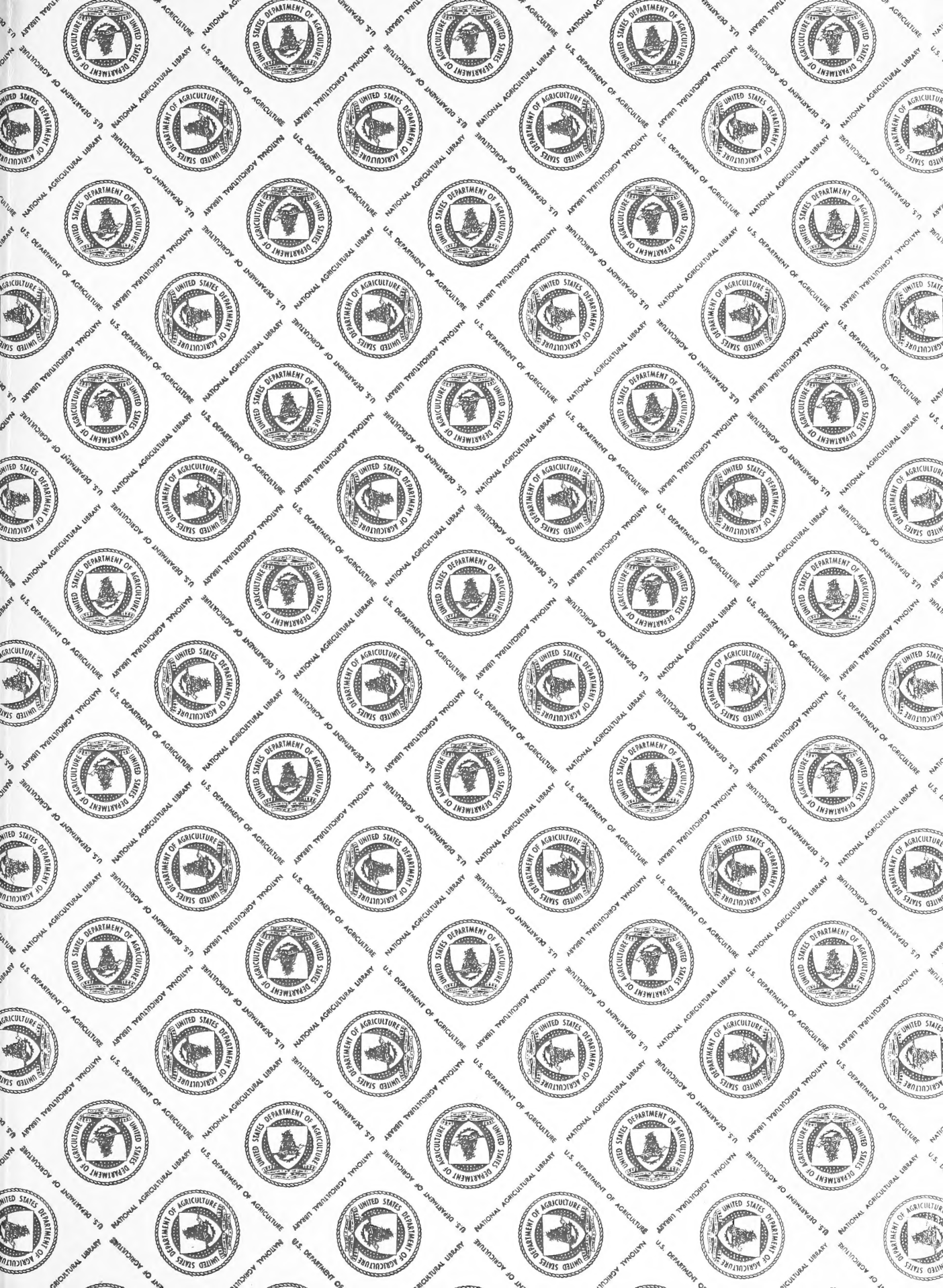


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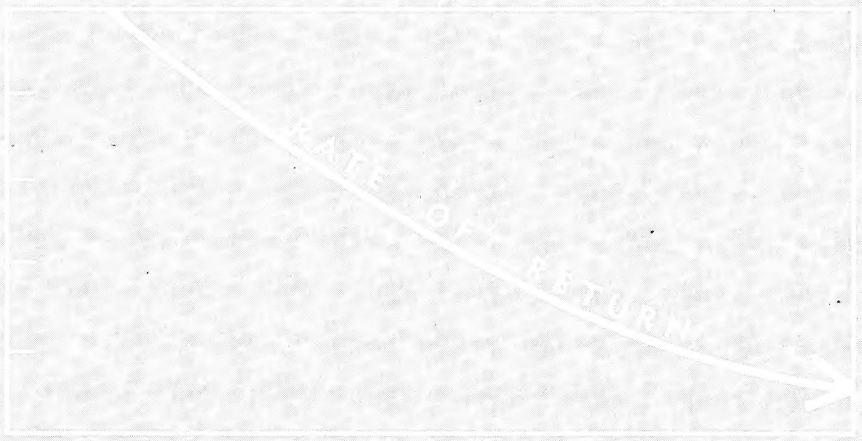
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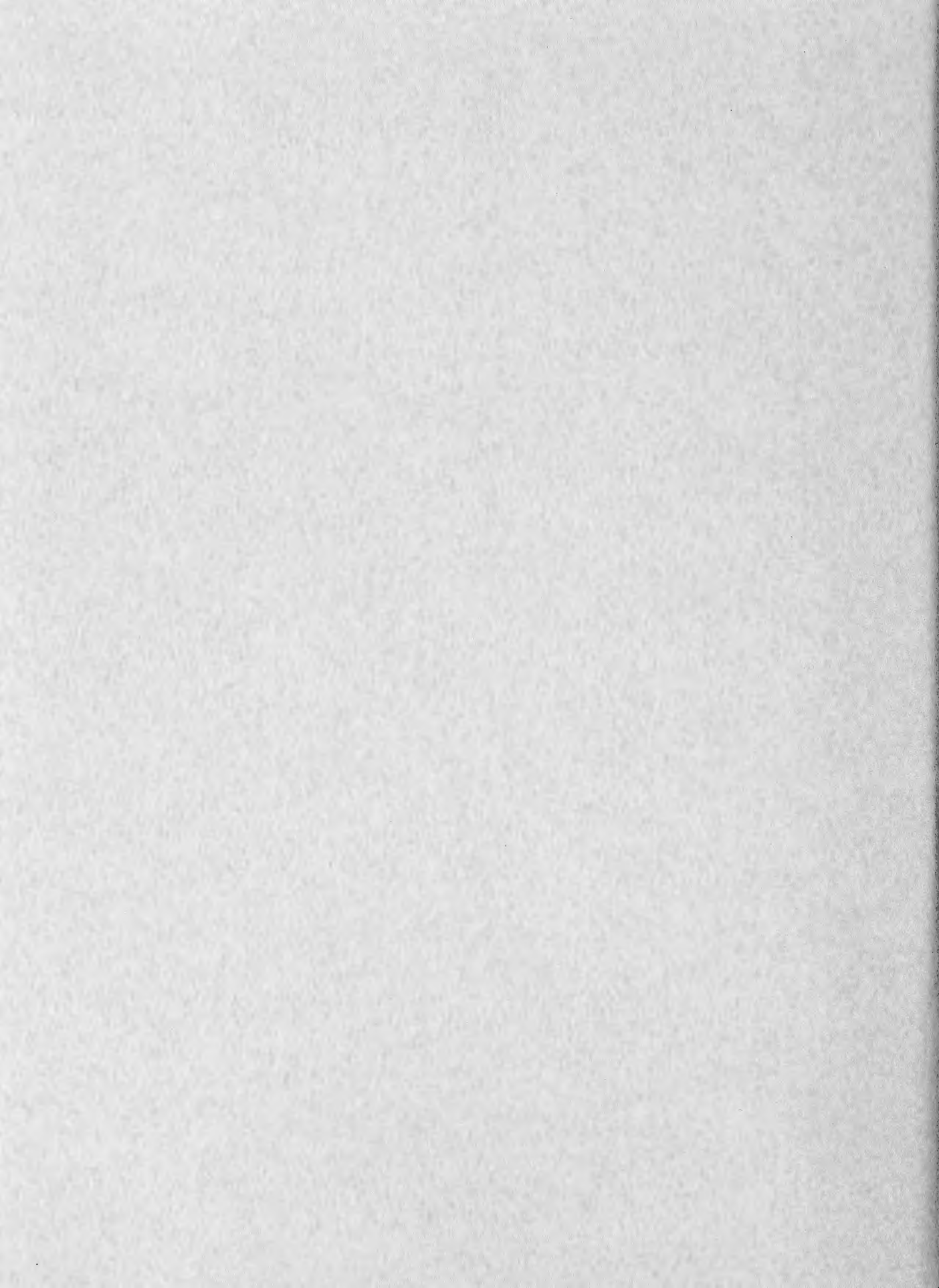
a method of
precommercial thinning of
ponderosa pine in the Northwest

BY DONALD F. FLORA



J.S. FOREST SERVICE
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INTRODUCTION

Shown in charts in this publication are some economic aspects--costs per acre and rates of return on investment--of precommercial thinning in even-aged ponderosa pine stands.

Precommercial thinning probably absorbs more money annually than any other aspect of stand improvement. For example, in fiscal year 1965, almost 29,000 acres of predominantly ponderosa

pine stands were thinned by the U.S. Forest Service in the Pacific Northwest, at an estimated cost of over \$1-1/2 million. Further, the number of acres thinned is increasing (fig. 1).

During the planning of stand improvement work, such questions arise as: Other things equal, do high-cost, dense stands give more growth response per dollar spent than low-cost, open stands?

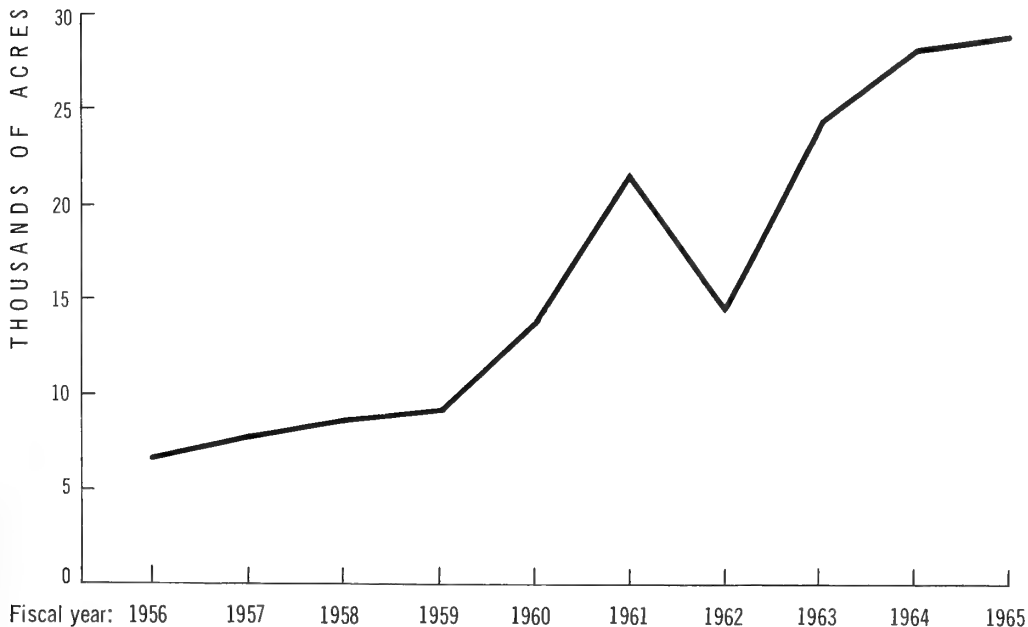


Figure 1.--Precommercial thinning by the U.S. Forest Service, Region 6, 1956-65. Source: U.S. Forest Service, Region 6. Annual planting and stand improvement report.

Should a high-site stand with dense stocking and small diameters be given priority over a low-site, open stand with larger trees? How should thinning be rated against pruning or dwarfmistletoe control? A convenient means of comparing these diverse alternatives is to rank them according to their rates of return on investment.

Because of widespread and continuing interest in ponderosa pine thinning, several economic evaluations have been made, mainly in other regions. Wikstrom and Wellner (1961) calculated rates of return for high, medium, and low sites in the northern Rocky Mountains. Their estimates assumed that returns will not be realized until the timber is cut; that is, they did not

include the allowable cut effect explained later in this publication. A rate of return of slightly over 3 percent was calculated for high sites.

Mowat (1953) estimated a 2-percent rate of return on ponderosa pine pre-commercial thinning investments in central Oregon, based on plot re-measurement data there.

For the Southwest, Gaines and Kotok (1954) made calculations of the dollar value of shortened rotations arising from early thinning, based on numerous thinning experiments. Shortening the growing time required to reach merchantable size could, according to their figures, return more than 5 percent on the treatment cost.

DEVELOPMENT OF METHOD

The rate-of-return chart (fig. 2) and thinning-cost diagram (fig. 3) are based on data collected during a study of dwarfmistletoe control economics (Flora 1966). The dwarfmistletoe study required estimates of ponderosa pine yields from uninfected as well as infected stands, both thinned and unthinned. Also involved were field studies of thinning costs in infected and uninfected stands. Thus, an analysis of thinning economics was possible without further data collection. The calculations are discussed in the appendix.

The method of thinning studied involved one-man Forest Service crews using powered circular saws commonly termed brushcutters (fig. 4). Stocking was reduced to prescribed levels (about 350 trees per acre) under a thinning program designed to favor "crotrees" rather than a fixed spacing between leave trees.

The rate-of-return calculations include allowance for nonproductive time--breakdowns, saw sharpening, fueling, and the like. Also included is an adjustment for travel on "company" time. The cost chart, too, allows for nonproductive time, but a separate adjustment must be made for travel. Cost estimates obtained from figure 3 should be multiplied by an appropriate factor from table 1.

Costs of roadbuilding and slash reduction are not incorporated in the calculations for this report.

Figure 2 was developed for organizations whose annual cut is based on the Austrian formula or similar method of calculating the allowable cut. In such a method, the allowable cut is determined partly by anticipated increment. Thus, a decision to thin produces an immediate and continuing adjustment of the allowable cut.¹ This, in turn, requires old growth or other merchantable timber from which the additional cut can in fact be taken.

The physical effect of an allowable-cut adjustment is the movement forward of the cutting of old-growth timber. The sooner income is generated by an investment, the greater will be the rate of return on investment. Hence, a policy of even-flow management, with release of old-growth cutting units in anticipation of volume growth elsewhere, increases the apparent "profitability" of thinning over what it would be if returns from treatment could not be obtained until the thinned acres are themselves harvested.

¹ If actual rather than anticipated increment is used, the effect on allowable cut is delayed until a forest inventory reflects the increased growth.

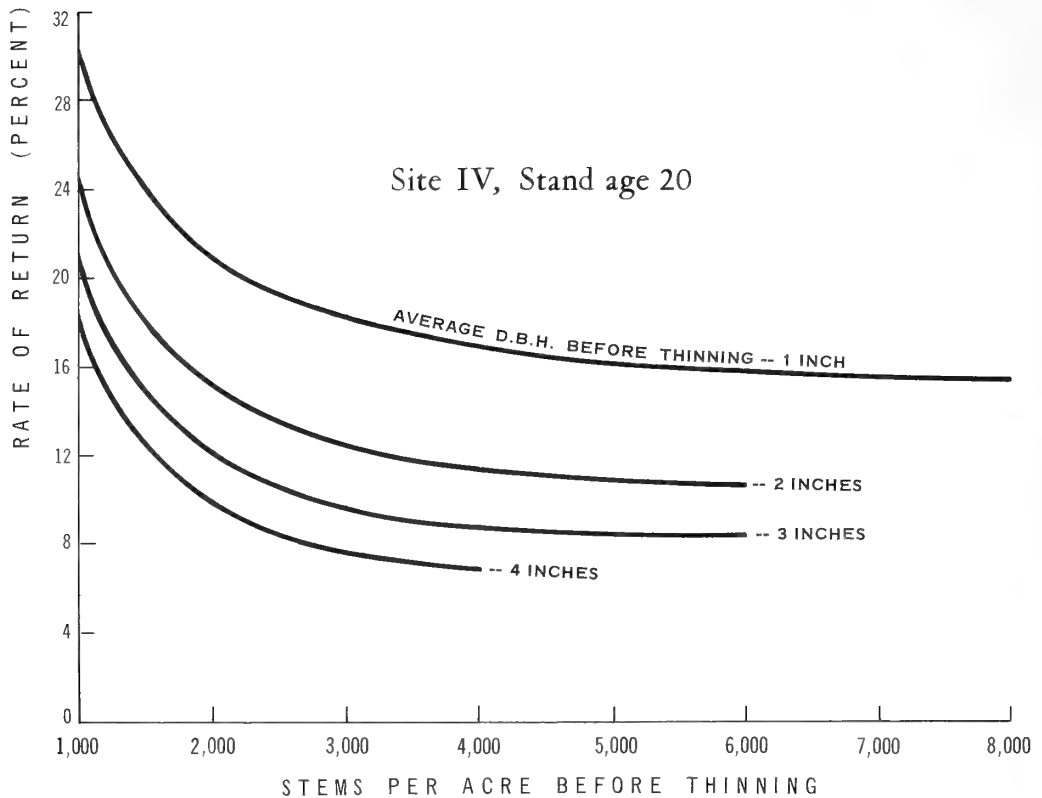


Figure 2.--Rate of return on investment, precommercial thinning, ponderosa pine. Site IV; stand age, 20 years. Rule: For each increase of site quality by one class, subtract $\frac{1}{2}$ percent; for each increase of stand age by 10 years, if average d.b.h. is: 1 inch, add $2\frac{1}{2}$ percent; 2 inches, add $1\frac{1}{2}$ percent; over 2 inches, no adjustment.

Table 1.--Factors for adjusting costs to include travel cost ¹

Travel time during an 8-hour shift (minutes)	Distance, round trip, miles							
	10	20	30	40	50	60	70	80
15	1.052	1.071	--	--	--	--	--	--
30	1.088	1.109	1.129	1.150	--	--	--	--
45	1.125	1.148	1.170	1.192	1.214	1.236	--	--
60	--	1.191	1.215	1.239	1.262	1.286	1.310	1.334
75	--	--	1.262	1.288	1.314	1.339	1.365	1.391
90	--	--	--	1.342	1.370	1.397	1.425	1.453

¹ Multiply estimated cost without travel by the appropriate adjustment factor. A vehicle and labor cost of 15 cents per mile is assumed.

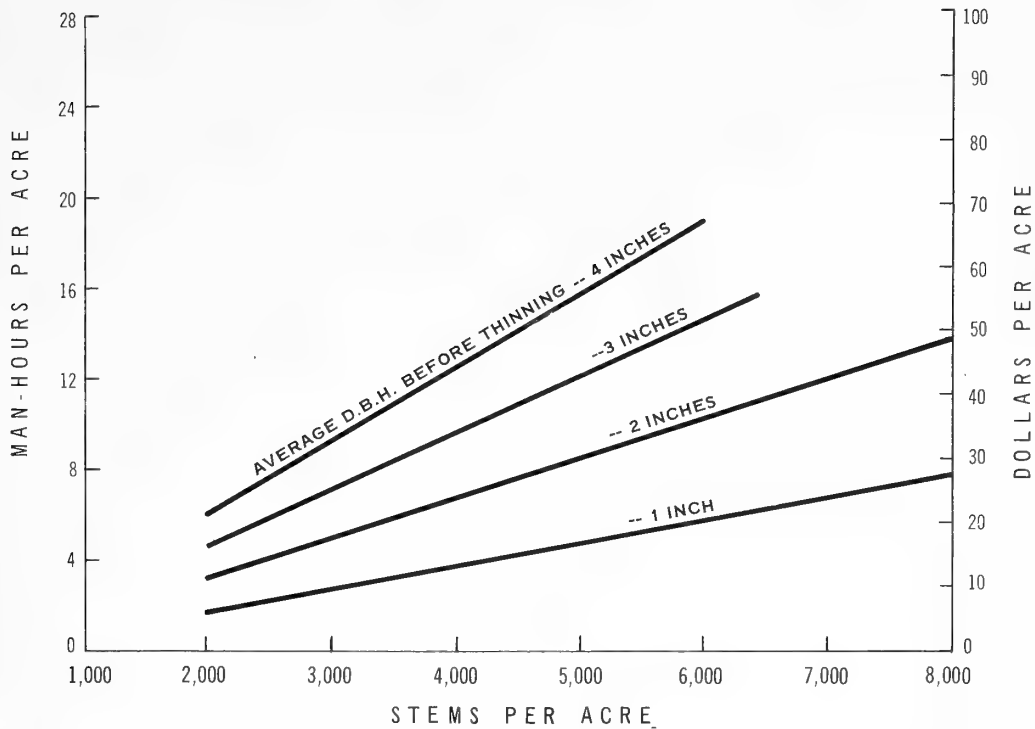


Figure 3.--Precommercial thinning of ponderosa pine, time and cost per acre.

Figure 4.--Brushcutter used in thinning young stands.



Use of the guides in this publication should be limited to areas where: (1) stands are accessible; (2) commercial timber production, on an even-flow basis, is the principal objective of stand management; and (3) assumptions outlined in the appendix are valid.

It will be noticed that the rule given in figure 2 for rates of return indicates that higher rates occur on lower sites, if other stand characteristics are equal. This circumstance, which appears unreasonable on the surface, is also discussed in the appendix.

PROCEDURE FOR USING CHARTS

GIVING STANDS PRIORITIES FOR TREATMENT

1. From type maps or field reconnaissance, estimate the following for each stand:

- Site class
- Stand age
- Average d.b.h. (before thinning)
- Stocking in stems per acre (before thinning)

2. Use figure 2 to estimate the rate of return for each stand.

3. Make a list of the stands, with columns for stand identity or location, its acreage, and its total thinning cost. List the stands in order with high rates of return at the top.

4. Using the procedure outlined below, estimate the total cost of thinning each stand. Enter this figure in the last column.

5. Choose for treatment those stands at the top of the list, working down until the figures in the total-cost column indicate that the amount of money available for thinning is nearly committed. Leave allowance for slash abatement, if required, and other contingencies.

ESTIMATING THE COST OF THINNING

1. From type maps or field reconnaissance, estimate the following for each stand:

- Average d.b.h. (before thinning)
- Stocking in stems per acre (before thinning)
- Acreage of the stand
- Round-trip distance to the stand "from town" and one-way travel time

2. Use figure 3 and table 1 to estimate thinning cost per acre.

3. Multiply thinning cost per acre by stand acreage to obtain total cost of thinning the stand.

APPENDIX

The computational background for this publication can be considered in four parts: time studies, cost analyses, growth data, and rates of return.

TIME STUDIES

In 1961, the Forest Service conducted studies of dwarfmistletoe control costs in young ponderosa pine stands in eastern Oregon. Over a hundred treatment areas, averaging 2 acres in size, were thinned. Of the compartments, 26 were free of dwarfmistletoe and were thinned according to Region 6 stand improvement guidelines to about 350 stems per acre.² Crop-tree thinning, rather than uniform thinning, was prescribed.

It was found that on both infected and uninfected compartments, thinning time per acre was related in linear fashion to stocking and to stocking multiplied by average d.b.h. Specifically, for uninfected stands, thinning time per acre was

$$T = -11 + 0.03416DS + 0.0122S$$

where T = Man-minutes per acre

D = Average d.b.h. before thinning

S = Stems per acre before thinning

² U.S. Forest Service. National Forest timber stand improvement handbook, Region 6. 1963.

This equation yielded a multiple correlation coefficient of 0.86. Not included are the various delays caused by equipment breakdowns, refueling, and the like, which added 30 percent on the average. Thus, the equation becomes

$$-14.6 + 0.04441DS + 0.0159S.$$

COST ANALYSES

The principal cost of precommercial thinning is, of course, labor. An average hourly labor cost of \$2.38 was used, based on actual crew costs and including FICA charges, payroll overhead, and field supervision.

Brushcutters, which use a chain-saw engine to power a small circular saw, cost about 93 cents per machine hour for maintenance, repair, replacement, and fuel.

To these direct costs were added 80 cents per acre for layout of string lines to guide the thinners and for selections of treatment areas and 16 percent of direct costs to cover overhead.

GROWTH DATA

The economic merits of thinning depend on growth of thinned versus equivalent but unthinned stands. Yield

estimates for unthinned stands in the Northwest were based on work by Lynch (1958). Separate projections were made of basal area per acre and stems per acre:

$$\text{Log } B = 2 + (\text{Log } S - 2)(A/L) - \text{Log} \\ (0.5663 - 0.2715H/L + \\ 15.2858/L)$$

$$\text{where } S = I(0.5663 - 0.2715H/A + \\ 15.2858/A)$$

B = Future (predicted) basal area per acre

I = Initial basal area per acre

H = Average height of dominant trees in initial stand

A = Initial stand age

L = Stand age for which basal area is being predicted.

$$\text{Log } N = 2.6078 \text{ Log } H - 11.215/L + \\ 1.4579 \text{ Log } B + 4.1007$$

where N = Future (predicted) stocking, stems per acre.

The constant, 4.1007, was not derived by Lynch, but was estimated from other yield data.

Yield estimates for managed stands were taken from stand improvement guidelines developed by the U.S. Forest Service.³ Adjustments were made for stands of different pretreatment stocking and average d.b.h. than those envisioned in the guidelines.

RATES OF RETURN

The economic effect of a decision to thin is defined in this publication as a change in allowable cut, beginning soon after the decision and lasting through the current rotation. Rotations were arbitrarily assumed to be 80 years for site class II, 100 years for site class III, 120 years for site class IV. However, rates of return are rather insensitive to rotation lengths.

³ See footnote 2.

Mean annual increment (M.A.I.) at rotation age was calculated for thinned and unthinned stands ranging in age from 20 to 40 years for site classes IV to II, average d.b.h. from 1 to 4 inches, accessibility from 10 to 40 miles' driving distance "from town," and stocking from 2,000 to 8,000 stems per acre. The difference of M.A.I. between a thinned and an unthinned stand was presumed to be the annual amount by which allowable cut was increased by a thinning decision. If, for example, M.A.I. was 350 board feet per acre per year with thinning and 250 without thinning, a gain in allowable cut of 100 board feet per acre per year was credited to thinning. If the stand was 30 years old and a rotation age of 120 years was anticipated, then the effect of thinning on allowable cut was assumed to continue for 90 years.

Gain in allowable cut was valued at \$15 per thousand board feet, reflecting stumpage price experience in the recent past and the national outlook for timber supply and demand. To establish the rate of return on investment, a rate of interest was used to discount each year's allowable-cut increase. The discounted gains were summed and compared with the investment outlay involved in thinning. Different rates of interest were tried until a rate was found which made the sum of discounted gains just equal to thinning cost.

This rate of interest, or rate of return on investment, was calculated for each of several hundred stands differing as to site, average d.b.h., stocking age, and accessibility. To permit portraying so many alternative conditions, regression equations were developed, relating rate of return to identifiable stand characteristics. Figure 2 is derived from the equations. It was found that accessibility, thought to influence the profitability of thinning, does not add

significantly to the precision with which rates of return can be estimated. The coefficient of determination for this equation is 0.92. The equation is:

$$P = -8.00 - 0.0457Q + 0.348A + 0.0002DS - 0.0976DA + 8.9817(1/D) + 18,414(1/S)$$

- where P = Rate of return on investment
 Q = Site index
 D = Average d.b.h. before thinning
 S = Stems per acre before thinning
 A = Stand age at time of thinning

In the equation, site index has a negative coefficient, indicating that as site quality increases rate of return drops. This fact, reflected in the rule of figure 2, can be explained with an example. Suppose that mean annual increment in stands on two different sites is as follows:

	High site (Bd.ft./acre)	Low site (Bd.ft./acre)
With thinning	400	350
Without thinning	300	200
Difference	100	150

In this hypothetical example, high site gives better yields than low site, with and without thinning, as would normally be expected. However, response to thinning is greater on low site, as indicated by the bottom figures. Hence, if thinning costs are the same on both sites, the lower site with its larger response offers a higher return on the thinning investment.

Because compound rates of interest are involved, rates of return are influenced most heavily by returns obtained in the near future. This fact is reflected in the stumpage values assumed. Further, it accounts for the insensitivity of rates of return to rotation decisions.

SENSITIVITY TO LABOR COSTS

Since most of the cost of stand treatment goes to labor, a change in prevailing wage rates can affect rates of return on treatment investments. In general, rate of return on treatment investment is inversely proportional to cost. Thus, if labor cost per hour increased to six-fifths of its former level, percent rate of return would become five-sixths of the previous figure.

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Cost per acre and dollar rate of return are given graphically for thinning in various young ponderosa pine stand types. Applicable only to holdings committed to even-flow management, the figures can aid in assigning treatment priorities.

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