Cutting Strategies & Timber Yields

FOR UNBALANCED EVEN-AGED NORTHERN HARDWOOD FORESTS

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CUTTING STRATEGIES FOR THE UNREGULATED FOREST

THE EVEN-AGED HARDWOOD forest, with a poorly balanced distribution of age-classes, can cause perplexing problems during the first rotation. What is the best cutting strategy to follow? By using linear programming, we developed some cutting strategies that maximize board-foot production and produce a balanced age distribution by the end of the first rotation.

We developed the strategies for four hypothetical northern hardwood forests with different unbalanced age distributions. Although these strategies may be used for forest lands with conditions similar to those assumed in this study, we urge that the linear programming techniques described in this paper be used to develop strategies tailored to particular forests and to particular management objectives.

THE PROBLEM

Even-aged management, using some form of clearcutting, is gradually becoming accepted in the northern hardwood forests of New England, especially where a high proportion of intolerant and intermediate species are desired.

On forest land committed to long-term timber production by even-aged methods, sustained-yield management by area control usually is the objective. Briefly, this is accomplished by building up a uniform distribution of age classes, and then harvesting roughly an equal acreage from the oldest age class during each operating cycle, producing a fairly steady flow of timber products. Of course, year-to-year fluctuations in cutting are required to meet market conditions.

However, most northern hardwood forests exhibit a poorly balanced age-class distribution: Some age classes predominate, while others account for only a few acres, or are absent. On some forests, a backlog of old-growth, uneven-aged timber is present.

Where a poorly balanced distribution of age classes exists, the first step toward developing a regulated even-aged forest is to devise an appropriate cutting strategy for the first rotation—the adjustment period. Generally, this cutting strategy should (1) mold the forest into a reasonably well-balanced distribution of age classes by areas, (2) maintain adequate or specified volume yields throughout the adjustment period, and (3) optimize forest production in either volume or monetary units.

The problem of developing appropriate cutting strategies has been recognized by forest managers for some time. However, two developments have recently made it possible to devise such strategies for northern hardwoods in New England. First, a series of investigations over the last few years have shown how linear programming, and related analytical techniques, can be used to maximize forest production while maintaining specified limits on area and volume *(Coutu and Ellertsen 1960; Curtis 1962; Kidd 1966; Leak 1964; Liittschwager and Tcheng 1967; Loucks 1964; McConnen 1967;* and *Paine 1966)*. Second, tables of volume yield have been developed recently for even-aged northern hardwood stands in New England for both managed and unmanaged conditons. Although tentative, these yield tables provide, for the first time, a reasonable basis for projecting volume yields of northern hardwoods over a full rotation.

METHODS

Management Situations

In this study, we assumed four management situations, each characterized by a specified distribution of age classes (table 1). Management situation I has a roughly bell-shaped distribution of age classes, typical of some of the large ownerships in the northern hardwood region. The 40- to 60-year age class predominates among the even-aged stands, and there is a fairly large backlog of uneven-aged timber. Management situation II has gradually increasing acres by age classes and a backlog of uneven-aged timber. Situation III has gradually decreasing acres by age classes, with a backlog of uneven-aged timber. Situation IV has a distribution of age classes similar to that in situation III, but without the backlog of uneven-aged timber.

Because of the tolerance and longevity of many of the species, uneven-aged northern hardwood timber can be stored fairly well

Table 1.—*Percent of forest area in 20-year stand age classes for four management situations*

Stand age class (years)	Management situation			
	I	II	III	IV
	Percent	*Percent*	*Percent*	*Percent*
0 - 20	4	2	22	26
20 - 40	15	6	18	22
40 - 60	26	10	14	19
60 - 80	10	14	10	15
80 - 100	8	18	6	11
100 - 120	4	22	2	7
120 - 140	2	0	0	0
140 - 160	0	0	0	0
160 - 180	0	0	0	0
Uneven-aged	31	28	28	0

on the stump. So we assumed that the backlog of uneven-aged timber, if any, could be removed at any time during the first rotation.

We chose a 20-year operating cycle. This means that each stand in each management situation would be examined and considered for treatment once every 20 years.

For each management situation, we compared the yield under management with the yield under no management. When the forest was assumed to be under management, any even-aged stand that was not scheduled for clearcutting during an operating cycle was assumed to be commercially thinned; any uneven-aged stand that was not clearcut was assumed to be partially cut. Several precommercial thinnings also were assumed under management. When no management was assumed, clearcutting was the only treatment.

For both the managed and unmanaged conditions, we assumed the same rotation objective: a mean stand diameter of about 14 inches d.b.h. In northern hardwoods, which have a typical J-shaped diameter distribution, this mean diameter represents heavy sawtimber. This mean diameter is equivalent to rotation age of 160 to 180 years in unmanaged stands, and 120 to 140 years in managed stands. No stands were to be allowed to exceed the appropriate rotation age unless necessary to achieve a balanced age distribution. As the results will later illustrate, many stands had to be scheduled for cutting before rotation age.

Initially, the linear programming analysis was set up so that volume yields would increase, rather than drop, during each succeeding operating cycle. However, this restriction was eliminated because it placed an arbitrary limitation upon forest yields that might not be appropriate for many forest lands. However, it should be noted that volume yield restrictions of almost any kind can be built into this type of analysis if so desired.

Yield Tables

Yield estimates were adapted directly from the tables in *A Silvicultural Guide for Northern Hardwoods in the Northeast (Leak, Solomon, and Filip 1969).* Gross board-foot yields (International $1/4$-inch rule) in trees 10.5 inches and over for managed and unmanaged conditions are for an average site, site index 60 (base age 50), for sugar maple.

Thinning yields were developed from the stocking guides in the above-mentioned silvicultural guide. The amount of basal area required to reduce a stand from full stocking to recommended residual stocking was converted to board feet, using conversion factors applicable to New England.

When a forest was assumed to be under management, both the harvest yields per acre and the thinning yields per acre were assumed to increase steadily with each operating cycle from the unmanaged yields up to the managed yields.

Table 2 gives the harvest yield estimates used for unmanaged conditions. Table 3 gives the harvest yields for managed forests during the adjustment period. Table 4 shows the thinning yields from managed forests during the adjustment period. These yield figures are tentative and are subject to change as new information is obtained. However, these are the best estimates available at this time.

With an operating cycle shorter than 20 years, thinning yields from even-aged stands and partial-cutting yields from uneven-aged stands no doubt would be higher, but perhaps more costly to log. Harvest yields would be higher, as well.

Table 2.—*Clearcutting harvest yields for unmanaged northern hardwoods, for all operating cycles*

Age class	Yield per acre	Age class	Yield per acre
Years	*Board feet*	*Years*	*Board feet*
0-20	0	100-120	7,800
20-40	0	120-140	11,200
40-60	0	140-160	14,100
60-80	2,500	160-180	15,800
80-100	5,650	Uneven-aged	13,000

Table 3.—*Clearcutting harvest yields in board feet per acre for managed northern hardwoods (several precommercial thinnings assumed)*

Operating cycle (years)	Age class in years								
	0-20	20-40	40-60	60-80	80-100	100-120	120-140	140-160	Uneven-aged
0 - 20	0	0	0	2,500	5,650	7,800	11,200	14,100	13,000
20 - 40	—	0	0	3,650	6,538	8,950	11,967	14,483	13,000
40 - 60	—	—	0	4,800	7,426	10,100	12,734	14,866	13,000
60 - 80	—	—	—	5,950	8,314	11,250	13,501	15,249	13,000
80 - 100	—	—	—	5,950	9,200	12,400	14,268	15,632	13,000
100 - 120	—	—	—	5,950	9,200	13,550	15,035	16,015	13,000
120 - 140	—	—	—	5,950	9,200	13,550	15,800	16,400	13,000

Table 4.—*Thinning or partial cutting yields in board feet per acre for managed northern hardwoods (several precommercial thinnings assumed)*

Operating cycle (years)	Age class in years							
	0-20	20-40	40-60	60-80	80-100	100-120	120-140	Uneven-aged
0 - 20	0	0	0	1,250	2,250	3,000	4,000	5,000
20 - 40	—	—	—	1,617	2,563	3,330	4,204	5,000
40 - 60	—	—	—	1,984	2,876	3,660	4,408	5,000
60 - 80	—	—	—	2,350	3,189	3,990	4,612	5,000
80 - 100	—	—	—	2,350	3,500	4,320	4,816	5,000
100 - 120	—	—	—	2,350	3,500	4,650	5,020	5,000
120 - 140	—	—	—	2,350	3,500	4,650	5,225	5,000

Linear Programming

The linear programming analysis generally followed the format previously outlined *(Leak 1964)*. The yield equation or objective equation was of the form:

$$Y=\Sigma \Sigma A_{ij} V_{ij} + \Sigma\Sigma B_{ij} T_{ij}$$

in which—

Y=Total yield.
A=Area harvested (acres clearcut).
V=Volume per acre harvested (clearcut).
B=Area thinned (acres).
T=Volume per acre thinned.
i=The number of the operating cycle (1, 2, 3, etc.).
j=The age class (1, 2, 3, etc.).

Area thinned (if any) in the above equation was expressed as initial acres minus previous acres harvested, so that the final objective equation was in terms of the variables A, V, and T.

Restrictions on the acres present in the forest were expressed by equations similar to these:

$$A_{11} + A_{22} + A_{33} + A_{44} \ldots\ldots + A_{99} = \_\_\_\_\_\_ \text{acres}$$

$$A_{12} + A_{23} + A_{34} + A_{45} \ldots\ldots + A_{89} = \_\_\_\_\_\_ \text{acres}$$

Restrictions of equal-acreage cuts per operating cycle were applied to ensure the buildup of a balanced age-class distribution. And no harvest cutting was allowed in new stands created during the adjustment period. Equations were of the form:

$$A_{11} + A_{12} + A_{13} \ldots + A_{19} - A_{22} - A_{23} - A_{24} \ldots - A_{29} = 0$$

The linear programming analyses were run on an IBM 360 computer, using a specially written program. Programming and analytical methods are available upon request to the authors. The output of each analysis consisted of the acres to harvest and thin by age classes and operating cycles for a given management situation so as to maximize the yield equation—the total yield over the first rotation period.

RESULTS

Cutting Strategies

Optimum cutting strategies are shown in the appendix for both managed and unmanaged treatments of situations I (tables 7 and 8), II (tables 9 and 10), III (tables 11 and 12), and IV (tables 13 and 14). These cutting strategies show the percent of total forest area to clearcut by stand age-class and operating cycle so as to (1) maximize board-foot production over the first rotation, (2) build up a balanced distribution of age classes by the end of the first rotation, and (3) keep within the acreage limitations of each forest situation.

These cutting strategies can be used as broad, guiding principles on northern hardwood forest properties with similar age-class distributions, where sustained yield and maximum volume production are of interest. The fairly long operating cycles—20 years—allow for considerable flexibility in year-to-year cutting activity, to allow for variations in markets and other local conditions.

Where age-class distributions, rotations, volume yields, and management objectives differ from those reported in this paper, appropriate cutting strategies probably can be developed by the linear programming methods that we have used.

Examination of the cutting strategies (tables 7 to 14) shows that where a backlog of old-growth exists (situations I, II, III), only a small amount of cutting should be done in stands less than 120 years old; and this small amount should be done within the first 20-year operating cycle. This indicates that, although pulpwood and small sawtimber sales might be required during the first cycle, cuts during following cycles would be concentrated in reasonably heavy sawtimber.

Under situation IV (decreasing acres by age classes and no uneven-aged backlog) the best strategy was to cut mostly in young stands up through the second or third operating cycle. And the managed situation IV required that some stands be carried over into the 140 to 160 class before harvest, one class beyond the chosen rotation age.

In most forest situations, there was a tendency toward more cutting in the younger age classes when the forest was under management. This was due primarily to the shorter rotation under management, which allowed less time, and consequently less freedom, for shifting the cutting into higher-volume stands. However, as previously noted, the degree of cutting in young stands under management appears feasible, except for situation IV; and perhaps during the first operating cycle of the other three situations. Where a strategy is found infeasible, a more acceptable cutting pattern probably can be developed by accepting lower volume yields, lengthening the rotation, or lengthening the adjustment period.

For example, in an attempt to reduce the degree of cutting in young stands, a reanalysis was made of situation I under management. This time, no clearcutting was allowed in stands less than 60 years old. The resultant strategy is shown in table 8 (figures in parentheses). The major change was an increase in the clearcutting of stands in the 60- to 100-year bracket. As shown in the next section, this new strategy resulted in only a small drop in volume yields.

Yields

By following the cutting strategies outlined in the previous section, yields generally will not vary greatly from one operating cycle to another, under both unmanaged (table 5) or managed (table 6) conditions. The only important exception to this is in situation IV (decreasing acreages by age class and no backlog of uneven-aged timber). Here, the yields during the first and second operating cycles are markedly low.

By incorporating volume yield restrictions into the linear programming analysis, it was found that, in some cases, yields could be made to follow a regular increasing progression. However, this is accomplished only with some loss in total yields.

Under management (table 6) total yields for all situations tended to be about equally divided between thinnings and harvest cuttings. However, under situations II and III, the harvest yields during the first operating cycle were proportionately low, and situation IV harvest yields were low during the first two operating cycles. During the remaining cycles, the proportion of harvest yields, which no doubt produced timber of higher quality than the intermediate cuts, was reasonably high.

The best appraisals of productivity of the various forest situations and the effects of management are made by converting the yields in tables 5 and 6 to yield per acre per year. Using a rotation age of 160 years for the unmanaged forests and 120 for the managed forests, the annual per-acre yields in board feet over the rotation are:

		Managed		
Situation	*Unmanaged*	*Intermediate*	*Harvest*	*Total*
I	82.4	96.7	102.2	198.9
II	88.6	114.4	100.3	214.7
III	82.4	83.0	103.6	186.6
IV	67.9	73.1	89.5	162.6

Those forest conditions with a higher proportion of large timber (situations I, II, and III) naturally show greater annual production rates than situation IV, which had no backlog of uneven-aged timber and a small proportion of acreage in the older age classes.

The managed forests had about 2-1/3 times the annual produc-

Table 5.—*Yields in board feet per acre of total forest land without management (clearcutting only)*

Operating cycle (years)	Management situation			
	I	II	III	IV
0 - 20	996	1,436	1,436	546
20 - 40	1,444	1,253	1,435	219
40 - 60	1,455	1,572	1,401	1,239
60 - 80	1,378	1,595	1,332	1,245
80 - 100	1,344	1,713	1,298	1,245
100 - 120	1,567	1,760	1,382	1,472
120 - 140	1,689	1,728	1,571	1,568
140 - 160	1,755	1,616	1,577	1,568
160 - 180	1,556	1,506	1,760	1,757
All	13,184	14,179	13,192	10,859

Table 6.—*Yields in board feet per acre of total forest land under management by management situation*

Operating cycle (years)	I			II			III			IV		
	Intermediate cutting	Harvest cutting	Total	Intermediate cutting	Harvest cutting	Total	Intermediate cutting	Harvest cutting	Total	Intermediate cutting	Harvest cutting	Total
0 - 20	1,654	1,060	2,714	2,297	892	3,189	1,565	403	1,968	636	17	653
20 - 40	1,639	1,815	3,454	2,396	1,597	3,993	1,312	1,838	3,150	1,104	442	1,546
40 - 60	1,849	1,654	3,503	2,302	1,820	4,122	1,273	1,843	3,116	1,219	1,893	3,112
60 - 80	1,740	1,690	3,430	1,948	1,928	3,876	1,360	1,909	3,269	1,364	1,932	3,296
80 - 100	1,668	2,039	3,707	1,729	1,985	3,714	1,452	2,035	3,487	1,453	2,042	3,495
100 - 120	1,550	2,149	3,699	1,550	1,961	3,511	1,498	2,150	3,648	1,498	2,152	3,650
120 - 140	1,500	1,858	3,358	1,500	1,856	3,356	1,497	2,259	3,756	1,496	2,261	3,757
All	11,600	12,265	23,865	13,722	12,039	25,761	9,957	12,437	22,394	8,770	10,739	19,509

tion rates of the unmanaged forests. Harvest yields under management were roughly 1¼ times greater than corresponding unmanaged yields; this difference reflects the shorter rotation possible with regular thinnings. However, the major effect of thinning upon total yields was the contribution of substantial intermediate yields, and a reduction in rotation lengths.

Under the revised strategy for situation I, where no clearcutting was allowed in stands less than 60 years old (table 8, figures in parentheses), total volume yields were reduced from 198.9 board feet per acre per year, to a little more than 197 board feet—a reduction of less than 1 percent. If clearcutting (or its equivalent, such as broadcast chemical liberation) of young stands up to 60 years old is not feasible, the revised strategy appears to be a good alternative.

DISCUSSION

The cutting strategies presented here are intended as examples of long-term guides—not inflexible rules—to the regulation of northern hardwood forests over the first rotation. These cutting strategies will maximize estimated board-foot production for the four situations examined, and produce a balanced even-aged forest by the end of the first rotation. Where forest conditions and management objectives are similar to those in this study, these cutting strategies might be used directly as broad guiding principles. However, in most cases, the strategy to be used on a given forest property should be based on an analysis of the type described in this paper, using local conditions and management policies.

In either case, the adoption of an appropriate cutting strategy must be followed by the development of a short-term (5 to 10 years, for example) cutting plan listing the areas to be marked, sold, and cut during the planning period. Toward the end of this period, it would be wise to develop another cutting strategy, incorporating any changes in forest conditions and management objectives.

Under the management situations investigated in this study, yields per acre per year for the first rotation in the managed forests were about 2-1/3 times those yields in the unmanaged forests. A portion of this difference was attributed to increased board-foot growth rates after thinning. However, the major factor was the intermediate yields from commercial thinning. Under operating cycles shorter than 20 years, total yields under management could no doubt be increased.

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Table 7.—*Situation I: unmanaged (clearcutting only) cutting strategy required to maximize production, by percent of total forest area to harvest*

Operating cycle (years)	Stand age class in years										
	0-20	20-40	40-60	60-80	80-100	100-120	120-140	140-160	160-180	Uneven-aged	All
0 - 20	—	—	—	—	3.44	3.06	2.00	—	—	2.61	11.11
20 - 40	—	—	—	—	—	—	—	—	—	11.11	11.11
40 - 60	—	—	—	—	—	—	—	0.94	—	10.17	11.11
60 - 80	—	—	—	—	—	—	6.56	4.56	—	—	11.12
80 - 100	—	—	—	—	—	—	7.67	3.44	—	—	11.11
100 - 120	—	—	—	—	—	—	—	11.11	—	—	11.11
120 - 140	—	—	—	—	—	—	—	3.89	7.22	—	11.11
140 - 160	—	—	—	—	—	—	—	—	11.11	—	11.11
160 - 180	—	—	—	—	—	—	—	—	4.00	7.11	11.11

Table 8.—*Situation I: managed cutting strategy required to maximize production by percent of total forest area to clearcut (unharvested areas will be thinned or partially cut). Figures in parentheses are the best cutting strategy when no clearcutting is allowed in stands younger than 60 years old*

Operating cycle (years)	Stand age class in years								
	0-20	20-40	40-60	60-80	80-100	100-120	120-140	Uneven-aged	All
0 - 20	4.00	0.71	1.14	—	—	—	2.00	6.43	14.28
	—	—	—	—	—	—	(2.00)	(12.28)	(14.28)
20 - 40	—	—	—	—	—	—	4.00	10.28	14.28
	—	—	—	(1.86)	—	—	(4.00)	(8.43)	(14.29)
40 - 60	—	—	—	—	—	6.29	8.00	—	14.29
	—	—	—	(.71)	(5.57)	—	(8.00)	—	(14.28)
60 - 80	—	—	—	—	—	10.57	3.71	—	14.28
	—	—	—	—	—	(4.29)	(10.00)	—	(14.29)
80 - 100	—	—	—	—	—	—	14.29	—	14.29
	—	—	—	—	—	—	(14.28)	—	(14.28)
100 - 120	—	—	—	—	—	—	14.29	—	14.29
	—	—	—	—	—	—	(14.29)	—	(14.29)
120 - 140	—	—	—	—	—	—	—	14.29	14.29
	—	—	—	—	—	—	(4.00)	(10.29)	(14.29)

Table 9.—*Situation II: unmanaged (clearcutting only) cutting strategy required to maximize production, by percent of total forest area to harvest*

Operating cycle (years)	Stand age class in years										
	0-20	20-40	40-60	60-80	80-100	100-120	120-140	140-160	160-180	Uneven-aged	All
0 - 20	—	—	—	—	—	—	—	—	—	11.05	11.05
20 - 40	—	—	—	—	—	—	9.42	—	—	1.52	10.94
40 - 60	—	—	—	—	—	—	—	11.15	—	—	11.15
60 - 80	—	—	—	—	—	—	—	9.71	1.43	—	11.14
80 - 100	—	—	—	—	—	—	—	2.86	8.29	—	11.15
100 - 120	—	—	—	—	—	—	—	—	11.14	—	11.14
120 - 140	—	—	—	—	—	—	—	—	10.00	1.14	11.14
140 - 160	—	—	—	—	—	—	—	—	6.00	5.14	11.14
160 - 180	—	—	—	—	—	—	—	—	2.00	9.15	11.15

Table 10.—*Situation II: managed cutting strategy required to maximize production, by percent of total forest area to clearcut (unharvested areas will be thinned or partially cut)*

Operating cycle (years)	Stand age class in years								
	0-20	20-40	40-60	60-80	80-100	100-120	120-140	Uneven-aged	All
0 - 20	2.00	0.86	—	—	—	11.43	—	—	14.29
20 - 40	—	—	—	—	—	3.71	10.57	—	14.28
40 - 60	—	—	—	—	—	—	14.29	—	14.29
60 - 80	—	—	—	—	—	—	14.00	0.29	14.29
80 - 100	—	—	—	—	—	—	10.00	4.29	14.29
100 - 120	—	—	—	—	—	—	5.14	9.14	14.28
120 - 140	—	—	—	—	—	—	—	14.28	14.28

Table 11.—*Situation III: unmanaged (clearcutting only) cutting strategy required to maximize production, by percent of total forest area to harvest*

Operating cycle (years)	Stand age class in years										
	0-20	20-40	40-60	60-80	80-100	100-120	120-140	140-160	160-180	Uneven-aged	All
0 - 20	—	—	—	—	—	—	—	—	—	11.05	11.05
20 - 40	—	—	—	—	—	—	—	—	—	11.04	11.04
40 - 60	—	—	—	—	—	—	3.13	2.00	—	5.91	11.04
60 - 80	—	—	—	—	—	—	8.28	2.87	—	—	11.15
80 - 100	—	—	—	—	—	—	9.42	1.72	—	—	11.14
100 - 120	—	—	—	—	—	—	6.57	4.58	—	—	11.15
120 - 140	—	—	—	—	—	—	—	11.14	—	—	11.14
140 - 160	—	—	—	—	—	—	—	10.86	0.29	—	11.15
160 - 180	—	—	—	—	—	—	—	—	11.14	—	11.14

Table 12.—*Situation III: managed cutting strategy required to maximize production, by percent of total forest area to clearcut (unharvested areas will be thinned or partially cut)*

Operating cycle (years)	Stand age class in years								
	0-20	20-40	40-60	60-80	80-100	100-120	120-140	Uneven-aged	All
0 - 20	7.70	3.40	—	—	—	—	—	3.10	14.20
20 - 40	—	—	—	—	—	—	2.00	12.30	14.30
40 - 60	—	—	—	—	—	—	6.00	8.30	14.30
60 - 80	—	—	—	—	—	—	10.00	4.30	14.30
80 - 100	—	—	—	—	—	0.30	14.00	—	14.30
100 - 120	—	—	—	—	—	—	14.30	—	14.30
120 - 140	—	—	—	—	—	—	14.30	—	14.30

Table 13.—*Situation IV: unmanaged (clearcutting only) cutting strategy required to maximize production, by percent of total forest area to harvest*

Operating cycle (years)	Stand age class in years									All
	0-20	20-40	40-60	60-80	80-100	100-120	120-140	140-160	160-180	
0 - 20	3.76	0.27	—	—	—	7.00	—	—	—	11.03
20 - 40	—	—	7.24	—	3.88	—	—	—	—	11.12
40 - 60	—	—	—	—	.12	—	11.00	—	—	11.12
60 - 80	—	—	—	—	—	—	11.12	—	—	11.12
80 - 100	—	—	—	—	—	—	11.12	—	—	11.12
100 - 120	—	—	—	—	—	—	3.37	7.76	—	11.13
120 - 140	—	—	—	—	—	—	—	11.12	—	11.12
140 - 160	—	—	—	—	—	—	—	11.12	—	11.12
160 - 180	—	—	—	—	—	—	—	—	11.12	11.12

Table 14.—*Situation IV: managed cutting strategy required to maximize production, by percent of total forest area to clearcut (unharvested areas will be thinned or partially cut)*

Operating cycle (years)	Stand age class in years								All
	0-20	20-40	40-60	60-80	80-100	100-120	120-140	140-160	
0 - 20	1.16	7.69	4.69	0.69	—	—	—	—	14.23
20 - 40	—	10.53	—	—	—	—	3.69	—	14.22
40 - 60	—	—	—	—	—	—	11.00	3.31	14.31
60 - 80	—	—	—	—	—	—	14.31	—	14.31
80 - 100	—	—	—	—	—	—	14.31	—	14.31
100 - 120	—	—	—	—	—	—	14.31	—	14.31
120 - 140	—	—	—	—	—	—	14.31	—	14.31

THE FOREST SERVICE of the U. S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.