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Harvesting Strategies for Management of Mountain Pine Beetle Infestations in Lodgepole Pine:

Preliminary Evaluation, East Long Creek Demonstration Area, Shoshone National Forest, Wyoming

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ABSTRACT

Diameter-limit and leave-tree cuts were tested as ways to reduce or minimize lodgepole pine losses to the mountain pine beetle. In the first year after treatment, loss reductions were proportional to the intensity of cut. According to the Rate of Loss Model, the 100-leave-tree cut was the best deterrent of recurring infestation, measured as amount of losses and length of time. The 100-leave-tree cut also should provide the best regeneration and has the added benefit of reducing dwarf mistletoe infection.

KEYWORDS: mountain pine beetle, *Dendroctonus ponderosae,* lodgepole pine, *Pinus contorta* var. *latifolia,* harvest strategies

East Long Creek in the Shoshone National Forest is one of a series of demonstration area projects that used management alternatives derived from research (Cole and Cahill 1976) and small-scale tests (Cahill 1978; McGregor and Cole, in press) in an attempt to reduce or minimize lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.) losses to the mountain pine beetle (*Dendroctonus ponderosae* Hopkins).

The objective of this initial large-scale application of management alternatives was to prevent undue losses of lodgepole pine by changing or reducing the food supply of the mountain pine beetle, and also to manipulate the stand to grow at or near optimum site capacity with continued prevention of large losses to the beetle.

Some constraints on the project were to protect or enhance key resource values, remove merchantable material through a commercial timber sale, develop permanent access roads for general land use and management, improve forest cover growing conditions through disease control and stocking to attain timber production potentials on regulated lands, and develop a cost-benefit analysis for each strategy. This report is limited to the reaction of the mountain pine beetle and tree growth response the first year after cutting.

Future efforts to manage stands to prevent losses to the beetle must be made before the beetle epidemic cycle. East Long Creek Demonstration Area provided this opportunity.

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STUDY AREA

The East Long Creek Demonstration Area lies between 7,600 and 8,800 ft (2 317 and 2 683 m) elevation, which is the lower half of the forested zone in the Wind River Drainage. The climate is cool and dry; moisture availability is the most limiting growth factor during the season.

Soils are derived from sedimentary formations and glacial moraines derived from the Wiggins formation. The clay content of the soils and seasonal distribution of precipitation make natural regeneration difficult on southerly and westerly aspects and flats, especially below 8,500 ft (2 591 m).

Cover types change with aspect and elevation; coniferous trees grow only on favorable aspects below 7,600 ft (2 317 m), and seldom occur on more adverse aspects at higher elevations.

Reestablishment of conifers following fire is extremely slow on adverse aspects. Recovery from any drastic disturbance on this area can be expected to be slow unless seedlings are planted as the regeneration method. On some of the adverse aspects, the scattered limber pine (*P. flexilis* James) and lodgepole pine trees appear to be pioneers of a first generation forest.

The lower part of the coniferous cover could be classed as *Abies lasiocarpa-Arnica cordifolia* habitat type, milk vetch phase. This habitat type on the Wind River District has almost no potential to be dominated by *Abies lasiocarpa* because the development of the climax community requires more time than is permitted by the natural fire cycle.

Inland Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) predominates in an alternative seral community on this habitat type where soils are basic. At this elevation, the inland Douglas-fir/mountain snowberry habitat is present on soils derived from limestone formations.

Aspen (*Populus tremuloides* Michx.) is a short-lived seral community replaced by limber pine or lodgepole pine in the first generation. Retention of aspen as a cover type requires a reduction in competition for moisture and cutting the live aspen to break the auxin flow so sprouting can occur.

In most of the stands in this zone, the lodgepole pine component of the stand is 150 to 200 years old and dying out rapidly. Younger stands are still dominated by lodgepole pine and have a manageable pole and small-size sawtimber component. This zone of the coniferous forest is an *Abies lasiocarpa-Vaccinium scoparium* habitat type.

Regeneration following disturbance is more rapid in this habitat and will tend to be mixed aged, with some tolerant species seedlings and saplings present in the first 50 years of stand development. The number of spruce and fir trees present during early stand development probably depends on seed source, once the lodgepole pine component accomplishes the necessary site modification. In some cases, competition by density stocked lodgepole pine may reduce spruce and fir regeneration.

Site index values for lodgepole pine are 30 to 35 ft (9.1 to 10.7 m) in 50 years in the *Abies lasiocarpa-Arnica cordifolia*-milk vetch phase habitat, increasing to 45 to 50 ft (13.7 to 15.2 m) in 50 years in the *Abies lasiocarpa-Vaccinium scoparium* habitats.

Throughout this area of the forest, basal area in natural stands follows the site index values, with basal areas as low as 65 ft^2/acre (14.4 m^2/ha) on the lower site index areas and increasing to 140 ft^2/acre (31.1 m^2/ha) on the most productive sites. Total live conifer trees over 2 inches (5.08 cm diameter at breast height) (d.b.h.) on the 1,789 acres (724 ha) cruised rarely exceeded 400 per acre (988 per ha).

The demonstration area contained approximately 1,898 acres (768 ha). Before harvesting, the area contained 3,777 board feet (bd.ft.) of gross green volume per acre and 1,664 bd.ft. of dead standing volume per acre. Net volumes were 3,397 bd.ft. of green volume per acre and 1,332 bd.ft. of dead volume per acre, or 4,729 bd.ft. total net volume per acre.

STAND PRESCRIPTIONS

Three general prescriptions were applied: (1) cutting levels based on diameters, (2) leave-tree cuts, and (3) clearcuts. In each case, the primary purpose was to remove the food supply from the beetle; the larger diameter trees generally contain the thicker phloem. However, other criteria were considered in each case. Each prescription required retention of adequate forest cover to promote natural regeneration, wildlife needs, and visual qualities, and was designed to fit the condition of the stand and its ecology to promote future development under natural conditions.

The prescriptions and their applications were:

1. Diameter cuts.
   a. Cut all lodgepole pine 7 inches (17.78 cm) d.b.h. and larger and salvage dead trees 8 inches (20.32 cm) d.b.h. and larger. This prescription was applied to three different stand conditions:
      (1) Late transitional stands that had converted to the spruce-fir type. The lodgepole pine component was decadent or dying rapidly. In this case, adequate lodgepole pine growing stock was to be retained. Lodgepole pine regeneration could be expected to fill in openings created by logging.
      (2) Two-aged lodgepole pine stands that contained very few tolerant trees. The understory was primarily lodgepole pine, and the residual stand of seedlings and saplings would be understocked. Trees less than 7 inches (17.78 cm) d.b.h. down to the seedling-sapling understory were not suitable growing stock because of disease—dwarf mistletoe (*Arceuthobium americanum*) and comandra blister rust (*Cronartium comandrae*). It was necessary on these sites to retain the undesirable pole timber to protect the site until natural regeneration occurs to bring the seedling-sapling stand up to 300 per acre (121 per ha). Timely removal of mistletoe-infected trees will be required.

In some cases where stocking was inadequate and residual trees were sparse—less than 100 per acre (40 per ha)—planting would be necessary. Lodgepole pine or inland Douglas-fir containerized stock should be planted at 200 to 400 trees per acre (81 to 162 per ha) depending on the number and size of residual growing stock trees.

(3) Heavily stocked lodgepole pine pole timber stands where the age and disease conditions made regeneration of the stand desirable, and enough trees less than 7 inches (17.78 cm) d.b.h. were present to furnish adequate cover to meet forest cover objectives, including site protection. Adequate natural regeneration was expected in these stands.

b. Cut all lodgepole pine trees 10 inches (25.40 cm) d.b.h. and larger and salvage all dead or attacked trees 8 inches (20.32 cm) d.b.h. and larger. This prescription was applied to isolated stands in the unthinned component where forest cover was not maintained for production of wood products, but primarily where lodgepole pine was the principal component and cover objectives required retaining forest cover to protect other values.

Site potential was low in these stands, ecosystems were exceptionally fragile, and values other than timber were paramount. The prescription was applied to stands that were sparsely stocked and on adverse aspects. These stands were suspected to be first-generation coniferous forests, hence were fragile ecotones, and disruption could reverse ecologic trends. Subsequent treatments on regulated lands will be overstory removal in one or two steps, depending on disease conditions, regeneration success, and visual quality needs.

c. Cut all lodgepole pine trees 12 inches (30.48 cm) d.b.h. and larger and salvage all dead or attacked trees 8 inches (20.32 cm) and larger. This prescription was applied to stands where lodgepole pine was the principal component, site potential was extremely low, stands were sparsely stocked, aspects were adverse, and stands contained trees exceeding this diameter limit.

2. Leave-tree cuts.

The leave-tree prescription was applied to two stands and required leaving 100 trees per acre (40 trees per ha), while removing the balance of the lodgepole pine component of the stand. All selected leave trees were the largest, most desirable lodgepole pine, growing stock, and sufficient desirable growing stock trees of other species were retained to result in an average stocking of 100 trees per acre (40 per ha) over 7 inches (17.78 cm) d.b.h.

Because of small islands of old lodgepole pine that escaped the fire that regenerated these two stands, and because these stands contained mistletoe infection centers, small clearcuts also were required. Natural regeneration could be expected in 5 years if these clearcuts did not exceed 5 acres (2 ha).

3. Clearcuts.

Six areas, averaging 14 acres (5.7 ha) each, were clearcut. These were in fire-regenerated pole timber stands. There were small islands of old-aged, larger diameter lodgepole pine trees that were diseased and decadent. Some of these islands had lodgepole pine and/or spruce-fir understories. Because of the heavy fuel accumulations in the pockets of old growth, bulldozer piling and slash burning were desirable to meet fuel management objectives.

METHODS

A total of 37 cutting units and one check block unit were laid out in the demonstration area:

- 10 units in the 7-inch (17.78-cm) cutting block
- 17 units in the 10-inch (25.40-cm) cutting block
- 2 units in the 12-inch (30.48-cm) cutting block
- 2 units in the 100-leave-tree cutting block
- 6 units in the clearcut block
- 1 check block unit

Harvesting began in January 1979 and was completed in February 1981, well before the 1981 beetle flight. A summary of the pretreatment stand structure and proposed cuts is shown in table 1.

A survey of the demonstration area was made in the spring of 1982 to determine tree loss to the mountain pine beetle. A 20-percent survey was conducted in 22 of the 38 units:

- 6 of 10 units in the 7-inch (17.78-cm) cutting block
- 11 of 27 units in the 10-inch (25.40-cm) cutting block
- 2 of 2 units in the 12-inch (30.48-cm) cutting block
- 2 of 2 units in the 100-leave-tree block
- 1 check block unit

The 20-percent survey used a 1-chain-wide strip (20 m) every 5 chains (100 m) and recorded beetle-killed trees in 1979, 1980, and 1981, other causes of death, and diameter.

Tree growth data were collected during the loss surveys. Basal area and radial growth measurements were taken at 5-chain (100 m) intervals along the cruise strip, using a 10 BAF gage. Unfortunately, similar data were not taken before the harvest for comparison.

Table 1.—Summary of stand data and proposed cuts for East Long Creek Demonstration Area

Stand structure and volumes	Treatment				
	7-inch	10-inch	12-inch	100-leave-tree	Clearcut
Acres					
Total	1,132.0	581.0	60.0	39.0	86.0
Mean	113.2	34.2	30.0	19.5	14.3
Live lodgepole/acre					
Total	1,633.0	3,668.0	686.0	428.0	1,475.0
Mean	163.3	215.7	343.0	214.0	245.8
< 7-inch	864.0	1,925.0	458.0	242.0	769.0
Mean	86.4	113.2	229.0	121.0	128.2
> 7-inch	769.0	1,743.0	228.0	186.0	706.0
Mean	76.9	102.5	114.0	93.0	117.7
> 10-inch	352.0	656.0	88.0	62.0	271.0
Mean	35.2	38.6	44.0	31.0	45.2
> 12-inch	166.0	282.0	14.0	24.0	156.0
Mean	16.6	16.6	7.0	12.0	26.0
Live species/acre					
Subalpine fir and other	768.0	699.0	66.0	30.0	1,006.0
Mean	76.8	41.1	33.0	15.0	167.7
Engelmann spruce	194.0	47.2	0	2.4	248.0
Mean	19.4	2.8	0	1.2	41.3
Aspen	1,683.0	232.0	0	64.0	34.0
Mean	168.3	13.6	0	32.0	5.7
Proposed cut					
T/A	769.0	656.0	14.0	228.0	1,475.0
Mean	76.9	38.6	7.0	114.0	245.8
Gross volume/acre					
Live cut	4,468.0	3,518.0	3,683.0	3,205.0	4,093.0
Mean	4,468.0	3,518.0	3,683.0	3,205.0	4,093.0
Salvage cut	2,290.0	1,480.0	1,583.0	1,231.0	2,337.0
Mean	2,290.0	1,480.0	1,583.0	1,231.0	2,337.0
Gross volume (M)					
Green	5,058.0	2,044.0	221.0	125.0	352.0
Mean	505.8	120.2	110.5	62.5	58.7
Dead (≥8″)	2,592.0	860.0	95.0	48.0	201.0
Mean	259.2	50.6	47.5	24.0	33.5
Uncut per acre					
Lodgepole pine (≥2″)	891.0	2,916.0	558.0	39.0	877.0
Mean	89.1	171.5	279.0	19.5	146.2
Total trees (≥2″)	1,602.0	3,661.0	624.0	43.0	2,132.0
Mean	160.2	215.4	312.0	21.5	355.3
Average gross volume per acre (M)					
Green	4.468	3.518	3.683	3.205	4.093
Dead	2.290	1.480	1.583	1.231	2.337
Average net volume per acre (M)					
Green	4.023	3.166	3.315	2.885	3.684
Dead	1.832	1.184	1.267	.985	1.870
Total adjusted net volume					
Volume per acre	5.855	4.350	4.582	3.870	5.554
Net volume	6.628	2.528	.275	.151	.478

RESULTS

The stand structure changed proportionally to the intensity of harvest cut used in each block (table 2). Stand average diameter (d.b.h.) changes were:

Treatment	Original diameter		Diameter after harvest	
	Inches	*cm*	*Inches*	*cm*
7-inch (17.78-cm) cut	7.8	19.81	7.0	17.78
10-inch (25.40-cm) cut	7.7	19.56	7.0	17.78
12-inch (30.48-cm) cut	7.4	18.80	7.3	18.54
100-leave-tree cut	7.5	19.05	8.0	20.32

Considering only the kill by the mountain pine beetle, the trend for the 3 years (2 years before the cut was completed and 1 year after completed cuts) is rather dramatic (table 3 and fig. 1). In all cutting blocks, the number of trees infested dropped considerably after harvesting; the check block continued to lose trees to the beetle at about the same rate.

It is evident that tree loss to secondary insects, such as *Ips*, *Pityophthorus*, *Pityogenes*, and *Pityokteines*, and comandra rust lessened after treatment (table 4). However, this apparent reduction of loss may be an artificial effect of sampling, because the check areas also showed no loss due to these factors in 1981 (the year after cutting was completed).

Table 2.—Stand structure before and after cutting

Treatment	Live lodgepole pine per acre by diameter class										
	Before cut					Trees cut per acre	After cut				
	Total	<7 inches	7-9 inches	10-11 inches	>12 inches		Total	<7 inches	7-9 inches	10-11 inches	>12 inches
7-inch cut	163.3	86.4	41.7	18.6	16.6	76.9	86.4	86.4	0	0	0
10-inch cut	215.7	113.2	63.9	22.0	16.6	38.6	177.1	113.2	63.9	0	0
12-inch cut	343.0	229.0	70.0	37.0	7.0	7.0	336.0	229.0	70.0	37.0	0
100-leave-tree cut	214.0	121.0	62.0	19.0	12.0	114.0	[1] 100.0	—	—	—	—
Clearcut	245.8	128.2	72.5	19.2	26.0	245.0	0	0	9	0	0
Check area	251.0	[2] 55.0	196.0	91.0	42.0	0	251.0	[2] 55.0	196.0	91.0	42

[1]Data not available on distribution.
[2]Include only 4- to 6-inch trees.

Table 3.—Tree mortality due to the mountain pine beetle

Treatment	Number of trees killed per acre			
	1979	1980		1981
7-inch cut	0.72	0.51	cut completed	0.09
10-inch cut	.35	.66		.07
12-inch cut	.19	5.00		1.15
100-leave-tree cut	.20	.10		0
Check area	2.53	5.77		4.23

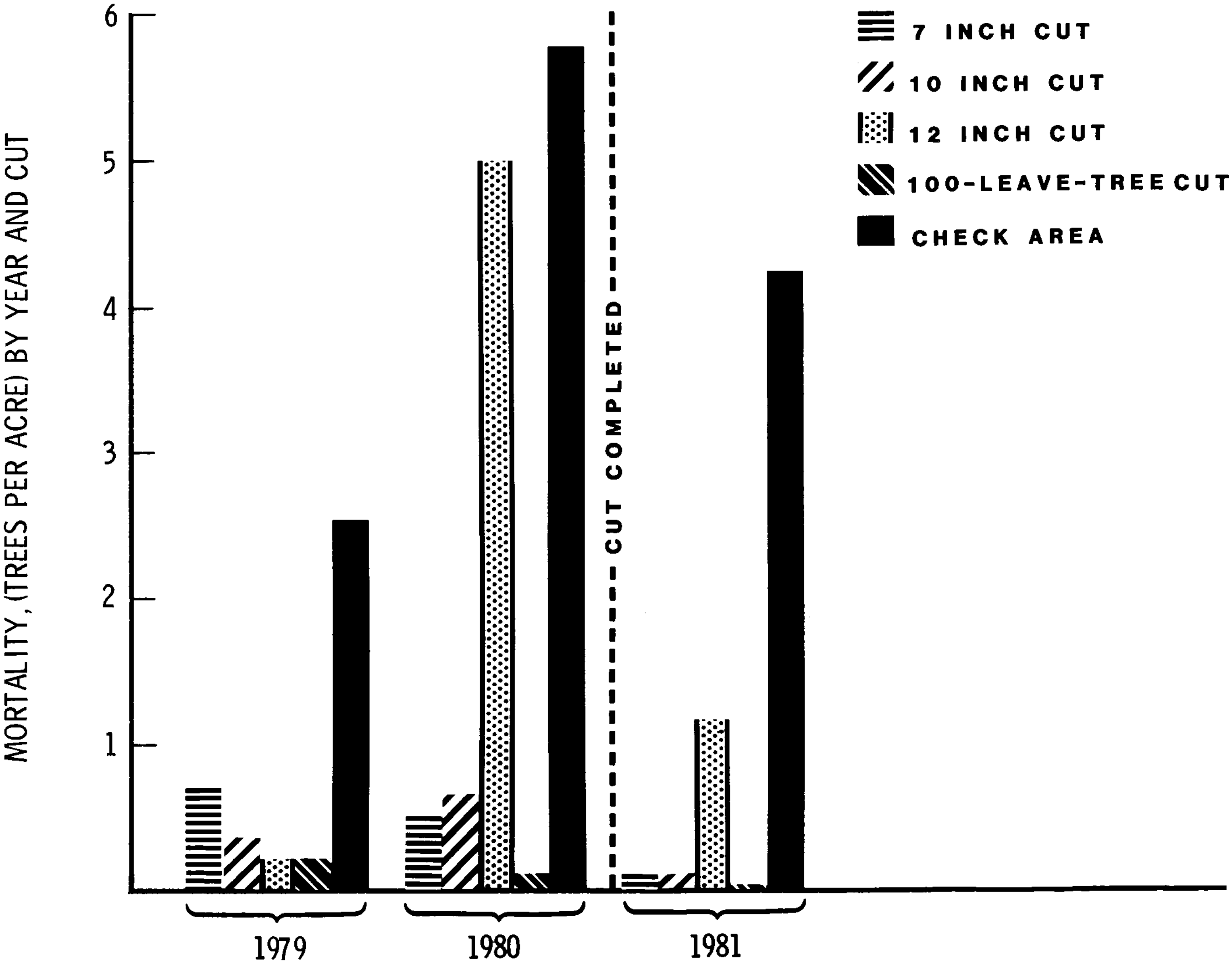

Figure 1.—Tree loss due to the mountain beetle within the demonstration areas.

Table 4.—Trees killed per acre by cutting block, year, cause, and diameter

Treatment	Year of kill	Cause of death	Diameter of tree killed (inches) 6	7	8	9	10	11	12	13	14	15	16	>17	Total trees killed	Trees killed per acre
7-inch cut	1979	MPB[1]	2	3	3	3	7	4	1	1					24	0.72
		Pity's[2]	1		1	1									3	.09
		Total		3	3	4	4	7	4	1	1				27	.81
	1980	MPB		2	3	5	1	2	3	1					17	.51
		Pity's			1	1									2	.06
		Comandra	1												1	.03
		Total	1	2	4	6	1	2	3	1					20	.60
	1981	MPB								1			1	1	3	.09
		Total								1			1	1	3	.09
	All years		4	5	8	10	8	6	4	3			1	1	50	1.51
10-inch cut	1979	MPB	1	2	2	10	2	2							21	.35
		Ips spp.	1	3	2										6	.10
		Pity's	6	8	3	5									22	.36
		Comandra		1	1										2	.03
		Total	8	15	9	15	2	2							51	.84
	1980	MPB	1	6	12	9	4	3	2	1	1			1	40	.66
		Pity's	4	3	4	1									12	.20
		Comandra		2	2	1									5	.08
		Total	5	11	18	11	4	3	2	1	1			1	57	.94
	1981	MPB			1	1	1						1		4	.07
		Total			1	1	1						1		4	.07
	All years		13	26	28	27	7	5	2	1	1		1	1	112	1.78
12-inch cut	1979	MPB											1		1	.19
		Comandra	2		1		1						1		4	.77
		Total	2		1		1						1		5	.96
	1980	MPB	1	1	4	5	5	7	3						26	5.00
		Pity's					1								1	.19
		Comandra		1									1		1	.19
		Total	1	2	4	5	6	7	3						28	5.38
	1981	MPB		1	2			3							6	1.15
		Total		1	2			3							6	1.15
	All years		3	3	7	5	7	10	3				1		39	7.50
100-leave tree cut	1979	MPB	1		1										2	.20
		Ips spp.	1			1		1							3	.30
		Total	2		1	1		1							5	.50
	1980	MPB		1											1	.10
		Ips spp.	1	1											2	.20
		Total	1	2											3	.30
	1981	MPB	1												1	.10
		Total	1												1	.10
	All years		4	2	1	1			1						9	.90
Check area	1979	MPB		4		9	5	9	1	5	1	1			36	2.53
		Pity's		3											3	.21
		Total		4	3	9	5	9	1	5	1	1			39	2.74
	1980	MPB	1	1	4	11	14	18	10	8	6	1	2	6	82	5.77
		Pity's				1									1	.07
		Comandra					1								1	.07
		Total	1	1	4	12	15	18	10	8	6	1	2	6	84	5.91
	1981	MPB			6	5	9	11	13	6	5		4	1	60	4.23
		Total			6	5	9	11	13	6	5		4	1	60	4.23
	All years		1	5	13	26	29	38	24	19	12	2	6	7	183	12.88

[1]MPB = Mountain pine beetle.
[2]*Pityophthorus, Pityogenes,* and *Pityokteines.*

Adding the loss due to the mountain pine beetle, secondary insects, and comandra rust to the trees cut per acre gives the gross number of trees removed and thus the residual trees per acre (table 5). All cutting blocks now contain almost the same number of trees per acre, which is about one-half the number per acre now in the check area, although the average stand diameter is different.

Residual basal area followed the level of cut as would be expected (fig. 2). Using the check blocks as a base, then 66 percent of the basal area was removed in the 7-inch (17.78-cm) blocks; 55 percent in the 10-inch (25.40-cm) blocks; 45 percent in the 12-inch (30.48-cm) blocks; and 63 percent in the 100-leave-tree blocks.

There was an apparent and slightly greater radial growth, of those residual trees measured, in the 12-inch (30.48-cm), 100-leave-tree, and check blocks as compared to the 7-inch (17.78-cm) and 10-inch (25.40-cm) blocks (fig. 3). This does not necessarily reflect release by cutting, because only 1 to 2 years of growth occurred since cutting was started.

Table 5.—Net effects to the stands from cutting levels and mortality factors

Treatment	Trees per acre						
	Before cut	Number cut	Trees Killed by: MPB[1]	*Ips* spp.	Pity's[2]	Comandra	Residual
7-inch cut	163.3	76.9	1.32	0	0.15	0.03	84.90
10-inch cut	215.7	113.2	11.08	0.10	.56	.11	90.76
12-inch cut	343.0	229.0	6.34	0	.19	.96	88.66
100-leave-tree cut	214.0	114.0	.30	.60	50	0	99.70
Check area	196.0	0	12.53	0	.28	.07	183.12

[1]MPB = Mountain pine beetle.
[2]*Pityophthorus*, *Pityogenes*, and *Pityokteines*.

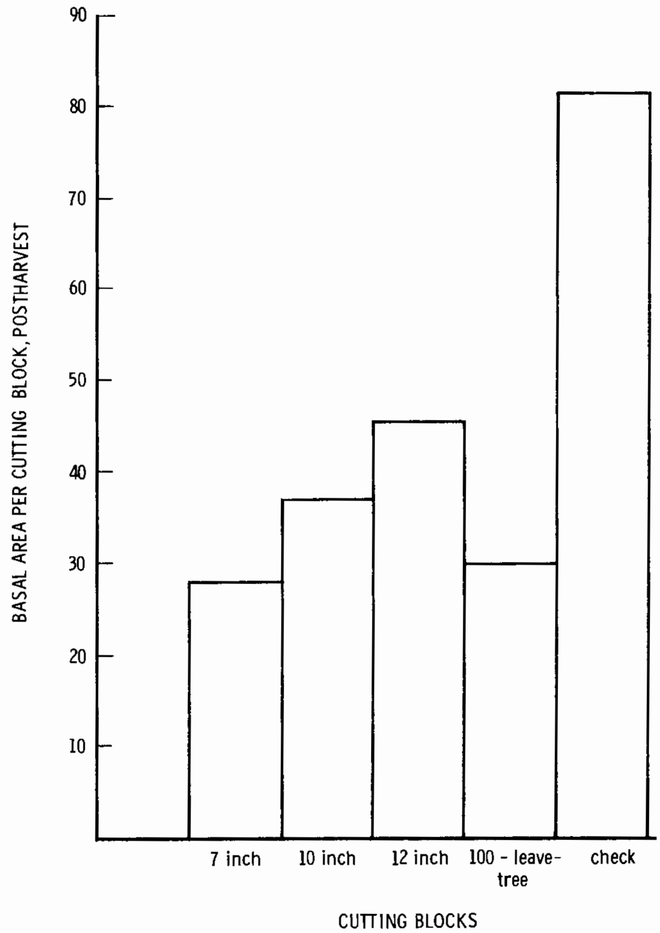

Figure 2.—Residual basal area of cutting blocks.

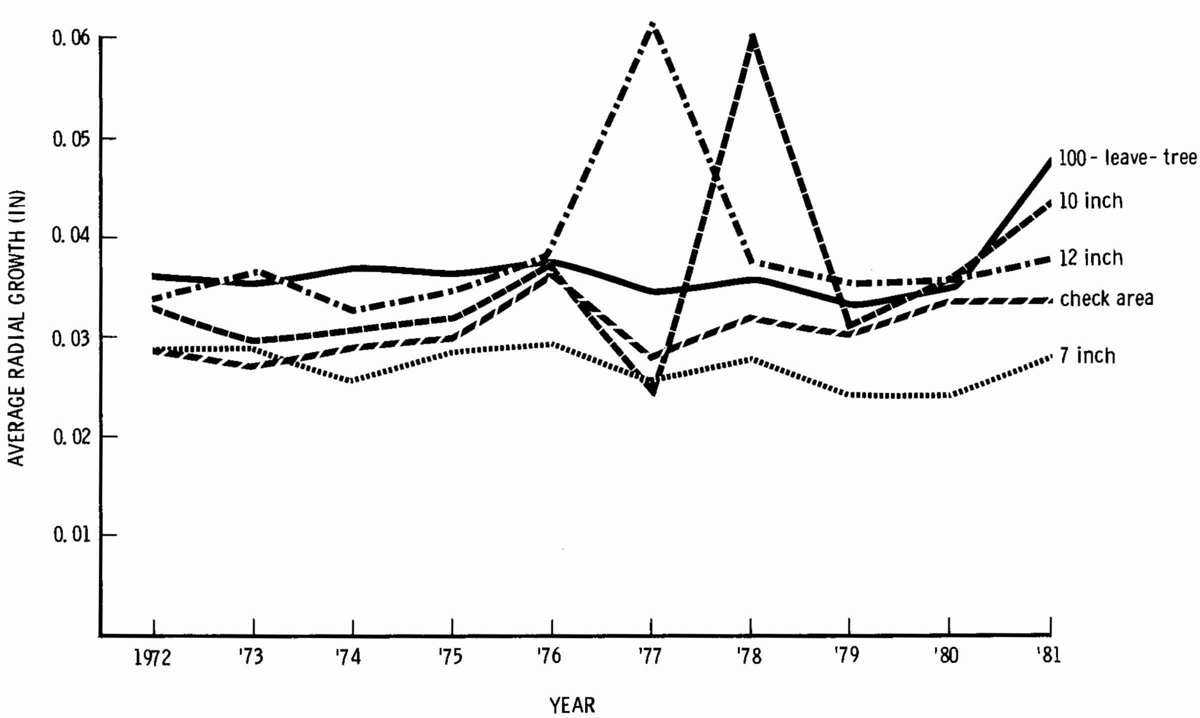

Figure 3.—Average radial growth of stand per year for last 10 years by cutting block.

DISCUSSION

Having seen the immediate results of the cutting levels, the question now is of the future of these stands, with respect to the activity of the beetle and stand development. The harvest levels reduced the current level of loss somewhat proportionally, but will the beetle resume killing trees at the same ratio as before treatment or has a change been induced in the course of the infestation? To project an answer to this question, these mortality trend data were used in the Rate of Loss Model (Cole and McGregor, in press) to predict the rate of future tree loss and number of years of such an infestation (fig. 4).

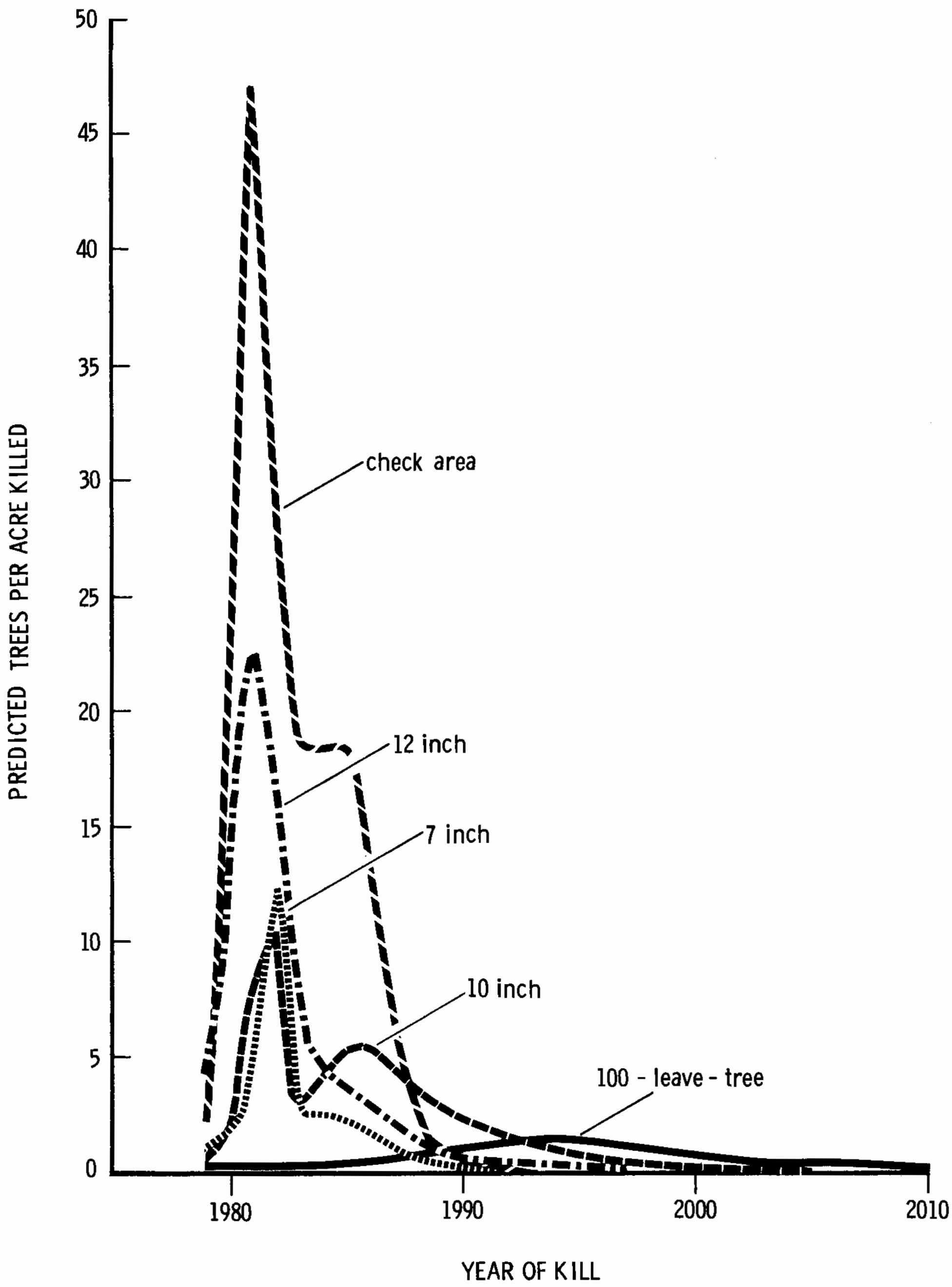

Figure 4.—Predicted trees per acre killed by mountain pine beetle, postharvest by cutting levels.

This projection showed that the infestation within the check area should peak in 1981, with 46.9 trees killed per acre (19 per ha), and subside to 1.1 trees per acre (0.44 per ha) by 1989, tailing to 0.02 tree per acre (0.008 per ha) by 1993. The diameter-limit cuts reduced the peak loss rather proportionally to the extent of cutting; for example, peak kill was greater in the 12-inch (30.48-cm) cuts than in the 7-inch (17.78-cm) cuts. The expected length of infestation changed accordingly, with the longest period of outbreak expected for the 7-inch (17.78-cm) cut. The exception was the 100-leave-tree cut. This cut extended the predicted life of the infestation to the year 2012, with peak tree loss of only 1.5 trees per acre (0.61 per ha) in the year 1993 (table 6).

Table 6.—Predicted peak loss, length of infestation, and annual drain from the mountain pine beetle by cutting level (trees per acre)

Treatment	Peak loss	Peak year	Years of infestation	Total loss	Annual drain
Check area	46.9	1981	14	180.5	12.9
12-inch cut	22.1	1981	18	80.1	4.4
10-inch cut	10.3	1982	26	62.5	2.4
7-inch cut	12.3	1982	13	32.8	2.5
100-leave-tree cut	1.5	1993	33	23.6	.7

The 100-leave-tree cut, according to these predictions, would reduce tree loss from the mountain pine beetle to a low amount. This cut would also be advantageous in reducing or minimizing dwarf mistletoe occurrence (Wicker 1967; Wicker and Shaw 1967). Once the area is reseeded and the regeneration height exceeds snow depth, the leave trees should be removed. The small target area of the regeneration, the washing action of the snow in removing dwarf mistletoe seeds, and the young stand being immune to the mountain pine beetle may well be the keys to producing a healthy new stand of lodgepole pine.

SUMMARY

The demonstration area on which diameter-limit and leave-tree cuts were applied to reduce or minimize lodgepole pine losses to the mountain pine beetle was evaluated the first year after cutting. First-year losses were reduced proportionally to the intensity of cut. Projected losses and continuation of the mountain pine beetle infestation were derived from the predictive Rate of Loss Model. The best deterrent of recurring infestation—amount of losses and length of time—was the 100-leave-tree cut. The 100-leave-tree cut also was the best in encouraging regeneration and reducing dwarf mistletoe infection.

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