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J. A. Baranyay

**PACIFIC FOREST RESEARCH CENTRE
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INTERNAL REPORT BC-29

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INTRODUCTION

Dwarf mistletoe (Arceuthobium americanum Nutt. ex Engelm.) affects lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.) and jack pine (P. divaricata (Ait.) Dumont) in Alberta, and lodgepole pine in British Columbia. Recently published research results (3) and survey records indicate that the estimated annual volume loss caused by the parasite is 9.6 million cu ft in Alberta and 90 million cu ft in British Columbia. Hawksworth and Hinds (10) reported losses of comparable magnitude in lodgepole pine stands of western United States.

In the past, fire acted as a major natural controlling agent of dwarf mistletoe. Improved fire protection and widely used selective harvesting methods create optimal conditions for spread and intensification of the disease. Survey records (2, 5, 11, 12) indicate that the disease is widely distributed in both provinces. In Alberta, lodgepole pine stands in the East Slope Rockies (SA1) and in the neighboring Upper Foothills (B19c) Sections and jack pine stands in the Mixedwood Section (B18a) are severely infected (2). In British Columbia, the area north of Clinton to Prince George, extending westward to Anahim Lake in the Chilcotin, and the area south of Spillimacheen in the Columbia River Valley to the border contains the most severely attacked lodgepole pine stands in western Canada. These regions have a large acreage of young lodgepole pine infected with dwarf mistletoe as the result of fire pattern or of infected stands having been cut, leaving infected residual overstory trees. If the mistletoe is not controlled on these areas, their value as commercial forest stands will be greatly reduced.

According to our present knowledge, the least expensive and most effective control measures are silvicultural, but precise information on the effect of various sanitation procedures is lacking. To determine the effects of various silvicultural treatments on control of the parasite, a cooperative study, involving the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, Northern Forest Research Centre, Edmonton, Alberta, and the Pacific Forest Research Centre, Victoria, British Columbia, was established in 1967-68. The objectives of this study are to obtain guidelines relating to silvicultural management of mistletoe-infected stands by testing the effectiveness of different thinning methods to control dwarf mistletoe at various intensity levels in different age classes. Concurrently, data on disease intensification and tree-growth relationships in treated and untreated stands are to be obtained. This paper summarizes the methods applied and data obtained during plot establishment in 1967-68, and the results of the first sanitation after three years in 1970-71.

METHODS

It was intended that our experimental design be similar to that used in Colorado by Dr. F. G. Hawksworth (7), so data from experiments would be comparable. A total of 23 half-acre sample plots were established in Alberta and B.C. in 1967 and 1968. These sample plots are located as follows: five in a 22-year-old lodgepole pine stand in the Crowsnest Forest, ten in a 27-year-old stand in the Bow River Forest, both in Alberta, and five and three in a 35- and a 39-year-old stand, respectively, in the Kamloops Forest District in B.C. (Appendix). All of these stands are of fire origin. Three sanitations were planned in these plots, the first at plot establishment in 1967 and 1968, the second in 1970-71 and the third in 1973-74. The sample plots represent the following treatments or conditions:

a. Infected untreated (check) plots (IC).

b. Healthy untreated (check) plots (HC).

c. Healthy thinned plots (HT): thinned to maintain a spacing of 6 to 8 feet, depending on site conditions.

d. Infected thinned plots (IT): on these plots, the main goal was to maintain adequate stocking; the eradication of dwarf mistletoe was secondary. Diseased trees and all overstory trees were marked first for cutting, and lightly infected trees were pruned where it was necessary to maintain the 6 to 8 foot spacing. During the first treatment, approximately 10% overstocking was left to maintain a reserve of trees.

e. Dwarf mistletoe eradication plots (DME): all infected and all overstory trees were removed, regardless of stocking. Overstocked plots were to be cleaned during the third sanitation (1973-74).

On each half-acre plot, two 0.025-acre subplots were established in randomly selected opposite corners for intensive sampling for disease incidence, intensification and tree growth data. Tree height, diameter and crown class was noted for each tree in these plots and disease intensity for each infected tree was determined according to Hawksworth's six-class system (9). Since this system was designed for the disease intensity rating of mature trees, a modified rating system was used for young trees in which the crown was divided into thirds and rated separately. If 1-

to 3-branch or stem infections were found in the crown one-third, one point was given, and for 4+ infections, two points were given. The infection class of each tree was obtained by summing the rating points for each third of the crown.

All the trees were tagged in the subplots of the untreated plots but only the leave trees were tagged in the treated plots. In the main plots, trees were tallied in healthy and infected classes to determine disease incidence. Around all treated infected plots, half-chain-wide isolation strips were established and treated as the plot in question.

Incipient infections do not have external symptoms. At the time of plot establishment, only visibly infected trees were sanitized. The minimum lag period (4) for lodgepole pine dwarf mistletoe is two years (13); therefore, the two additional sanitations were planned in each third growing season after plot establishment to avoid seed dissemination from newly established aerial shoots of incipient infections. The second sanitation was performed in 1970-71. During this operation, the main portion of the healthy untreated plots were not re-surveyed.

Since the necessary supervision and labor could not be provided within one year, ten plots were established in 1967 and 13 in 1968. The re-survey and treatment of plots was also spread over a two-year period and did not create a heavy burden on available staff in a single year. One of the infected untreated plots (IC), in the Bow River Forest, was accidentally cleaned by an Alberta Forest Service crew in 1970. This plot was replaced by a newly established one in 1971.

RESULTS AND DISCUSSION

Data obtained during the establishment and first re-survey of plots are included in Tables I, II and III.

Subplot data indicate that disease incidence varied considerably within the half-acre sample plots (Table I). The pattern depended mainly on the distribution of the infected residual trees within the plot or in the nearby isolation strip. At the time of establishment, the infected treated main plots represented a disease incidence ranging from 15.3 to 60.5% (Avg 43.6) (Fig. 1). The plots in the 35- and 39-year-old stands had higher disease incidence; however, disease incidence was not related to age alone, but also to the density and distribution of the infection sources. For example, in the 22-year-old IT plot at Dutch Creek, the 25 infected residual trees were evenly scattered, resulting in a 59.7% disease incidence in the plot. The range of disease incidence in the above plots, three years after the first sanitation and before the second sanitation, was from 12.6 to 55.5% (Avg 25.3). Most of the infections developed from incipient infections during the 3-year period between plot establishment and re-survey. A reduction in disease incidence of about 50% was observed in 70% of the plots. The exceptions were the IT plots at Etherington Creek, Beaverdam Lake and Tin Cup Lake. When disease incidence was grouped according to kind of treatment (Fig. 1), the DME treatment seemed to be a more effective control than the IT treatment. However, actual spacing was not conducted on the DME plots, with the result that the disease incidence was reduced by the relatively large number of healthy trees still present.

Natural factors had an important bearing on the incidence of

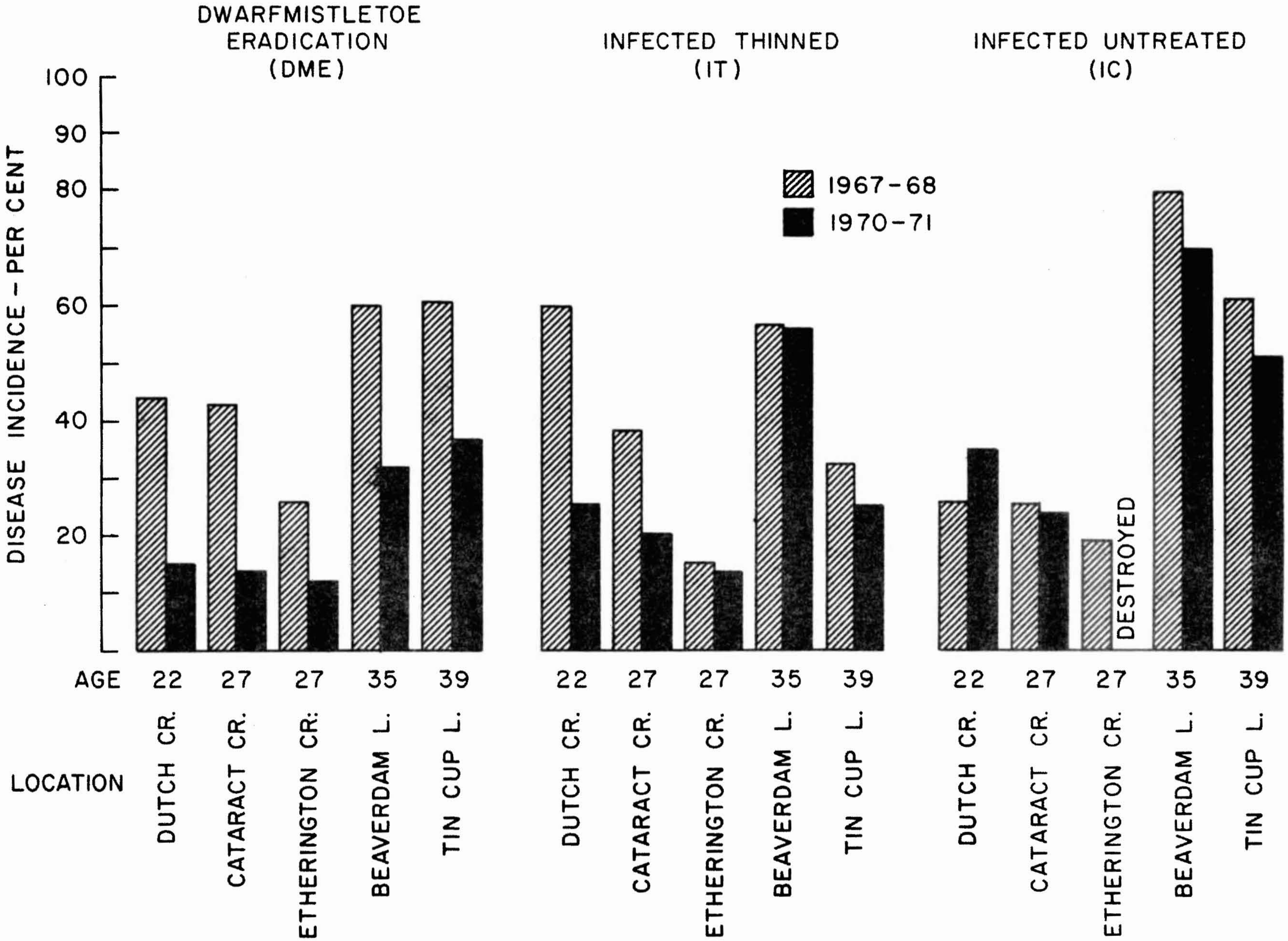

Fig. 1 Incidence of dwarf mistletoe in the main sample plots at the time of plot establishment and re-survey 3 years after the first sanitation. Data are grouped according to treatment.

TABLE I. DATA OBTAINED DURING THE ESTABLISHMENT AND FIRST RE-SURVEY OF DWARF MISTLETOE SILVICULTURAL CONTROL PLOTS

Location	Plot No.	Treatment		Main plot					Sub plot							Main plot	Sub plot		
				Number of Trees												Disease Incidence Per Cent[3]		Stand[4] Infection Index	Orientation
		Kind[1]	Year	Dead	Healthy	Infected Res.	Infected	Total Living	Dead	Healthy	Infected	Total Living	Cut	Pruned	Left[2]				
Dutch Creek (Alta.) Age: 22	3	DME	1968		1184	29	914	2127		53 50	38 28	91 78	49 28		42 50	44.3	41.8 35.9		N.E. S.W.
			1971	1	1007		177	1184	1	30 41	11 9	41 50	11 9		30 41	14.9	26.8 18.0		
	2	IT	1968		414	25	589	1028		58 72	62 72	120 144	94 113	3 2	26 31	59.7	51.7 50.0		N.W. S.E.
			1971	8	127		49	176	3 5	8 10	15 16	23 26	2 5	13 11	21 21	27.8	65.2 61.5		
	1	IC	1968		644	3	229	876		77 98	39 18	116 116			116 116	26.2	33.6 15.5	0.51 0.16	N.E. S.W.
			1971	44	537	3	292	832		79 97	37 19	116 116			116 116	35.5	31.9 16.4	0.51 0.18	
	4	HT	1968		1488			1488		86 46		86 46	60 24		26 22				N.W. S.E.
			1971		280			280		26 22		26 22			26 22				
	5[5]	HC	1968		1586			1586		234 31		234 31			234 31				N.W. S.E.
			1971							234 31		234 31			234 31				N.W.

TABLE I. DATA OBTAINED DURING THE ESTABLISHMENT AND FIRST RE-SURVEY OF DWARF MISTLETOE SILVICULTURAL CONTROL PLOTS. (Continued).

Location	Plot No.	Treatment		Main plot					Sub plot							Main plot	Sub plot		
				Number of Trees												Disease Incidence Per Cent[3]		Stand[4] Infection Index	Orientation
		Kind[1]	Year	Dead	Healthy	Infected Res.	Infected	Total Living	Dead	Healthy	Infected	Total Living	Cut	Pruned	Left[2]				
Cataract Creek (Alta.) Age: 27	1	DME	1967		1534	48	1110	2692			82 24	120 115	82 24		38 91	43.0	68.3 20.9		N.W. S.E.
			1970	14	1310		210	1520	5 9		16 5	33 82	16 5		17 77	13.8	48.5 6.1		
	2	IT	1967		1247		770	2017		50 108	256 59	306 167	287 147		19 20	38.2	83.7 35.3		N.E. S.E.
			1970	2	269		71	340	1 1	3 11	15 8	18 19	2	13 8	16 19	20.9	83.3 42.1		
	3	IC	1967		1155	5	382	1542		78 34	60 17	138 51			138 51	25.1	43.5 33.3	0.70 0.45	S.E. S.W.
			1970	283	949	5	305	1259	4		76 18	134 51			134 51	23.9	56.7 35.3	0.99 0.51	
	4	HT	1967		913			913		69 81		69 81	52 61		17 20				N.E. N.W.
			1970		277			277		17 20		17 20			17 20				
	5	HC	1967		1142			1142		130 47		130 47			130 47				N.E. S.E.
			1970						1 1	129 46		129 46			129 46				

TABLE I. DATA OBTAINED DURING THE ESTABLISHMENT AND FIRST RE-SURVEY OF DWARF MISTLETOE SILVICULTURAL CONTROL PLOTS. (Continued).

Location	Plot No.	Treatment		Main plot					Sub plot							Main plot	Sub plot		
				Number of Trees												Disease Incidence Per Cent[3]		Stand[4] Infection Index	Orientation
		Kind[1]	Year	Dead	Healthy	Infected Res.	Infected	Total Living	Dead	Healthy	Infected	Total Living	Cut	Pruned	Left[2]				
Etherington Creek (Alta.) Age: 27	6	DME	1967		17420	9	6145	23574		385 263	76 328	461 591	79 328		382 263	26.1	16.5 55.5		N.E. S.W.
			1970	31	15203		2186	17389	16 15	320 153	46 95	366 248	46 95		320 153	12.6	12.6 38.3		
	7	IT	1967		5287	28	925	6240		284 144	42 55	326 199	305 182	3	21 17	15.3	12.9 27.1		N.W. S.E.
			1970	3	332		56	388	1 2	19 10	1 5	20 15		1 5	20 15	14.4	5.0 33.3		
	8[6]	IC	1967		5289	11	1196	6496		157 123	93 47	250 170			250 170	18.6	37.2 27.6	0.52 0.34	E. W.
			1971		354	3	205	562		17 24	17 10	34 34			34 34	35.6	50.0 29.4	1.05 0.32	
	9	HT	1967		18994			18994		320 893		320 893	300 896		20 24				N.W. S.E.
			1970	2	404			404	1 1	19 23		19 23			19 23				
	10	HC	1967		24877			24877		871 533		871 533			871 533				N.E. S.W.
			1970						47 16	824 517		824 517			824 517				

TABLE I. DATA OBTAINED DURING THE ESTABLISHMENT AND FIRST RE-SURVEY OF DWARF MISTLETOE SILVICULTURAL CONTROL PLOTS. (Continued).

Location	Plot No.	Treatment		Main plot					Sub plot							Main plot	Sub plot		
				Number of Trees												Disease Incidence Per Cent[3]		Stand[4] Infection Index	Orientation
		Kind[1]	Year	Dead	Healthy	Infected Res.	Infected	Total Living	Dead	Healthy	Infected	Total Living	Cut	Pruned	Left[2]				
Etherington Creek (Alta.) continued Age: 27	11[7]	IC	1971		3839	3[8]	1768	5607		98 16	127 212	225 228			225 228	31.5	56.4 93.0	0.97 2.18	N.E. S.W.
Beaverdam Lake (B.C.) Age: 35	1	DME	1968		922	50	1349	2321		27 29	104 108	131 137	106 109		25 28	60.3	79.4 78.8		N.E. S.W.
			1971	588	228		106	334	20 12		1 2	5 16	1 2		4 14	31.7	20.0 12.5		
	2	IT	1968		1182	23	1532	2737		44 107	60 41	104 148	75 111	12 2	29 37	56.8	57.7 27.7		N.W. S.E.
			1971	100	154		192	346	2 5	5 18	22 14	27 32	3	19 14	24 32	55.5	81.5 43.8		
	3	IC	1968		358	15	1401	1774		26 9	60 58	86 67			86 67	79.8	69.8 86.6	1.34 2.34	N.W. S.E.
			1971	499	393	13	869	1275	13 10	23 6	50 51	73 57			73 57	69.2	68.5 89.5	1.32 2.63	
	4	HT	1968		618			618		37 67		37 67	17 44		20 23				N.E. S.E.
			1971	3	183		4	187	3	20 16	4	20 20		4	20 20	2.7	20.0		

TABLE I. DATA OBTAINED DURING THE ESTABLISHMENT AND FIRST RE-SURVEY OF DWARF MISTLETOE SILVICULTURAL CONTROL PLOTS. (Continued).

Location	Plot No.	Treatment		Main plot					Sub plot							Main plot	Sub plot		
				Number of Trees												Disease Incidence Per Cent[3]		Stand[4] Infection Index	Orientation
		Kind[1]	Year	Dead	Healthy	Infected Res.	Infected	Total Living	Dead	Healthy	Infected	Total Living	Cut	Pruned	Left[2]				
Beaverdam Lake (B.C.) continued Age: 35	5	HC	1968			682		682		31 56		31 56			31 56				N.E. S.E.
			1971						7 10	24 46		24 46			24 46				
Tin Cup Lake (B.C.) Age: 37	6	DME	1968		623	11	942	1576		22 40	54 44	76 84	54 44		22 40	60.5	71.1 52.4		N.W. S.E.
			1971	150	299		174	473	10 20	8 11	4 9	12 20	4 9		8 11	36.8	33.3 45.0		
	7	IT	1968		700	4	331	1035		31 48	45 11	76 59	58 29	2 1	18 30	32.4	59.2 18.6		N.E. S.E.
			1971	83	263		88	351	1 2	7 18	10 10	17 28	5	5 10	12 28	25.1	58.8 35.7		
	8	IC	1968		618	10	945	1573		26 51	59 30	85 81			85 81	60.7	69.4 37.0		N.W. S.E.
			1971	443	553	10	567	1130	4 11	17 36	64 34	81 70			81 70	51.1	79.6 48.6		

TABLE I. DATA OBTAINED DURING THE ESTABLISHMENT AND FIRST RE-SURVEY OF DWARF MISTLETOE SILVICULTURAL CONTROL PLOTS. (Continued).

Location	Plot No.	Treatment		Main plot					Sub plot							Main plot	Sub plot	
				Number of Trees														
		Kind[1]	Year	Dead	Healthy	Infected Res.	Infected	Total Living	Dead	Healthy	Infected	Total Living	Cut	Pruned	Left[2]	Disease Incidence Per Cent[3]	Stand[4] Infection Index	Orientation

NOTE: Footnotes 1 through 5 apply throughout TABLE I.

1 DME = Dwarf mistletoe eradication; IT = Infected cleaned; IC = Infected untreated; HT = Healthy thinned; HC = Healthy untreated.

2 Trees left after plot establishment were all tagged.

3 Disease incidence per cent = $\frac{\text{(Infected Residual + Infected)} \times 100}{\text{Total Living}}$

4 Stand infection index = The average of individual tree ratings for the sub-plot.

5 Only the sub-plots of the HC plots were re-surveyed in 1970-1971.

6 Plot 8 was thinned without consideration of the disease by mistake in 1970; it was re-surveyed in 1971.

7 Plot 11 was established in 1971 to replace plot 8.

8 Many dead residuals are present.

the disease in the infected untreated (IC) plots. Natural thinning and self-pruning removed infections from the population of dense older stands. Incidence in the IC plots changed approximately ± 10% during the 3-year period (Fig. 1). In the relatively open Dutch Creek plot, incidence increased 9.3% (876 trees on plot), and declined 1.2% at Cataract Creek (1,542 trees on plot), 10.6% at Beaverdam Lake (1,774 trees on plot) and 9.6% at Tin Cup Lake (1,573 trees on plot) (Table I). In the latter 3 plots, tree mortality was 283, 499 and 443, respectively, because of a combination of suppression and dwarf mistletoe infection and other causes (Table III). Seventy-seven of the 283 dead trees, all the 499, and 378 of the 443 were infected by dwarf mistletoe. Due to this mortality, the number of infected trees declined during the 3-year period, from 387 to 310 at Cataract Creek; from 1,416 to 882 at Beaverdam Lake, and from 955 to 577 at Tin Cup Lake. Thirty-five dwarf mistletoe-infected trees at Beaverdam Lake, initially classified diseased, were found to be healthy during the re-survey, due to rodent chewing or self-pruning of the lower infected branches. This type of biological control was observed to a lesser degree in the other plots. "Stand infection index" (4, and see footnote 4 of Table I) was calculated for all the IC subplots (Table I and Fig. 2). This index shows that though incidence declined in the Cataract Creek, Beaverdam Lake and Tin Cup Lake plots, the intensity of the disease increased within the infected trees, increasing disease potential within the plots. In the more open IC plot at Dutch Creek, disease incidence increased (Fig. 1) but intensity within the trees remained about the same (Fig. 2).

Distribution in the subplots of the infected trees by crown

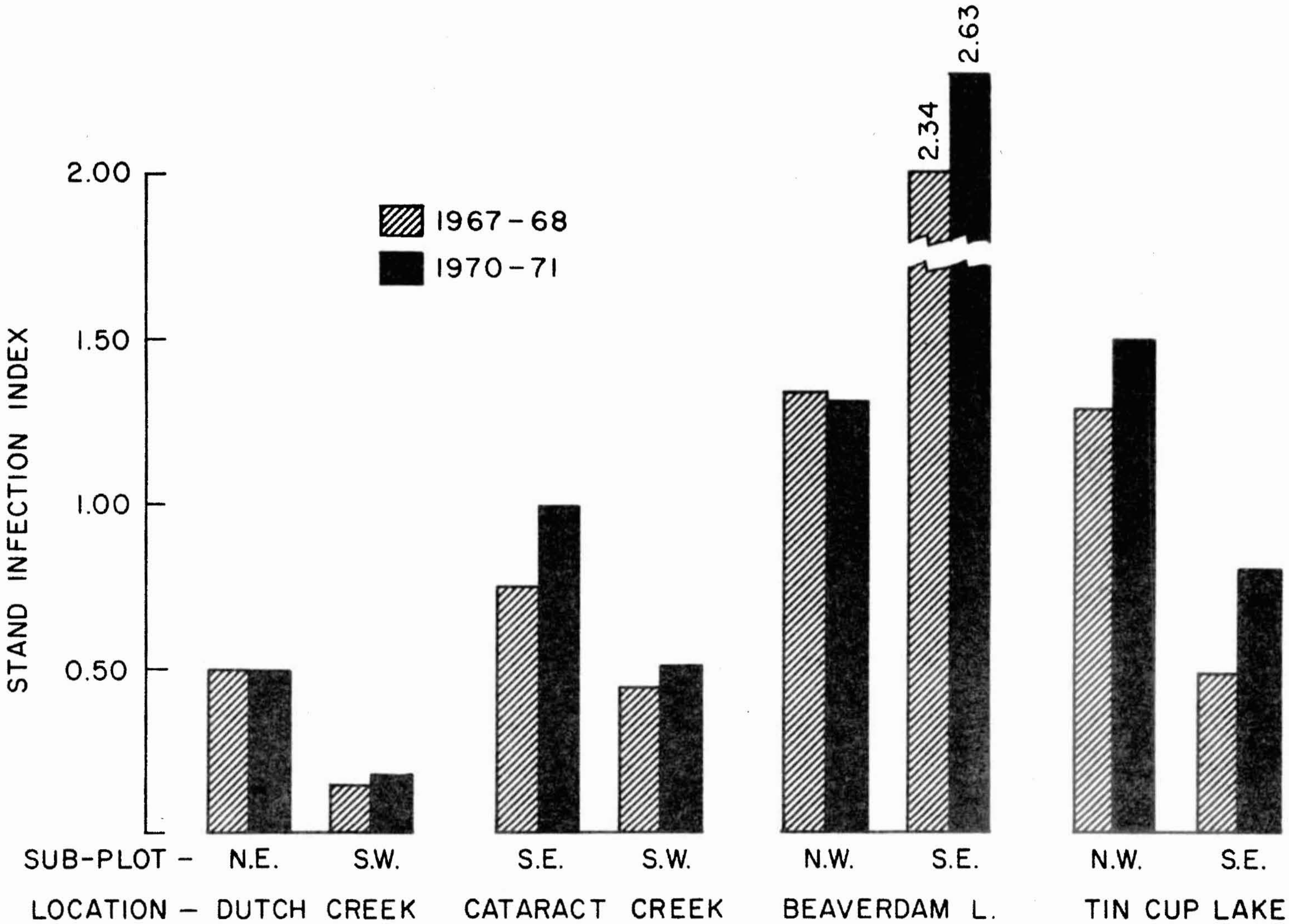

Fig. 2 Change of stand infection index (disease intensity) in the subplots of the infected untreated plots (IC) during the 3-year period between first sanitation and re-survey. (Since the IC plot at Etherington Creek was destroyed, only 4 plots are included.)

class is shown in Table II and illustrated by Fig. 3. Disease incidence was highest in the dominant and codominant crown classes, declining in the intermediate and suppressed crown classes. In dense stands, over 30 years of age, the main resource of healthy trees has been in the suppressed crown class. Lodgepole pine does not respond well to release after a prolonged period of suppression and for this reason a high proportion of released trees in the Beaverdam Lake and Tin Cup Lake areas died after treatment. Furthermore, because of the patchy occurrence of the disease in these two stands, large patches had to be almost clearcut during DME treatment, and the stand was badly broken up. In the infected thinned plot (IT) at Beaverdam Lake, where disease incidence was 56.8%, the higher crown classes did not contain enough healthy trees for a well-stocked stand, and though spacing was achieved by releasing disease-free suppressed trees, a high proportion of these died. In this plot, disease incidence was up to 55.5% at the time of retreatment. At Tin Cup Lake, the IT plot originally had only 32.4% disease incidence. It was easy to maintain a well-stocked stand here after treatment. Disease incidence declined to 25.1% at the time of retreatment. With the foregoing in mind, the justification of sanitation in stands over 30 years of age seems to be questionable if disease incidence in the dominant and codominant crown classes exceeds 50%. On the other hand, in the 22-year-old Dutch Creek IT plot, disease incidence was 59.7% at establishment, but was reduced to 27.8% as a result of sanitation. Suppressed trees seemed to respond well to release, since mortality was negligible and almost 50% of the mortality was caused by snow or windthrow.

TABLE II. DISTRIBUTION OF INFECTED TREES WITHIN CROWN CLASSES IN THE SUB-PLOTS.

Plot No.	Crown Class															
	Dominant				Co-dominant				Intermediate				Suppressed			
	Healthy	Infected	Total	Incid.%	Healthy	Infected	Total	Incid.%	Healthy	Infected	Total	Incid.%	Healthy	Infected	Total	Incid.%
DUTCH CREEK																
1					5	3	8	38	21	10	31	32	149	44	193	23
2		3	3	100	1	8	9	89	7	27	34	79	122	96	218	44
3		1	1	100	2	2	4	50	8	7	15	47	93	56	149	38
CATARACT CREEK																
1	12	120	320	62	40	47	87	54	45	31	76	41	32	8	40	20
2	4	20	24	83	67	175	242	72	70	117	187	63	17	3	20	15
3	4	5	9	56	69	66	135	49	24	4	28	14	14	1	15	7
ETHERINGTON CREEK																
6	20	21	41	51	239	195	434	45	370	130	500	26	54	23	77	30
7	114	45	159	28	213	47	260	18					102	4	106	4
8	3	50	53	94	17	95	112	85	26	108	134	81	68	86	154	56
BEAVERDAM LAKE																
1						11	11	100	2	32	34	94	51	172	223	77
2		1	1	100	8	4	12	33	14	15	29	52	129	81	210	39
3					1	3	4	75	2	8	10	80	36	95	131	73
TIN CUP LAKE																
6					1	2	3	66	4	14	18	78	57	82	139	59
7					3	2	5	40	5	5	10	50	71	49	120	41
8	4	7	11	64	10	24	34	71	21	15	36	42	41	42	83	51

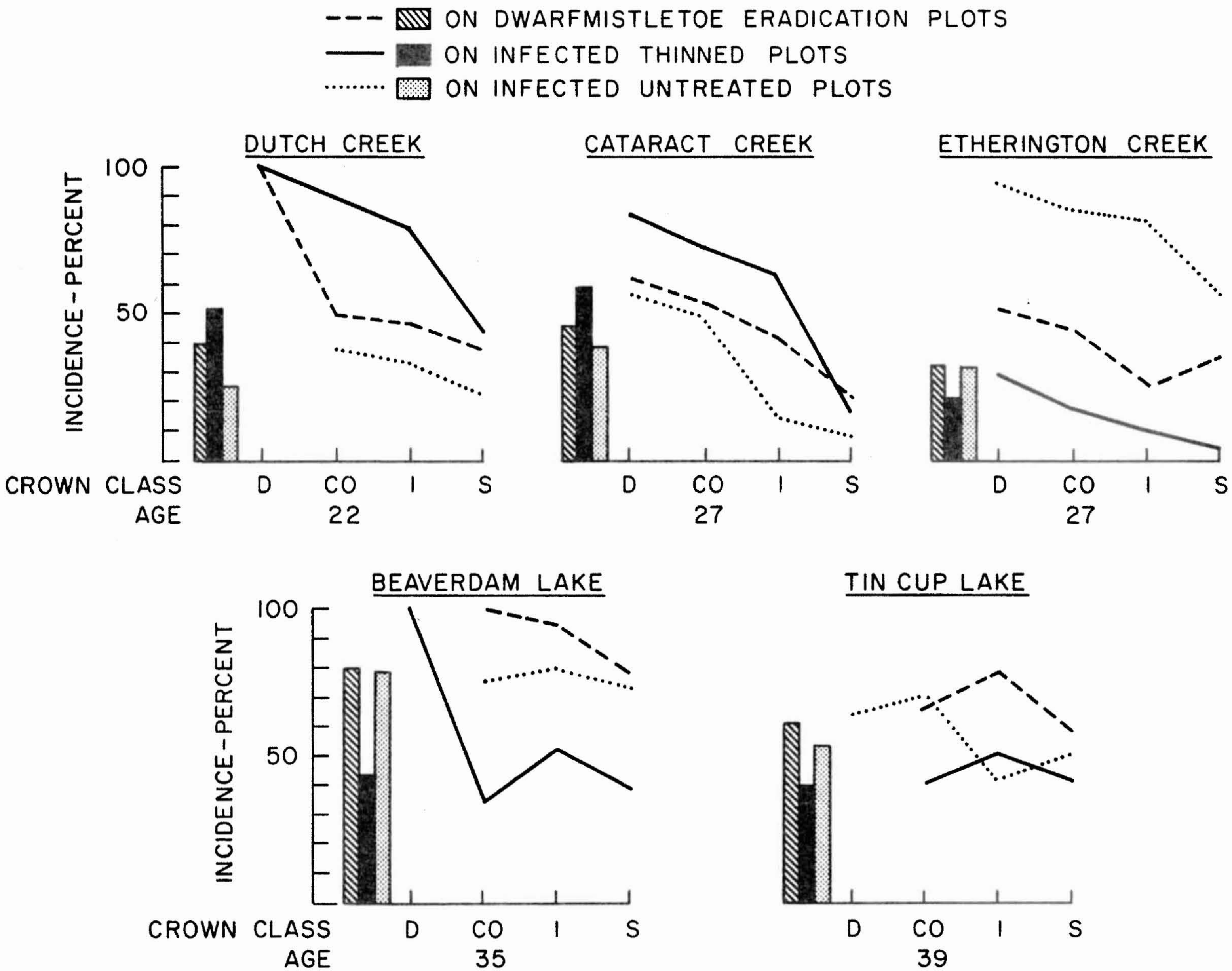

Fig. 3 Incidence of dwarf mistletoe in various crown classes before the first sanitation on the basis of subplot data. Bars represent the average incidence of the two subplots.

The apparent cause of mortality in the subplots is summarized in Table III. Over 70% of mortality was caused by suppression. Armillaria damage (1.9%) was found only in the Cataract Creek plots. Snow and wind-throw (4.2%) was sporadic in most areas. Twenty per cent of the tagged trees, generally small sized, were missing, likely due to big-game browsing. Broken and dead tops were commonly observed in each area, but the actual cause of this damage was not identified.

The infected untreated plot (IC) at Etherington Creek was thinned inadvertently by the Minimum Security Crew, operated by the Alberta Forest Service, without taking into account the presence of the disease. It nevertheless provides an excellent object lesson on the hazards of thinning operations without the knowledge of disease situations or guidelines for handling them. Because the presence of the disease was disregarded and a large proportion of healthy trees were removed, the proportion of diseased trees in the stand was increased by 91.4%. Most of the intermediate and suppressed trees were cut during this operation and the leave trees were selected from the heavily infected dominant and codominant crown classes. According to data obtained in the subplots of this plot at establishment (Table II and Fig. 3), most of the healthy trees were in the intermediate (19%) and suppressed (44%) classes. Since disease incidence in the Cataract Creek IC plot, which is in the same age class, declined by 1.2% (Table I) during the 3-year period; likely the original disease incidence of 18.6% would not have changed considerably in the Etherington Creek IC plot. Consequently, the increase from 18.6 to 35.6% (91.4%) in disease incidence is the result of the thinning. At the same time, the opening up of the stand provides ideal

TABLE III. CAUSE OF MORTALITY AND OTHER DISORDERS OBSERVED ON THE SUB-PLOTS DURING THE 1970-71 RE-SURVEY OF THE DWARF MISTLETOE SILVICULTURAL CONTROL PLOTS.

Location	Plot No.	Kind of Treat-ment	Orienta-tion of Sub-plot	Dead					Missing	Browsed	Damaged by		Rust Infected		Top	
				Total	Sup-pression	Armil-laria	Rodent	Snow or Wind			Rodent	Sap-sucker	Stem	Gall	Broken	Dead
Dutch Creek	3	DME	N.E.	1	1								1			
			S.W.													
	2	IT	N.W.	3	3											
			S.E.	5	1			4								
	1	IC	N.E.							3						
			S.W.							2					1	
	4	HT	N.W.													
			S.E.													
	5	HC	N.W.												4	3
			S.E.												1	1
Cataract Creek	1	DME	S.W.	5	2	1			2							
			S.E.	9	5	1		3								7
	2	IT	N.E.	1					1							
			S.E.	1					1							
	3	IC	S.E.	4	1	3				3	4					
			S.W.												1	
	4	HT	N.E.								1				5	
			N.W.												12	
	5	HC	N.E.	1	1						2					
			S.E.	1					1							

TABLE III. CAUSE OF MORTALITY AND OTHER DISORDERS OBSERVED ON THE SUB-PLOTS DURING THE 1970-71 RE-SURVEY OF THE DWARF MISTLETOE SILVICULTURAL CONTROL PLOTS. (Continued).

Location	Plot No.	Kind of Treat-ment	Orienta-tion of Sub-plot	Dead					Missing	Browsed	Damaged by		Rust Infected		Top	
				Total	Sup-pression	Armil-laria	Rodent	Snow or Wind			Rodent	Sap-sucker	Stem	Gall	Broken	Dead
Etherington Creek	6	DME	N.E.	16	16								3		11	3
			S.W.	15	14		1				3				10	2
	7	IT	N.W.	1					1							
			S.E.	2				2								
	9	HT	N.W.	1				1								
			S.E.	1					1						4	
	10	HC	N.E.	47	16			1	30	14					9	11
			S.W.	16	14				2	1					2	1
Beaverdam Lake	1	DME	N.E.	20	20[1]					3						
			S.W.	12	12										5	
	2	IT	N.W.	2	2											
			S.E.	5	5							4			2	
	3	IC	N.W.	13	13					1	2				3	2
			S.E.	10	10					1				5	1	1
	4	HT	N.E.													
			S.E.	3	3											
	5	HC	N.E.	7	7											
			S.E.	10	10										1	

TABLE III. CAUSE OF MORTALITY AND OTHER DISORDERS OBSERVED ON THE SUB-PLOTS DURING THE 1970-71 RE-SURVEY OF THE DWARF MISTLETOE SILVICULTURAL CONTROL PLOTS. (Continued).

Location	Plot No.	Kind of Treat-ment	Orienta-tion of Sub-plot	Dead					Missing	Browsed[1]	Damaged by		Rust Infected		Top	
				Total	Sup-pression	Armil-laria	Rodent	Snow or Wind			Rodent	Sap-sucker	Stem	Gall	Broken	Dead
Tin Cup Lake	6	DME	N.W.	10	8				2					1		1
			S.E.	20	9				11					1		
	7	IT	N.E.	1					1							
			S.E.	2	2									1		
	8	IC	N.W.	4	4						2			2	2	5
			S.E.	11	11						3			1	1	1
	TOTAL			260	190	5	1	11	53	28	17	4	4	11	75	38
					73.2%	1.9%	0.3%	4.2%	20.4%							

[1] Big game browsing was very heavy here.

light conditions for increased dwarf mistletoe seed production (1) and the wider spacing for greater distance of seed dissemination (6, 8). After such a stand treatment, infection incidence level is expected to increase faster in treated than in untreated stands.

The three years between treatments was too short a period to justify a comparison of tree-growth data among the different treatments.

CONCLUSIONS

It is too early to draw any firm conclusions after the first re-treatment (second sanitation) of the plots, but some noteworthy observations are offered. In the DME plots, where all infected trees were cut and thinning will not be done until the 1973-74 sanitation, disease incidence declined by approximately 50% (Fig. 1). In the IT plots, where the first sanitation and thinning was done at the same time and stocking was reduced considerably, disease incidence was not reduced proportionally. If pruning had not been acceptable (e.g. large-scale operational control), and it was necessary that all infected trees be cut, stocking in these plots would have been reduced radically. It seems that the maintenance of a large reserve of healthy trees until after the first two sanitations are accomplished will ensure a better stocking of the future stand. In heavily infected stands, 30+ years of age, most of the healthy trees are in the suppressed crown class. These trees do not respond to release, and after treatment usually die. Sanitation in these stands is justified only if less than 50% of the dominant and codominant trees are infected. On the other hand, the 22-year-old stand with high disease incidence responded well to sanitation.

The large-scale thinning operations conducted by the Alberta

Forest Service in dwarf mistletoe-infected young pine stands of the Clearwater and Bow River forests in Alberta should include sanitation measures. Otherwise, their operations will increase dwarf mistletoe damage beyond that expected without any treatment. Ignoring sanitation measures during spacing treatment of dwarf mistletoe-infected hemlock stands, in British Columbia, could result in a similar increase in disease incidence.

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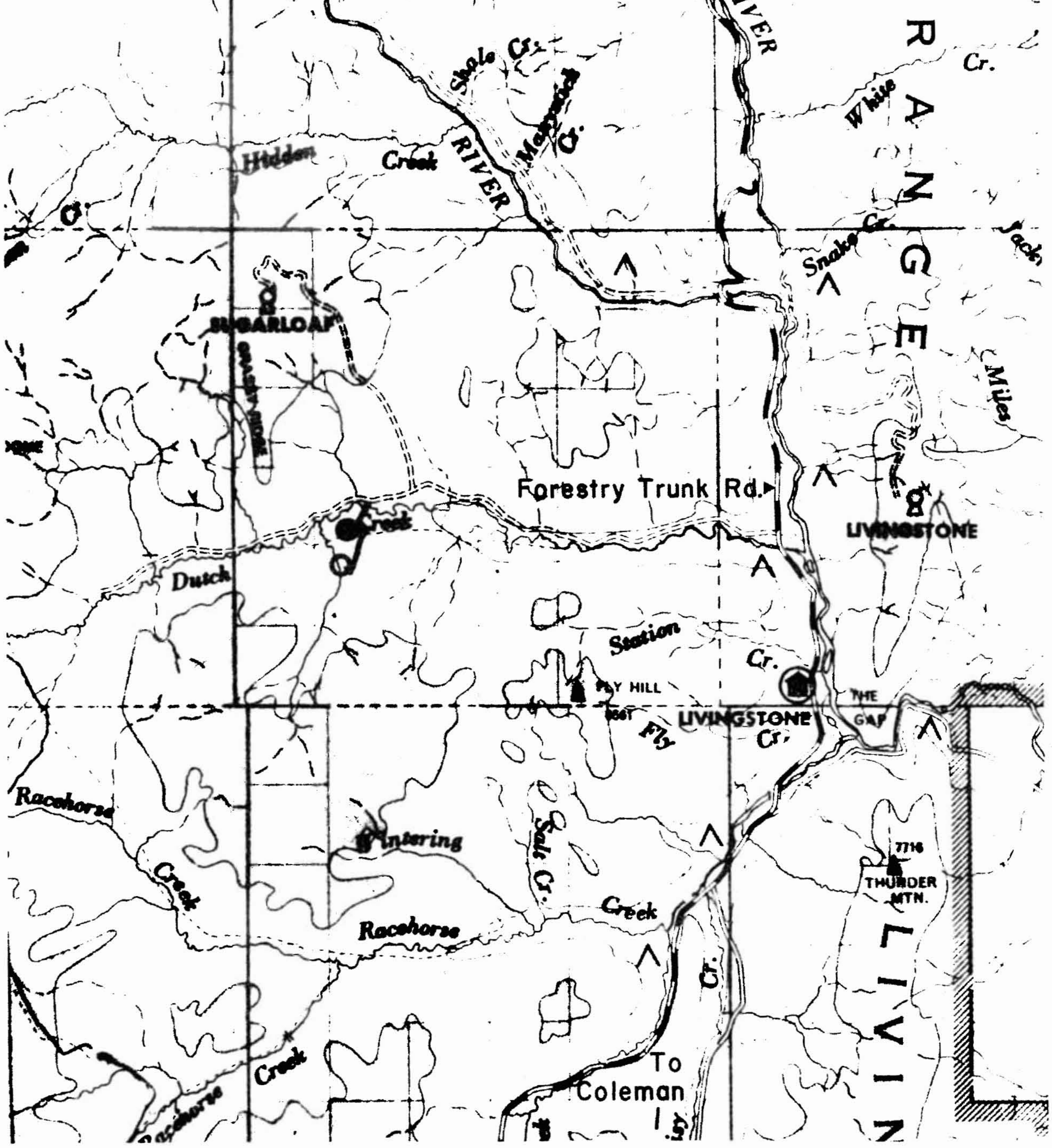
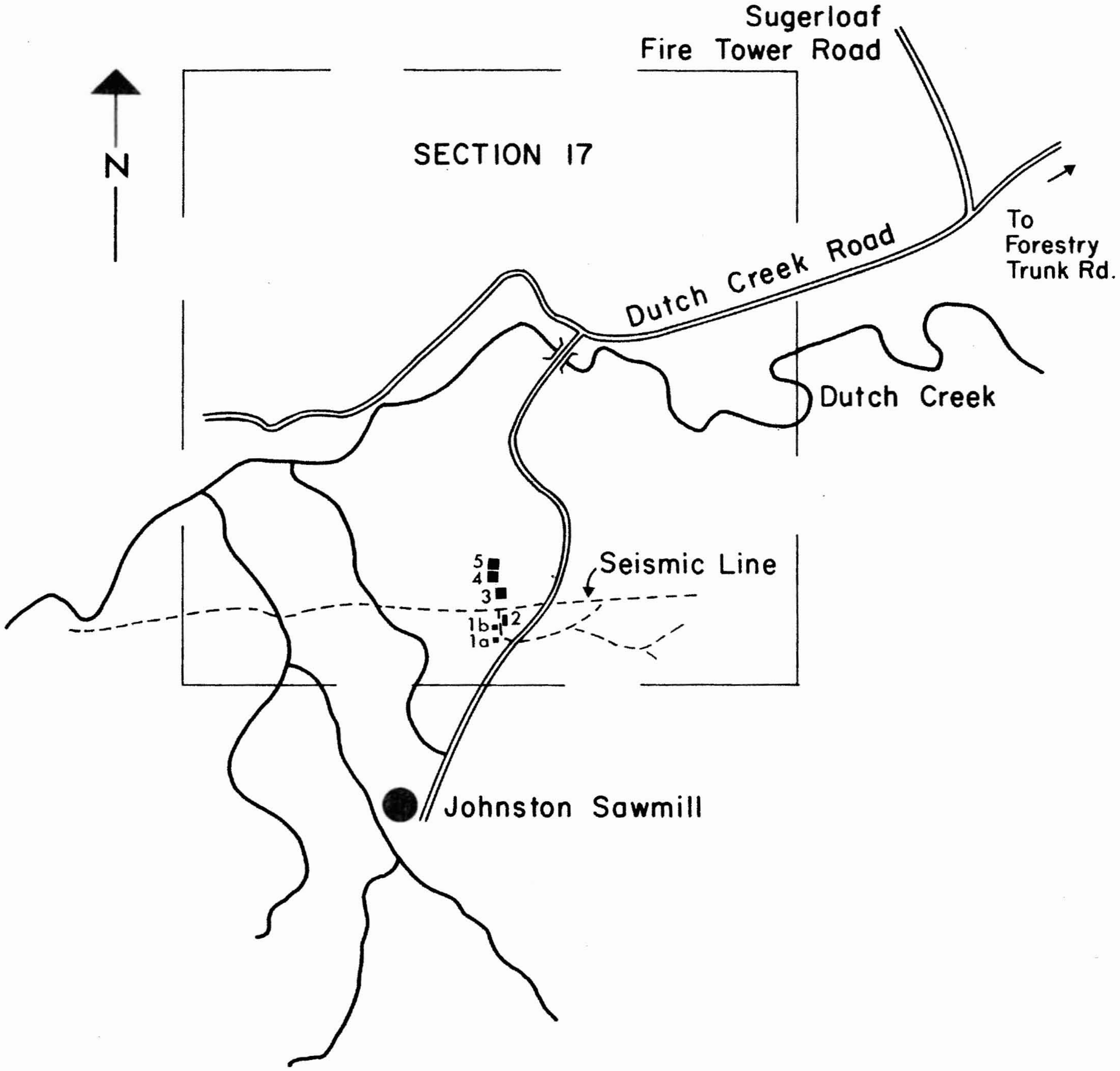
APPENDIXES



DUTCH CREEK SAMPLING AREA

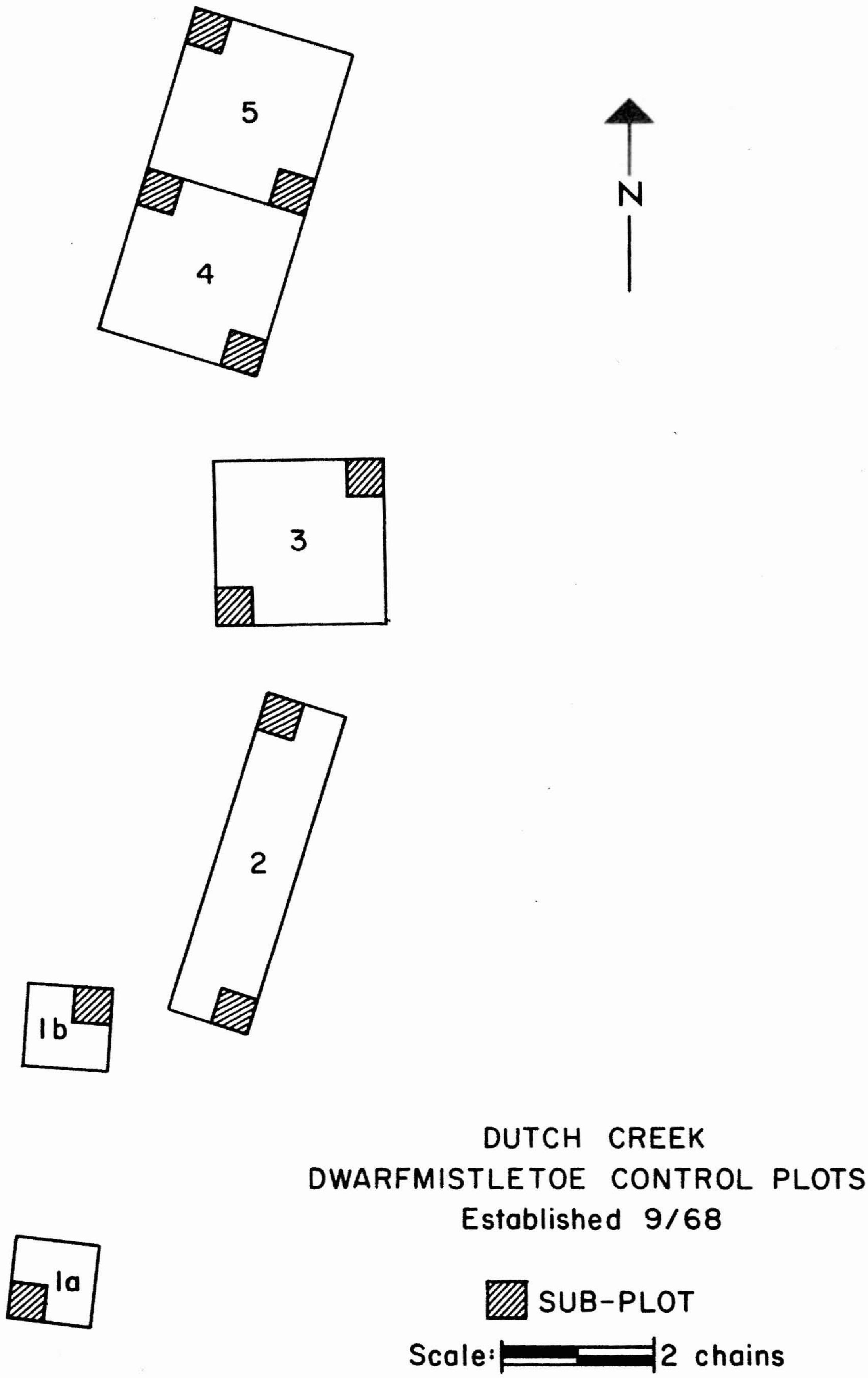
Study Plot Locations ●
Johnston Sawmill ○

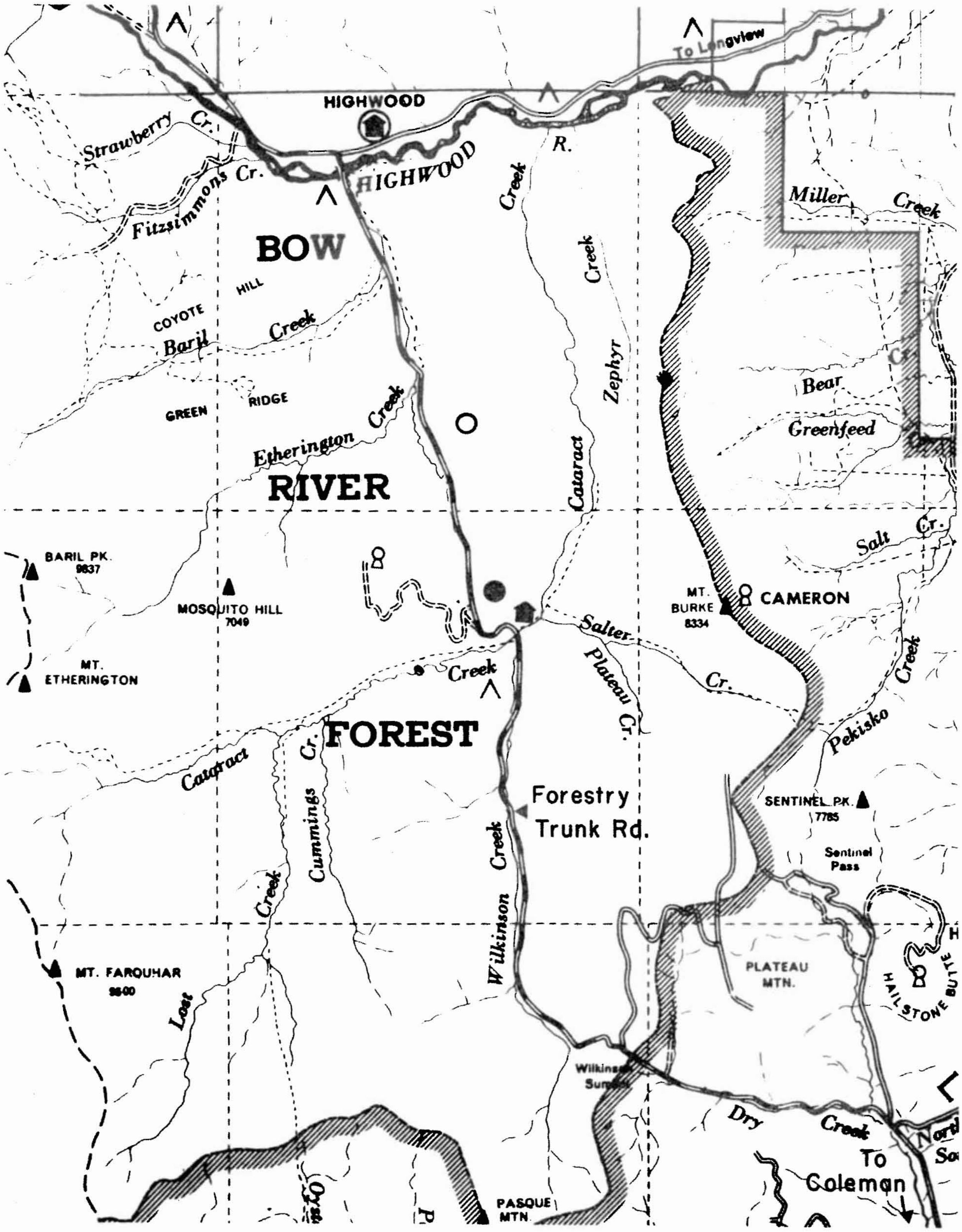


DUTCH CREEK

■ Dwarfmistletoe Control Plots

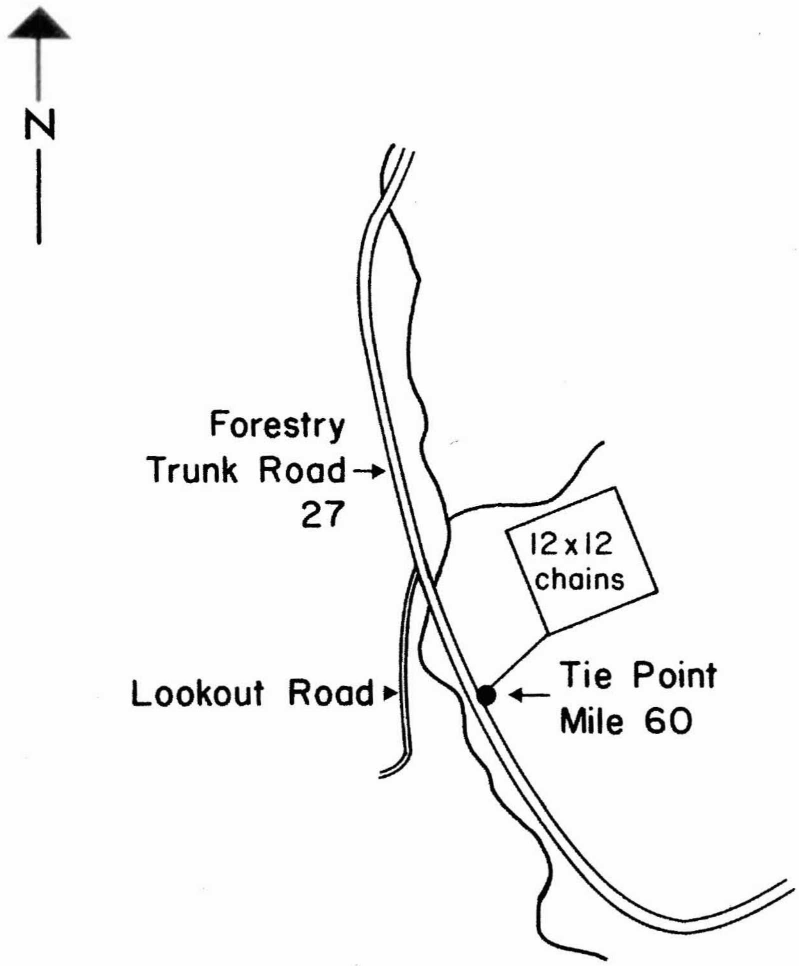
Scale: 1/4 Mile


5
4
3
2
1b
1a
N
DUTCH CREEK
DWARFMISTLETOE CONTROL PLOTS
Established 9/68
SUB-PLOT
Scale: 2 chains



● CATARACT CREEK SAMPLING AREA

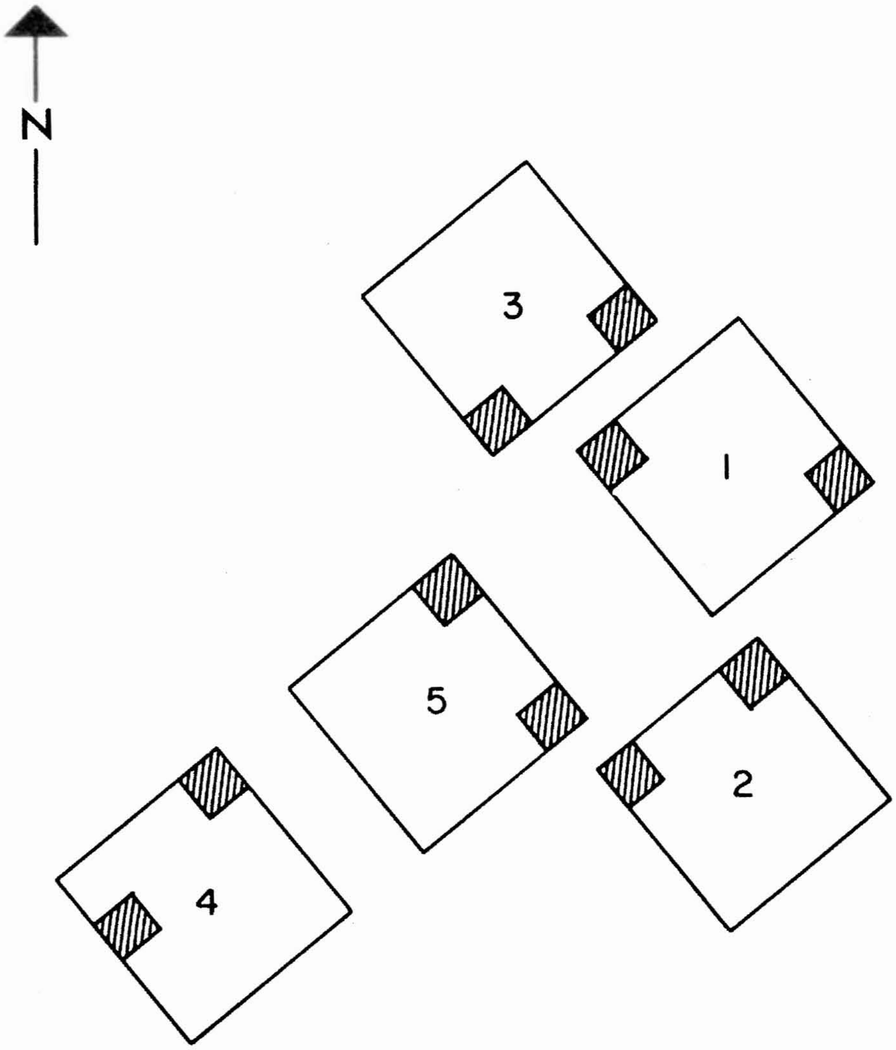
○ ETHERINGTON CREEK SAMPLING AREA



CATARACT CREEK

TRAVERSE

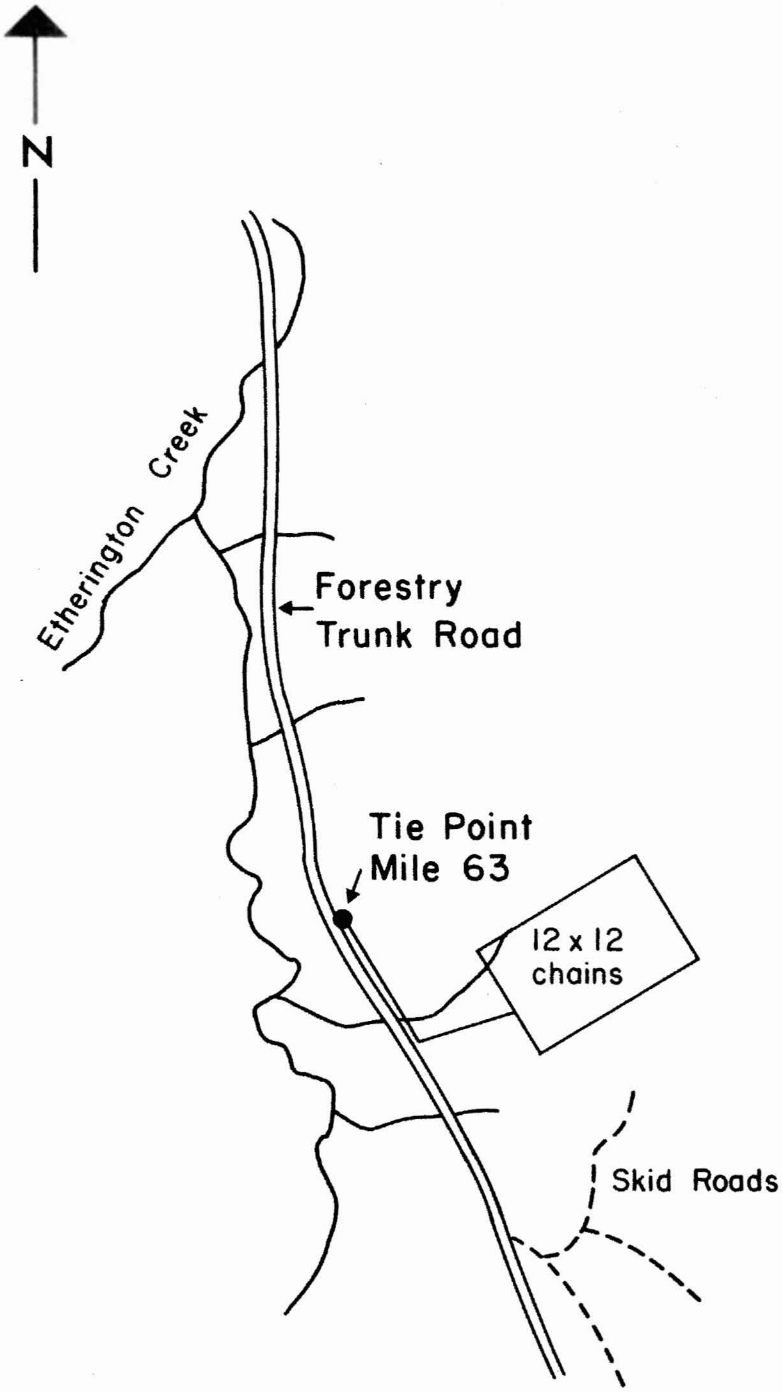
N 50° E : 9.8 CHAINS TO S.W. CORNER OF PLOT



CATARACT CREEK
DWARFMISTLETOE CONTROL PLOTS
Established 7/67

SUB-PLOT

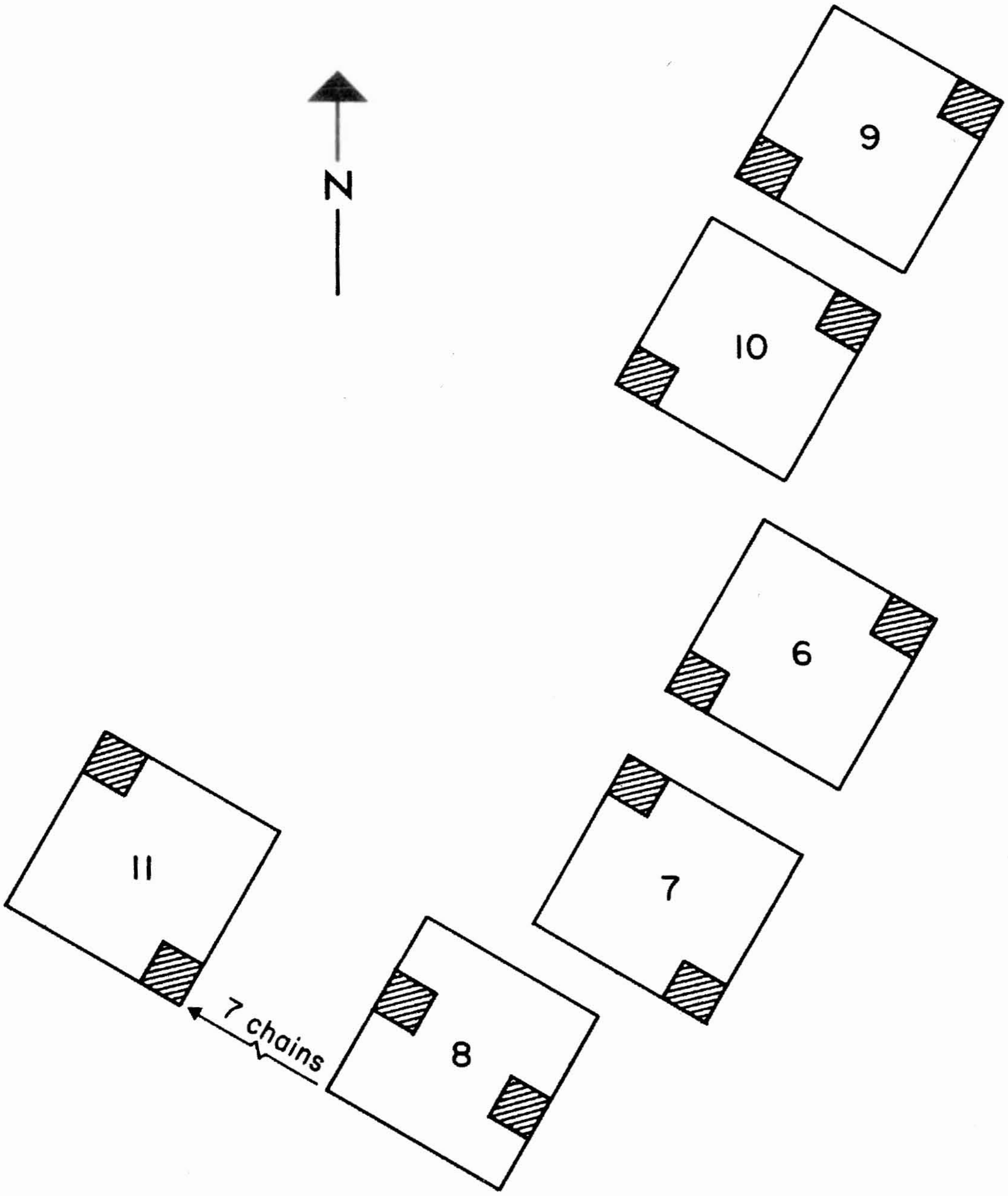
Scale: 2 chains



ETHERINGTON CREEK

TRAVERSE

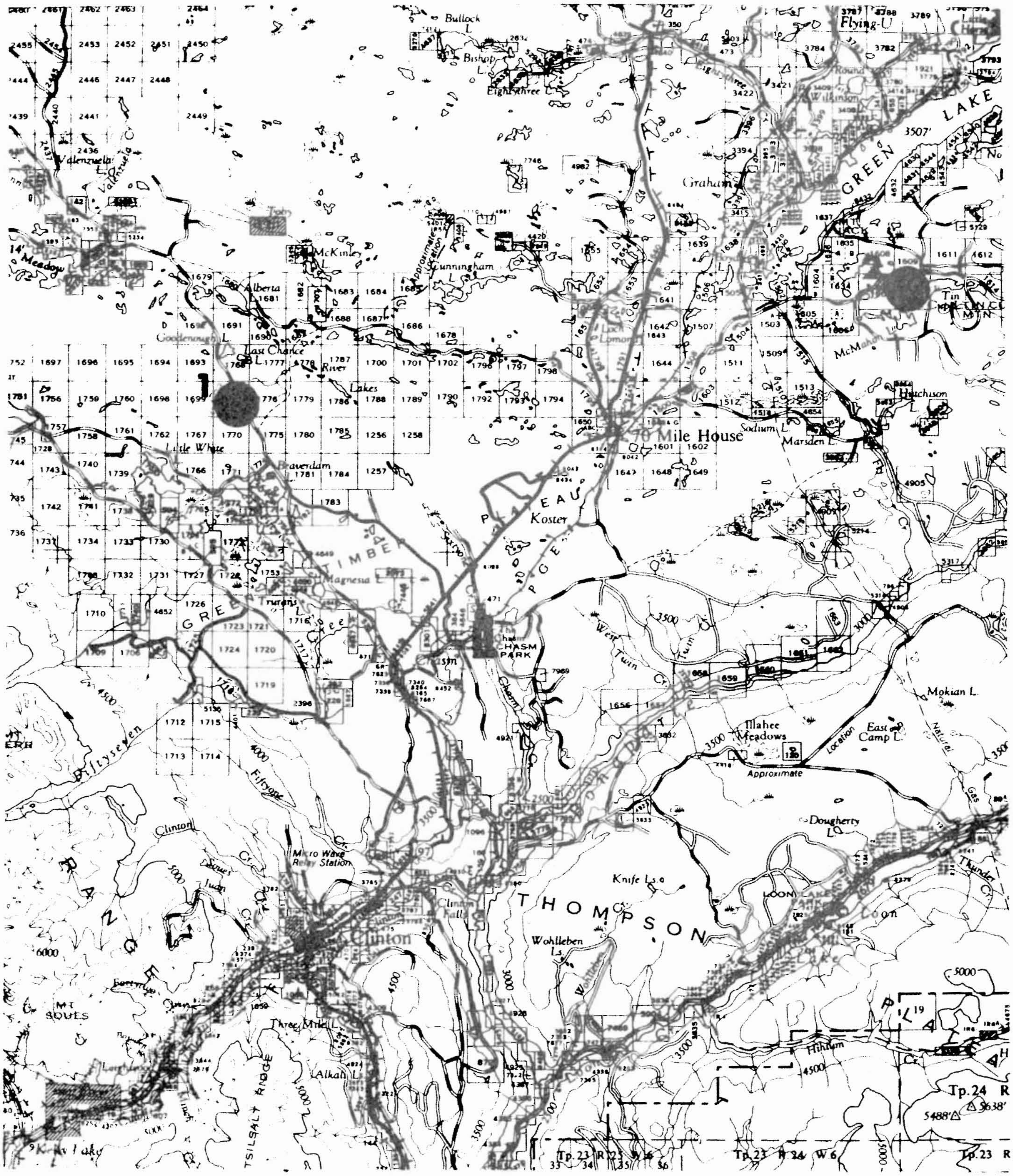
S34°E : 15 CHAINS : ON ROAD
N70°E : 10 CHAINS : WEST LINE OF PLOT
N30°W : 7 CHAINS : N.W. CORNER OF PLOT



ETHERINGTON CREEK
DWARFMISTLETOE CONTROL PLOTS
Established 7/67

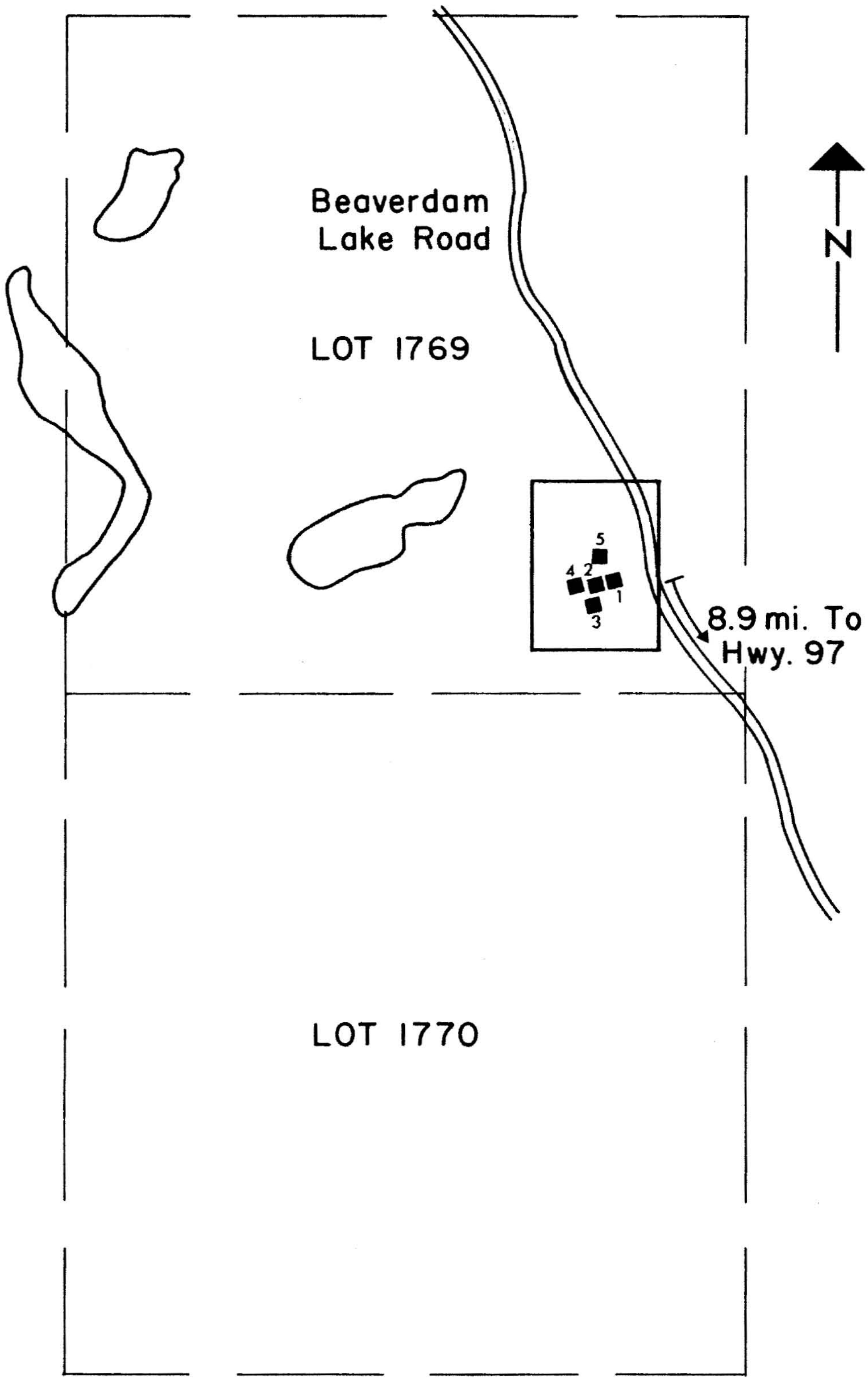
SUB-PLOT

Scale : 2 chains



1 BEAVERDAM LAKE SAMPLING AREA

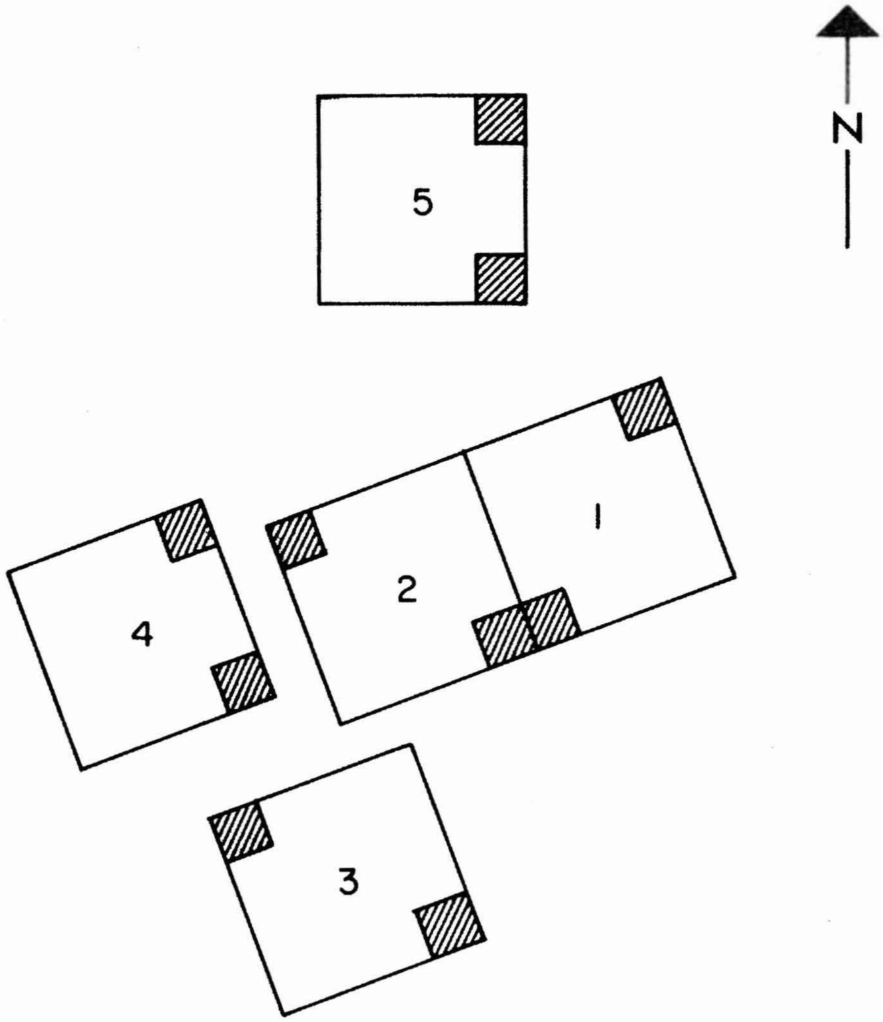
2 TIN CUP LAKE SAMPLING AREA



BEAVERDAM LAKE

Dwarfmistletoe Control Plots

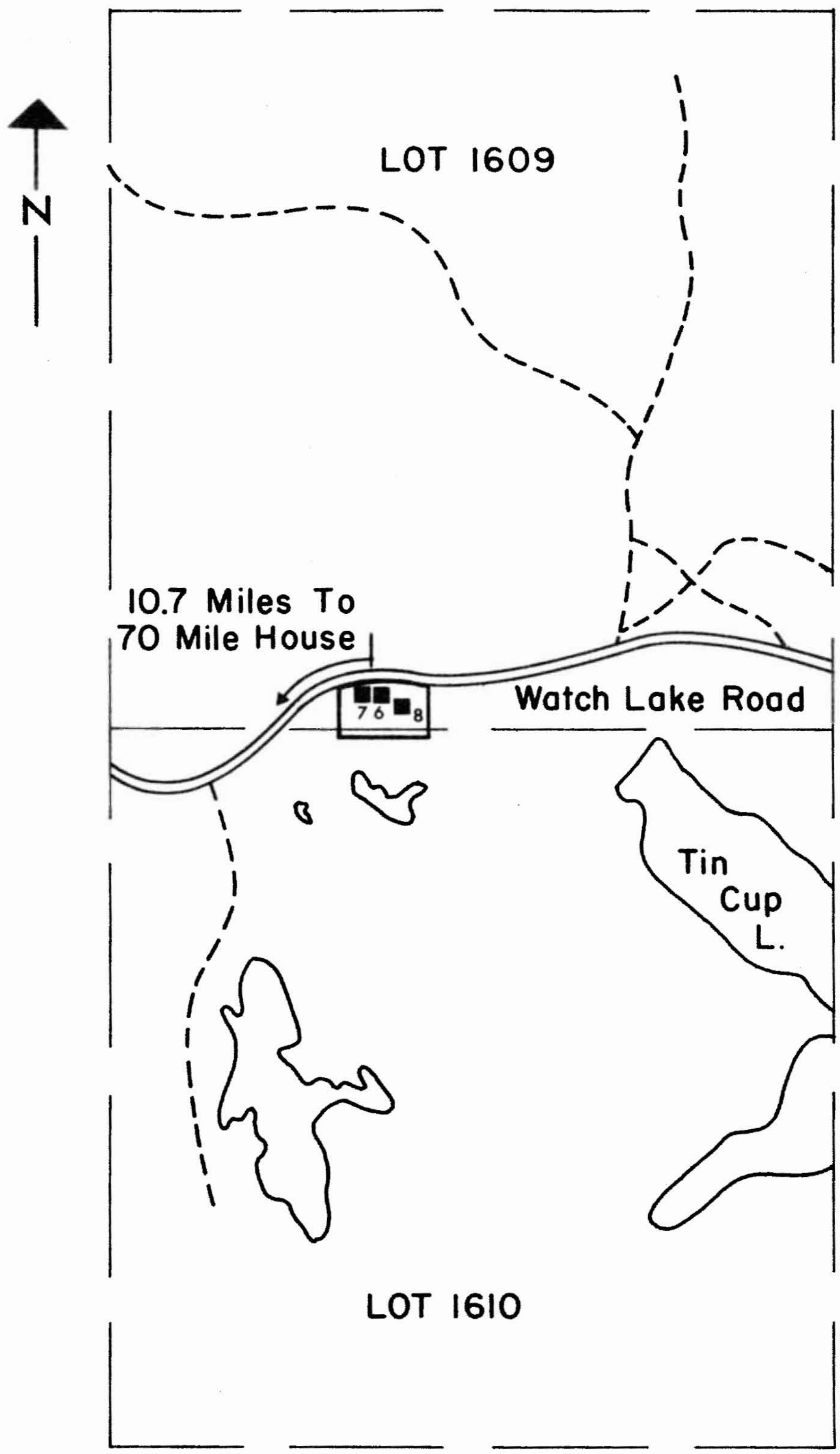
Scale: 20 chains



BEAVERDAM LAKE
DWARFMISTLETOE CONTROL PLOTS
Established 8/68

SUB-PLOT

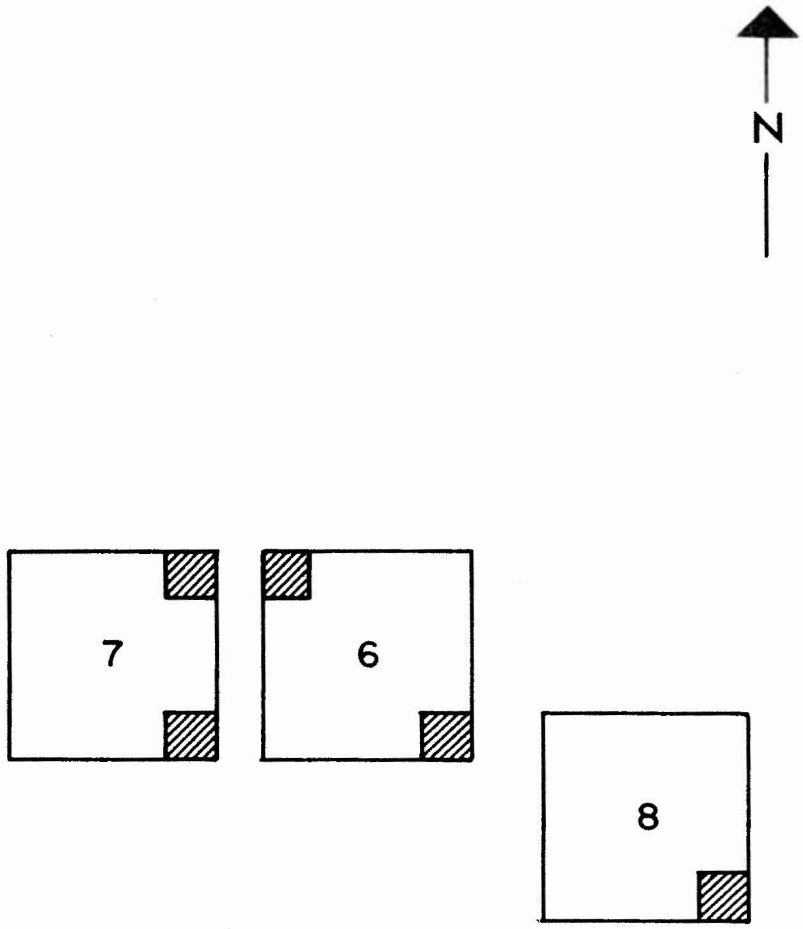
Scale:  2 chains



TIN CUP LAKE

■ Dwarfmistletoe Control Plots

Scale: 20 chains



TIN CUP LAKE
DWARFMITLETOE CONTROL PLOTS
Established 8/68

SUB-PLOT

Scale : 2 chains