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THE CHEMICAL CONTROL OF DENSITY IN YOUNG STAGNATING STANDS OF LODGEPOLE PINE

by
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Project K. 56

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INTRODUCTION

A preliminary investigation initiated in 1949 (Crossley, 1950) which dealt with the use of 2, 4-D and ammate in the thinning of young, dense lodgepole pine stands (*Pinus contorta* Dougl. var. *latifolia* Engelm.), produced results sufficiently encouraging to warrant further study. In 1950 a second more comprehensive series of tests was conducted on milacre quadrats selected in the same dense, 14-year-old stand of lodgepole pine[1] in the subalpine forest region on the Kananaskis Forest Experiment Station in Alberta. This second phase of the study into effective methods of thinning dense young stands was designed to investigate a variety of formulations and dosages of both 2, 4-D and ammate applied at different seasons of the year in an attempt to discover inexpensive and sufficiently lethal treatments. Such objectives were not wholly attained, and in 1952 a third series of milacre quadrats was prepared and treated using new formulations of 2, 4-D, and incorporating into the investigation the herbicide 2, 4, 5-T, both by itself, and in combination with 2, 4-D.

The results of these studies are now sufficiently clear to warrant their publication, and this Technical Note deals with each in turn. They will be referred to as the second and third series of tests. It will be noted that white spruce (*Picea glauca* (Moench) Voss var. *albertiana* (S. Brown) Sarg.) are referred to. This species occurred as an understory to the pine.

SECOND SERIES

Method

Both the 2, 4-D ester[2] and ammate[3] were selected for trial in 1950 and were tested in four quantities, each in 5 different volumes of both oil and water diluents as follows:

2, 4-D per acre	Diesel fuel * per acre or Water per acre	
½ gal.	5 gals.	5 gals.
	10	10
	25	25
	50	50
	100	100
½ gal.	5 to 100 gals. (as above)	5 to 100 gals. (as above)
1 gal.	5 to 100 gals. " "	5 to 100 gals. " "
2 gals.	5 to 100 gals. " "	5 to 100 gals. " "
Ammate per acre		
10 lbs.		5 to 100 gals. (as above)
50 lbs.		5 to 100 gals. "
100 lbs.		5 to 100 gals. "
200 lbs.		10 to 100 gals. "

* a light winter diesel fuel was used.

[1] The average density of the stand was 226,000 stems per acre, 78 per cent of which were pine, 11 per cent spruce, 9 per cent willow, and the remaining 2 per cent alpine fir and poplar. The spruce and fir were growing as an understory.

[2] 2, 4-dichlorophenoxyacetic acid, 6¼ oz. acid equivalent per Imperial gallon.

[3] 80 per cent ammonium sulphamate.

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PLATE 1. Fourteen-year-old reproduction stand of lodgepole pine. Density is more than a quarter of a million stems per acre.

Application of the complete range of these 60 formulations and dosages was undertaken in the spring of 1950 just as the buds of lodgepole pine were bursting. A second complete set was applied during the latter part of June when growth was considered to be at its maximum. Each treatment was applied to a milacre quadrat using a power paint spray, the nozzle of which produced a mist with droplet sizes in the neighbourhood of 100 microns. There were two replicates of both spring and summer treatments, and the whole series therefore included 240 individually treated milacre quadrats.

Results (second series)

Previous experience with the first series (1950) studied had revealed the difficulty of deciding during the first season when an affected tree had succumbed. For this reason mortality tallies did not begin on the second series of

treated quadrats until the conclusion of the second season. Figure 1 presents a generalized picture of the comparative results and indicates that 2, 4-D in a diesel fuel carrier proved to have the most lethal effect on lodgepole pine, with the additional suggestion that spring application was more effective than midsummer. On the other hand the midsummer application of ammate in water was considerably more effective than the spring application. The spring application of ammate, together with all treatments involving 2, 4-D with a water carrier, showed little increase over the natural mortality experienced during the same period on the controls.

Diesel fuel's penetrating power apparently makes it a far more effective carrier for 2, 4-D than does water, and while some of the lighter dosages proved to be relatively ineffective, the heavier concentrations often resulted in a most satisfactory kill. Table 1 presents the information on treatments that resulted in greater than 50 per cent mortality of lodgepole pine over a five-year period.

TABLE 1. CUMULATIVE THINNING EFFECT OF 2, 4-D IN DIESEL FUEL ON A DENSE, YOUNG LODGEPOLE PINE REPRODUCTION STAND FIVE SEASONS AFTER APPLICATION

Per acre dosages		Original stem tally per milacre	Per cent mortality	
2, 4-D	Diesel Fuel		lP	weS
			Spring Application	
½ gal.	100 gal.	258	67	19
1 gal.	100 gal.	152	84	29
	50 gal.	204	61	9
2 gal.	100 gal.	281	92	42
	50 gal.	336	79	35
Controls		191	13	0
			Midsummer Application	
½ gal.	100 gal.	122	62	25
1 gal.	100 gal.	187	59	30
	50 gal.	217	54	0
2 gal.	100 gal.	98	95	57
	50 gal.	167	76	35
	25 gal.	190	73	21
Controls		163	16	17

Figure 2 was prepared for the purpose of indicating the steady increase in mortality of lodgepole pine as the proportion of 2, 4-D in an average dosage of diesel fuel carrier was increased. In order to emphasize the effects of varying amounts of 2, 4-D, average mortality figures for the full range of diesel fuel volumes were adopted. Consequently the figures in the graph do not correspond

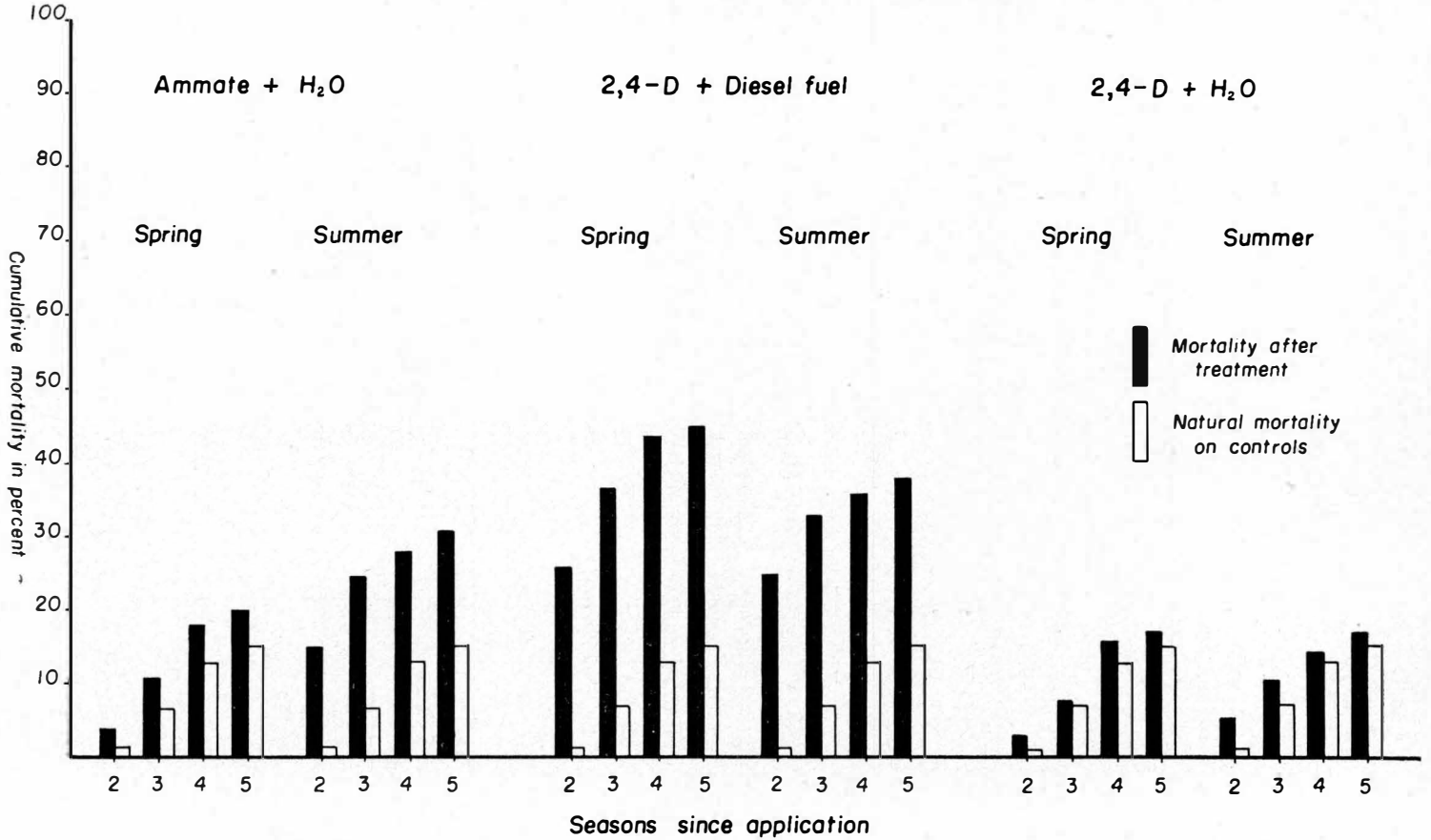

FIGURE 1. Comparative lethal effectiveness of treatments on lodgepole pine over a 5-year period.

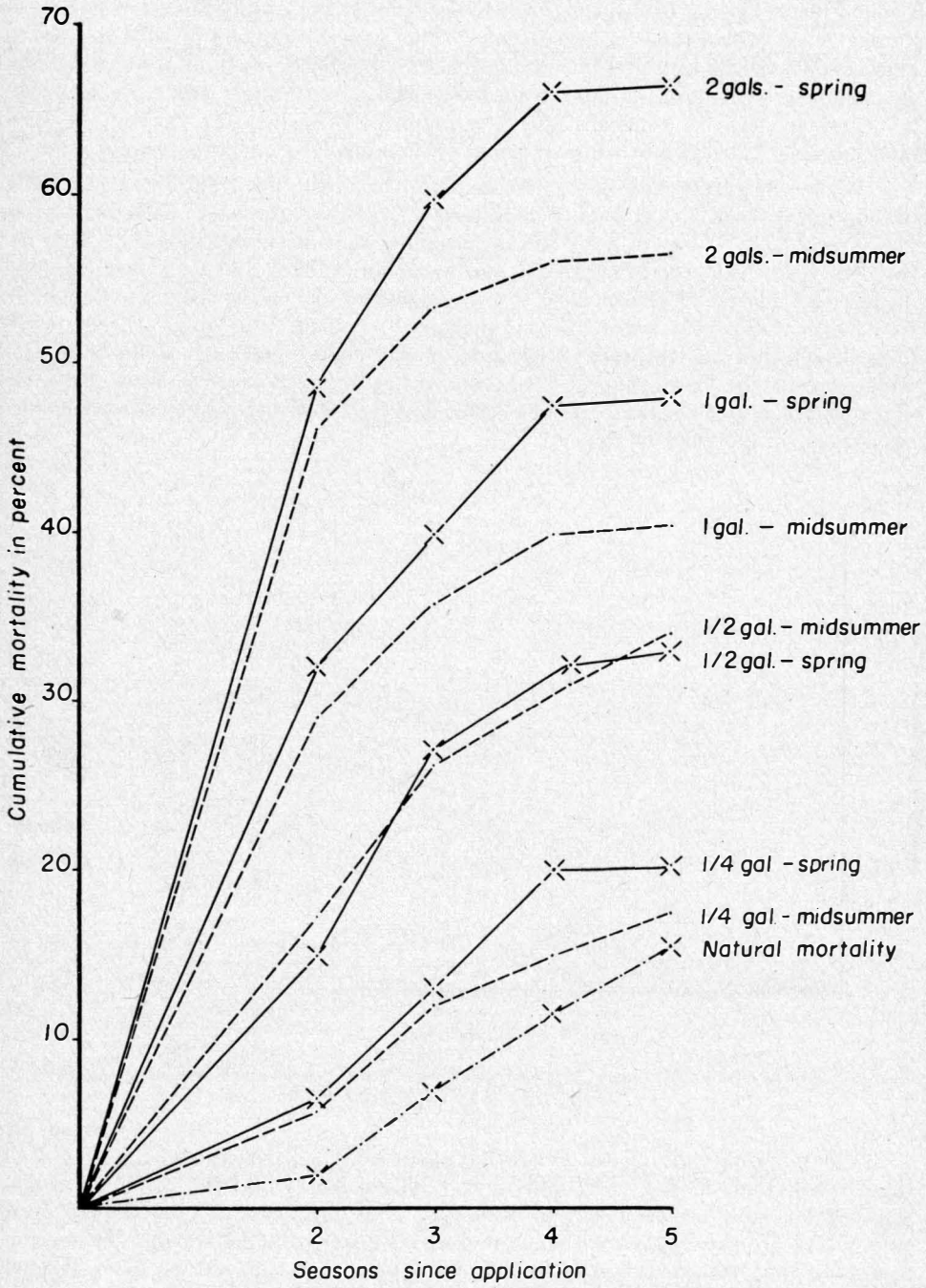

FIGURE 2. Lethal effect of varying per acre concentrations of 2, 4-D in a diesel fuel carrier on lodgepole pine.

with those in Table 1. The same trend is evident whether the material was applied in the spring or in midsummer, but almost invariably the mortality was lowest with midsummer applications. The general flattening of the curves between the fourth and fifth years confirms the field observations that mortality as a result of treatment is almost complete. Those individuals that have survived to the fifth year are generally growing vigorously again after varying degrees of setback. Natural mortality in untreated quadrats is continuing unabated.

While the results are not so consistent, the mortality trends in the spruce understory presented in Figure 3 indicate a similar increase with increased volumes of 2, 4-D, but in contrast to the pine, mortality continues, at least to the fifth year. Natural mortality in spruce on the controls has been non-existent during this period of study, and it was negligible on the treated quadrats for two years following herbicide application. During the next three years mortality following treatment increased rapidly, but observations made in the fifth year in the field suggest that the spruce remaining alive were growing vigorously and are showing the beneficial effects of release from the dense crown cover and competition of pine.

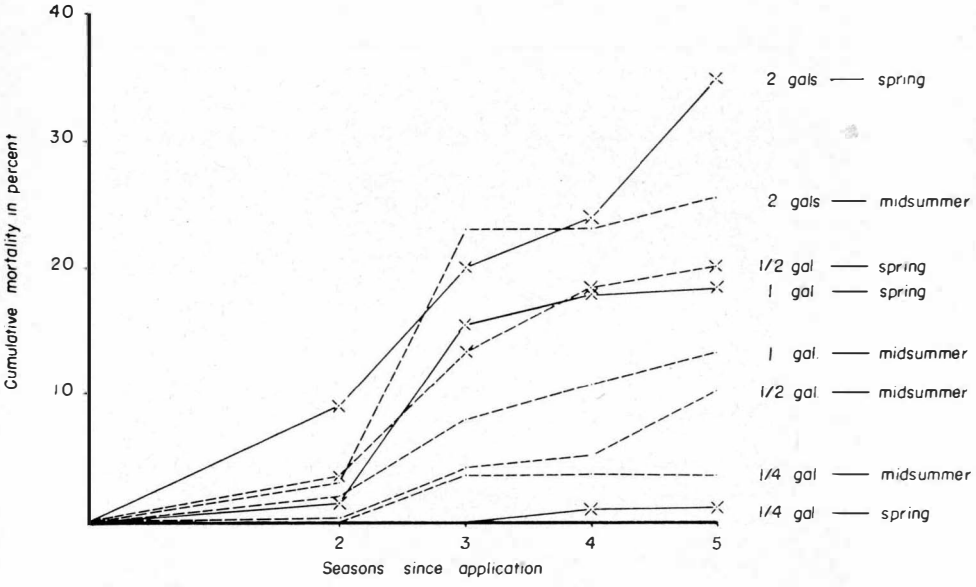

FIGURE 3. Lethal effect of varying per acre concentrations of 2, 4–D in a diesel fuel carrier on an understory of white spruce in a lodgepole pine stand.

Using ammate and water as a lethal agent, only a few of the dosages resulted in greater than 50 per cent mortality. These were confined to midsummer applications and are reported in Table 2. For purposes of comparison mortality data are presented for the same dosages applied in the spring. It is quite apparent that in these instances summer application proved to be far more lethal, i.e. the opposite trend to that noted for 2, 4-D.

Figure 4 indicates the steady increase in mortality of lodgepole pine as the proportion of ammate in an average dosage of water was increased. The same trend is evident whether the spray was applied in the spring or in midsummer,

TABLE 2. CUMULATIVE THINNING EFFECT OF AMMATE IN WATER ON A DENSE YOUNG LODGEPOLE PINE REPRODUCTION STAND FIVE SEASONS AFTER APPLICATION

Per acre dosages		Original stem tally per milacre	Per cent mortality	
Ammate	Water		lP	weS
			Spring Application	
200 lbs.	100 gal.	116	18	14
	50	205	31	20
	25	354	25	19
	10	228	24	24
Controls		177	15	9
			Summer Application	
200 lbs.	100 gal.	257	57	36
	50	282	56	32
	25	196	68	40
	10	370	67	25
Controls		177	15	9

but unlike the effects of 2, 4-D the ammate appears to have been more lethal when applied during the latter period. The effects of ammate concentration and of season of application on the spruce understory are not so clear (Figure 5). The initial effect of ammate on spruce was similar to that of 2, 4-D in that mortality for the first two seasons following applications was very light. The slope of the curves indicates that while mortality is diminishing it has not yet ceased during the fifth season.

THIRD SERIES

Method

The previous two series of tests had indicated that a high rate of mortality of dense pine stands could be obtained through the use of lethal herbicide sprays. However, the intensity of kill desired appeared to require the use of diesel fuel rather than water as a carrier and in acceptably lethal formulations the oil dosages were considerable. This meant that the carrier became the most expensive item in the formulation. The third series was therefore initiated in an attempt to discover formulations and dosages that would reduce this cost and was confined, on the basis of Series Two results, to midsummer application. This third series included 2, 4-D ester containing 64 oz. of 2, 4-D acid equivalent per Imperial gallon, and 2, 4, 5-T[4] containing 64 oz. of 2, 4, 5-T acid equivalent per gallon, as well as an equal mixture of both 2, 4-D and 2, 4, 5-T which is sold under the trade name "Brushkiller". In this last series the diesel fuel-oil carrier was emulsified with varying amounts of water. The formulations and dosages tested are listed below and apply to all three herbicides.

[4]2, 4-5 trichlorophenoxyacetic acid.

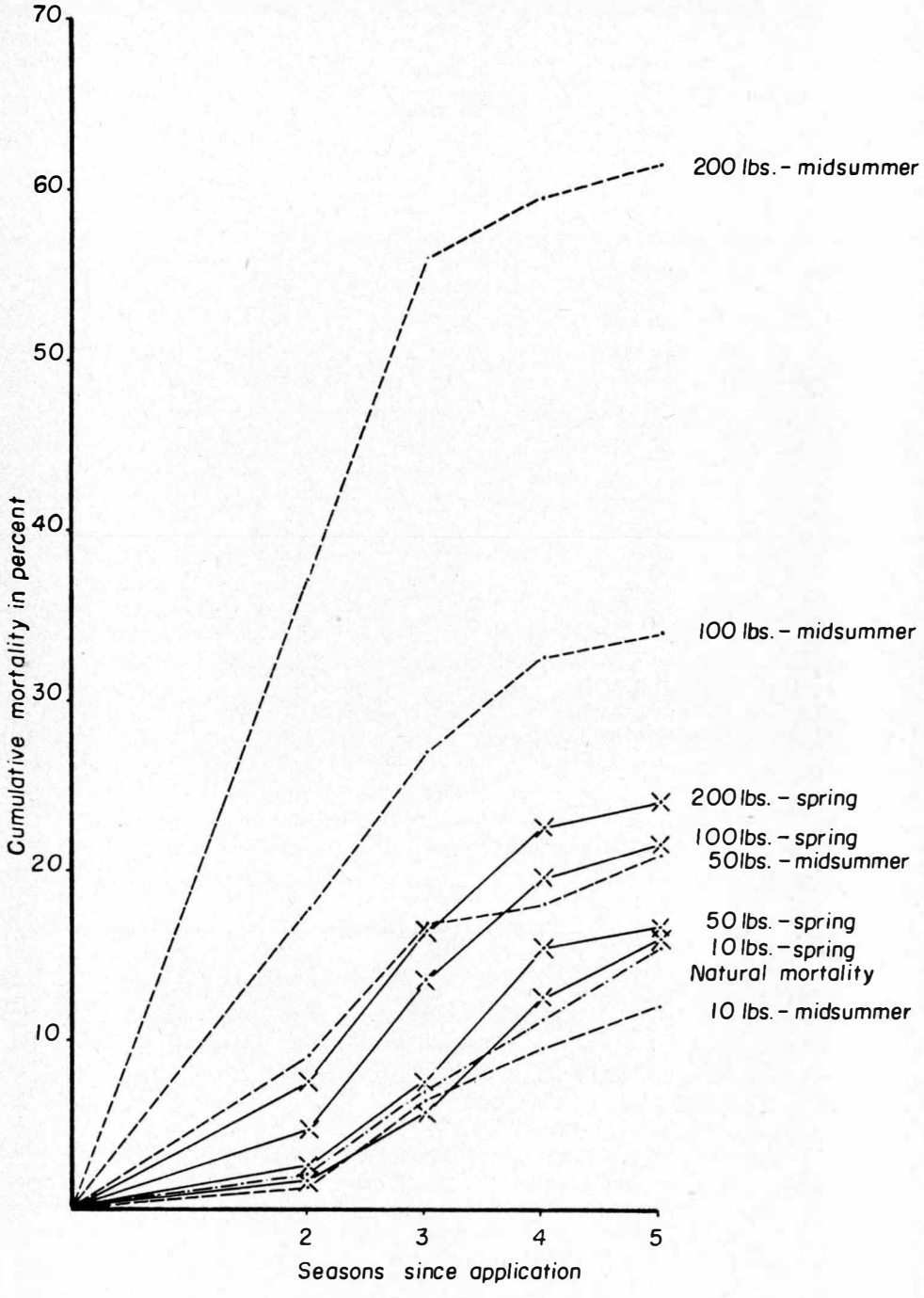

FIGURE 4. Lethal effect of varying per acre concentrations of ammate in a water carrier on lodegpole pine.

Herbicide per acre	Diesel fuel per acre	+ Water per acre	Total carrier per acre
1 gal.	100 gal.	none	100 gal.
1	25	75 gal.	100
1	12	38	50
2	100	—	100
2	25	75	100
2	12	38	50

Applications of these 18 treatments were made in midsummer of 1952 on replicated milacre quadrats in a 16-year-old stand of waist-high, stagnating lodgepole pine, using the same spraying equipment as specified for the second series. Stand densities throughout the third series of tests were not as great as in the first two, nor was the amount of spruce understory as great[5]. Some quadrats unfortunately contained no spruce at all. Mortality tallied in the autumn in 1953 and 1954 provides data on the effect of treatment three seasons after application.

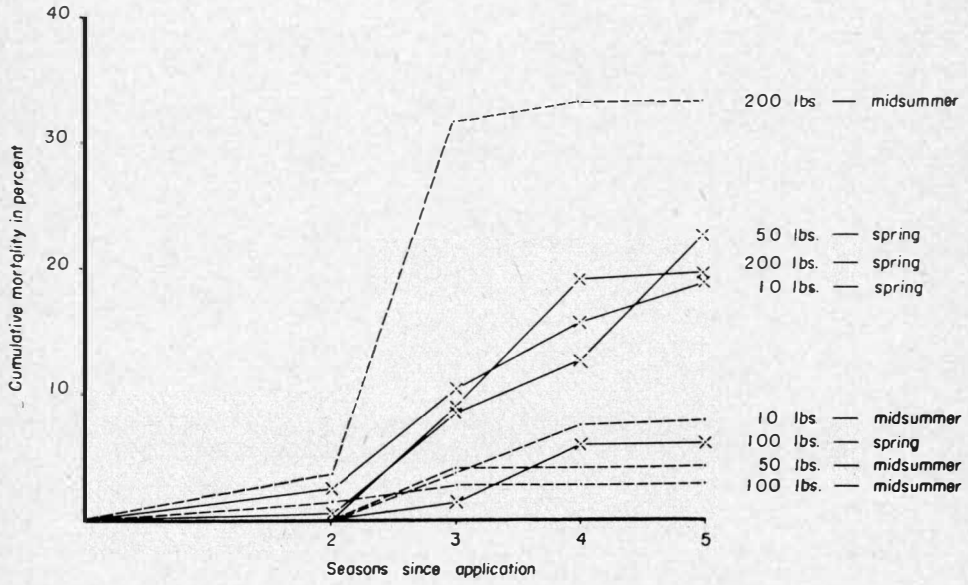

FIGURE 5. Lethal effect of varying per acre concentrations of ammate on a water carrier on an understory of white spruce in a lodgepole pine stand.

Results (third series)

The results are presented in Tables 3, 4 and 5. The treatment numbers assigned refer to similar formulations and dosages of each of the three herbicides.

[5]The average density of the stand was 110,760 stems per acre, 94 per cent of which were pine, 0·5 per cent spruce, 5 per cent poplar, and the remainder alpine fir and birch.

TABLE 3. CUMULATIVE THINNING EFFECT OF 2, 4-D ON A DENSE, YOUNG LODGEPOLE PINE STAND THREE SEASONS AFTER APPLICATION

Treatment Number	Per acre dosages			Original stem tally per milacre	Per cent mortality	
	2, 4-D	+ Diesel Fuel	+ Water		lP	weS
1	1 gal.	100 gal.	none	140	91[1]	—
2	1	25	75 gal.	101	53	—
3	1	12	38	94	12	0
4	2	100	none	81	93	—
5	2	25	75	94	96	0
6	2	12	38	92	49	0
7	controls			128	7	0

[1] Referring to Table 1, it will be noted that this same treatment applied in midsummer in Series Two resulted in 59 per cent mortality.

TABLE 4. CUMULATIVE THINNING EFFECT OF 2, 4, 5-T ON A DENSE, YOUNG LODGEPOLE PINE STAND THREE SEASONS AFTER APPLICATION

Treatment Number	Per acre dosages			Original stem tally per milacre	Per cent mortality	
	2, 4, 5-T	+Diesel Fuel	+ Water		lP	weS
1	1 gal.	100 gal.	none	91	64	—
2	1	25	75 gal.	106	52	—
3	1	12	38	74	28	—
4	2	100	none	108	86	0
5	2	25	75	125	65	50
6	2	12	38	116	61	0
7	Controls			128	7	0

TABLE 5. CUMULATIVE THINNING EFFECT OF BRUSHKILLER ON A DENSE, YOUNG LODGEPOLE PINE STAND THREE SEASONS AFTER APPLICATION

Treatment Number	Per acre dosages			Original stem tally per milacre	Per cent mortality	
	Brushkiller	+ Diesel Fuel	+ Water		lP	weS
1	1 gal.	100 gal.	none	145	89	0
2	1	25	75 gal.	111	52	0
3	1	12	38	119	49	0
4	2	100	none	140	98	68
5	2	25	75	138	88	100
6	2	12	38	125	64	33
7	controls			128	7	0

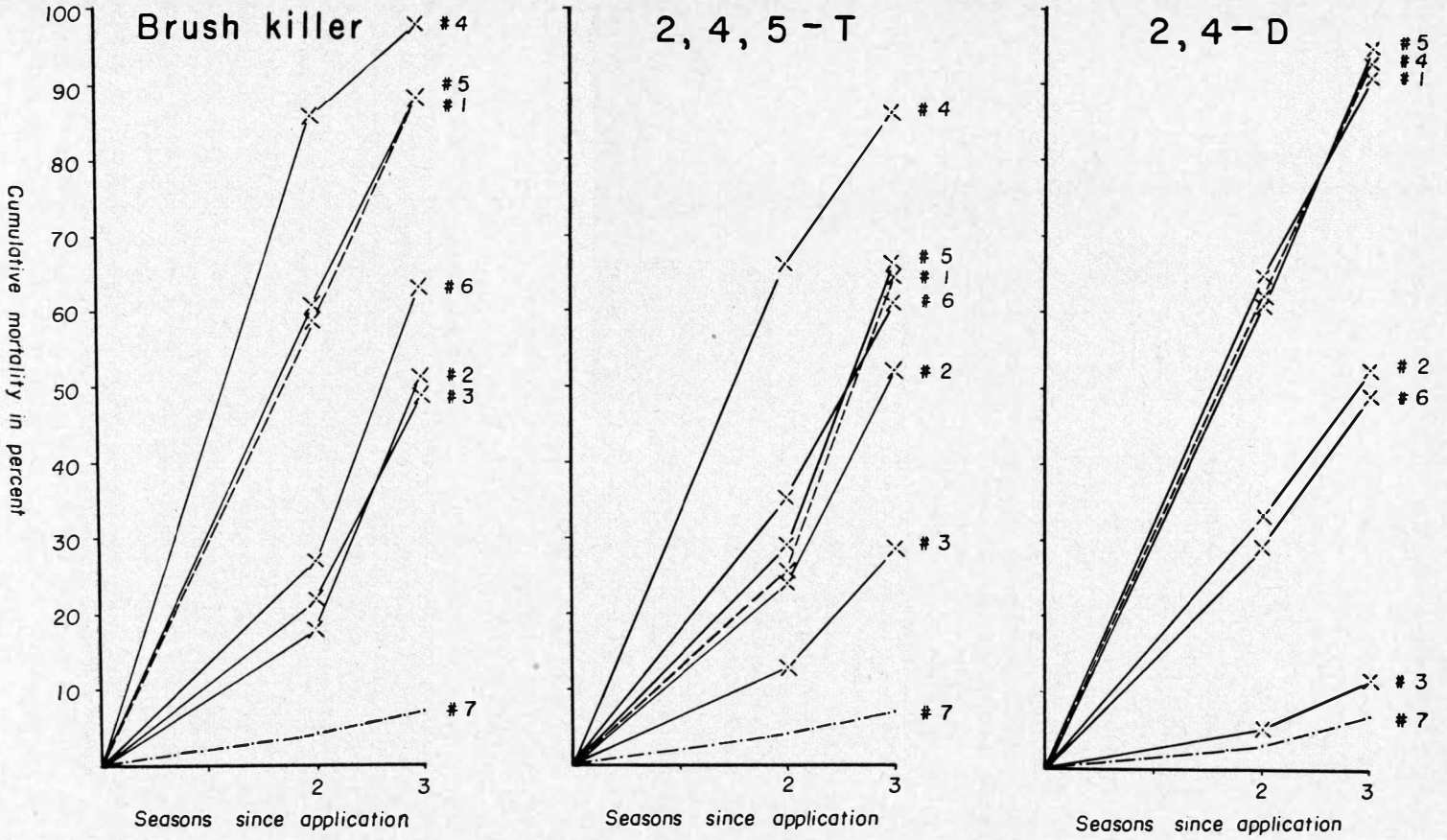

FIGURE 6. Lethal effect of 2, 4-D, 2, 4, 5-T, and Brushkiller on lodgepole pine. Numbers correspond to treatment numbers in Tables 3, 4 and 5.

In order to present the rate of mortality, the data from each of the three herbicide treatments are graphically portrayed in Figure 6. The numbered curves refer to the treatment number as presented in Tables 3, 4 and 5. There is the suggestion when comparing these graphs with those presented in Figure 2, that mortality due to treatment is not yet[6] complete, and an additional small percentage of survivors will drop out over the next two years or more. In this connection it is of interest to note that when mortality due to treatment is high the survivors do not escape the effects unscathed. Such individuals usually go through a year or two following treatment in a rather moribund condition. The herbicide usually kills all buds, many of the needles die and drop off, and twigs and branches may wither. The tree then usually stays in what appears to be a dormant condition throughout the following growing season, forcing adventitious buds during the spring of the succeeding year. The effect is as illustrated in Plate 2.

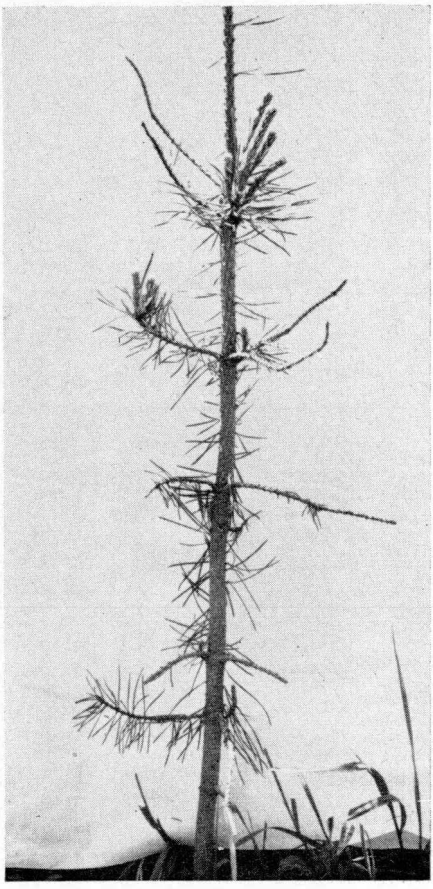

PLATE 2. Adventitious budding of a lodgepole pine that has survived the effect of herbicide treatment.

DISCUSSION AND CONCLUSIONS

From the third series it is apparent that all three herbicides tested have proved to be sufficiently lethal to effectively reduce the density of young stagnating lodgepole pine stands. From the many formulations and dosages tested a variety of choice is offered depending upon the limitations imposed. Such limitations include the percentage kill sought, the cost per acre, feasible spray volumes to apply per acre, and so on. Nothing is offered on the cost of the physical application of the spray per acre since such information is not yet available, but from the very nature of dense lodgepole pine stands which usually contain vast quantities of down-timber resulting from the burn from which the reproduction stand originated, it seems obvious that the only feasible method of spray application is from the air.

An idea of the cost of the spray itself, and this does not include its cost of application either from the ground or the air, can be provided by listing the price of ingredients F.O.B. Calgary, Alberta. This information is presented in Table 6. Prices are for 5-gallon drums of the herbicide, F.O.B. Calgary, in minimum quantities of 20 Imperial gallons. Prices would be approximately 4 per cent less than those listed if orders were placed in 45-gallon drums. Pine mortality listed is at the conclusion of the third year following application.

An efficiency rating is assigned to each treatment listed in Table 6 in an attempt to evaluate the results by relating the per cent mortality of lodgepole pine with the per acre cost. This was obtained by dividing the mortality by

[6] April 1955.

TABLE 6. LETHAL EFFICIENCY AND COSTS PER ACRE OF HERBICIDE APPLICATIONS

Treatment Numbers	2, 4-D	2, 4, 5-T	Brush-killer	Diesel fuel	Total	1P mort.	Efficiency rating
	($)	($)	($)	($)	($)	(per cent)	
1	3.55	—	—	15.20	18.75	91	4·9
	—	11.60	—	15.20	26.80	64	2·4
	—	—	8.50	15.20	23.70	89	3·8
2	3.55	—	—	3.80	7.35	53	7·2
	—	11.60	—	3.80	15.40	52	3·4
	—	—	8.50	3.80	12.30	52	4·2
3	3.55	—	—	1.82	5.37	12	2·2
	—	11.60	—	1.82	13.42	28	2·1
	—	—	8.50	1.82	10.32	49	4·7
4	7.10	—	—	15.20	22.30	93	4·2
	—	23.20	—	15.20	38.40	86	2·2
	—	—	17.00	15.20	32.20	98	3·0
5	7.10	—	—	3·80	10.90	96	8·8
	—	23.20	—	3.80	27.00	65	2·4
	—	—	17.00	3.80	20.80	88	4·2
6	7.10	—	—	1.82	8.82	49	5·5
	—	23.20	—	1.82	25.02	61	2·4
	—	—	17.00	1.82	18.82	64	3·4

the cost per acre; the figure arrived at in each case represents the per cent mortality obtained for each dollar spent on the chemical spray. Such a rating must be used with caution because low mortality arising from a light and therefore a cheap spray could result in a fairly high efficiency rating. It is suggested that in stands of extreme density, lethal figures of at least 90 per cent must be obtained to effect release from stagnation, and if one confines oneself to the efficiency ratings applicable to this level or above then it is quite easy to decide on the optimum formulation and dosage to use. The highest rating of 8.8 resulted in a very acceptable reduction in density; for an expenditure of $10.90 per acre for spray, a pine mortality figure of 96 per cent was obtained.

It will be recalled that the three series of tests were conducted in stands that had already reached waist height. It would appear logical, when contemplating such methods of thinning in future stands, to treat them as soon as it is evident that regeneration is superabundant. In that event treatment could take place sometime before the stands reached knee height, and it appears probable that the dosages could then be substantially reduced without loss of lethal power.

SUMMARY

Experiments with some chemicals as lethal agents in reducing the density of young, overdense, stagnating lodge pole pine stands suggest the feasibility of such a method of thinning.

Ammonium sulphamate reduced densities as much as 68 per cent over a five-year period. While there is the suggestion that a further small increase in mortality may be expected in the next year or two it is not likely that the density of the stands will be reduced sufficiently to effect release.

The herbicides 2, 4-D, 2, 4, 5-T, and Brushkiller, were the most promising, and lodgepole pine mortalities of 90 per cent or better were frequently reached over a three- to five-year period following treatment. At the same time mortality among the white spruce in the understory was quite light.

The most effective and efficient spray formulation investigated proved to be a per acre dosage of 2 gallons of 2, 4-D in an oil-water emulsion consisting of 25 gallons of diesel fuel and 75 gallons of water. At the conclusion of the third year following treatment, 96 per cent of the pine had succumbed. The remaining 4 per cent have been set back but now appear healthy and will undoubtedly survive.

The second most efficient formulation was a per acre dosage of 1 gallon of 2, 4-D in 100 gallons of diesel fuel. At the conclusion of the third year following treatment, 91 per cent of the pine were dead.

Differences in mortality due to date of application, i.e. spring vs. midsummer, were noted. In the case of ammate and water dosages, midsummer application noticeably increased mortality; in the 2, 4-D diesel fuel treatments, spring applications produced slightly greater mortality than did midsummer spraying. However, at acceptable mortality levels these differences were of little practical importance.

Throughout the three series of tests, mortality of white spruce was considerably lighter than in the pine. This suggests that wherever spruce is present in dense pine stands herbicide treatments may result in mixedwood stands of pine and spruce, or even spruce and pine.

REFERENCE

CROSSLEY, D.I. 1950. Chemical thinning of young stagnating lodgepole pine stands. Canada, Dept. of Resources and Development, Forestry Branch, For. Res. Div. Silv. Leaflet No. 42.

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1956