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A COMPARISON OF METHODS OF DIRECT SEEDING ON MOUNTAIN LITHOSOLS

by

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by

R.F. Ackerman[1]

INTRODUCTION

Mountain lithosols occupy extensive areas in the Subalpine Region of the Rocky Mountains. They are, by definition, shallow, stony soils, skeletal in nature due to the large amount of contained rock. They occur most frequently on steep slopes where erosion is active, removing the products of weathering about as fast as they are formed (Lutz and Chandler, 1947). With perhaps the exception of the driest of aspects, these soils can support forest stands in Alberta, particularly where the underlying rock is broken or fractured, permitting penetration of tree roots.

Forest cover is considered necessary on these areas to limit watershed erosion and maintain optimum stream flow. At present the greatest agent of denudation is fire. Although the fire-type lodgepole pine normally regenerates abundantly immediately after burning, the danger lies in a second fire occurring before the re-established stand can produce seed in sufficient quantities to regenerate the area a second time. This occurrence is not rare and calls for artificial regeneration.

Due to the amount of rock in lithosols, planting with hand tools is tedious and costly and in many cases impractical. An alternative method is direct seeding. Seeding has not received much acclaim in this country as a method of reforestation. Results in general have been poor and the practice has been largely abandoned in favour of planting. Schopmeyer and Helmers (1947) point out however, that seeding in the Northern Rocky Mountains has never been adequately tested and failure in most cases can be attributed to extremely dry sites or to loss of seeds to birds and rodents. Roe and Boe (1952) reported success in seedspotting lodgepole pine on freshly cut and burned land in Montana. In these tests success was attributed to control of the rodent population by poisoning and favourable moisture conditions. The cost of seedspotting was considerably less than planting, primarily due to the savings realized by the use of seed at $2.16 per acre, rather than the use of nursery-propagated planting stock. These experiments indicate that, under conditions similar to those in the Subalpine Region of Alberta, success can be expected if loss of seed to birds and rodents can be overcome, particularly on sites where moisture conditions are favourable.

The experiments with direct seeding described in this report were initiated by D.I. Crossley[2] to develop successful methods of reforestation on difficult lithosol sites. There are two separate investigations, the first initiated in 1948, the second in 1955. The latter study was undertaken to investigate and confirm, by a stronger statistical design, several promising methods indicated by the preliminary results of the initial investigation.

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DESCRIPTION OF THE AREA

The experiments were conducted on the Kananaskis Forest Experiment Station (51° 0' N., 115° 10' W.), on the east slope of the Rocky Mountains. The experimental site is located on the Mount Kidd Bench (elevation 5,000 feet) immediately above and west of the Kananaskis River (Plate 1).

The forest cover on the bench was completely destroyed by fire in 1920. Lodgepole pine established itself following the fire, only to be completely consumed before reaching seed-producing age, by a second severe fire in 1936. The area did not regenerate a second time and is now barren of any significant forest growth.

The site of these experiments is highly unfavourable to regeneration. The area is constantly subjected to the desiccating effect of the prevailing winds of the valley. In addition, the soil is shallow and rocky with limited capacity for water storage, and surface run-off is rapid. There is little organic material and the minor vegetation is light, consisting chiefly of grass, with rose shrubs, shepherdia and amelanchier (Plate 2).

EXPERIMENT 1

TREATMENTS

Of the many factors that may influence the success of seeding, the following were chosen for study:

1. Species - Lodgepole pine - *Pinus contorta* Dougl. var. *latifolia* Engelm.
   - White spruce - *Picea glauca* (Moench) Voss var. *albertiana* (S. Brown) Sarg.
   - Douglas fir - *Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco
2. Slope and aspect
3. Seedbed treatment
4. Season of sowing; spring vs. fall
5. Method of sowing; broadcast vs. spot seeding
6. Rodent damage to seed

All species and treatments were tested on each of three aspects; N 57° E, sloping 10-20°; level; and S 50° W, sloping 10-18°.

In selecting the actual seedspot within a treatment unit, care was taken to pick the most promising location. Usually this amounted to choosing a depression comparatively free of surface stones and with some marginal vegetative protection. In most cases the choice was very limited. Following selection of the seedspot the seedbed was treated in one of the following ways.

(a) Vegetation not removed.

(b) Vegetation not removed, soil cultivated to a depth of four inches.

(c) Vegetation removed in a circular area 12 inches in diameter.

(d) Vegetation removed, soil cultivated to a depth of four inches.

(e) Surface stones removed in a circular area 12 inches in diameter.

(f) Surface stones removed, soil cultivated to a depth of four inches.

Rather than throw the stones away whenever the seedbed treatment called for their removal, they were stacked on the SW. side of the seed spot, the direction of the prevailing winds. In this manner a degree of protection was provided on a site that is severely exposed.

Approximately 20 seeds, of local origin, were sown on each spot. Autumn seeding was completed between September 18th and 20th, 1948 and spring seeding on May 10th and 11th, 1949. The seed of all three species sown in the spring was stratified in moist sawdust at 35° F. for six weeks prior to sowing.

Broadcast seeding placed the seed on the selected spot without any soil covering. Spot seeding permitted a light covering of soil, 1/8 inch for spruce and pine, 1/4 inch for Douglas fir. Depth gauges were employed to insure a uniform depth of covering.

To investigate the rodent population, mouse traps were set on August 18th, 1948, at 50-foot intervals in a brushy area. The traps were examined twice a day for a period of 11 days. During this period 12 mice (two Microtus sp. and ten Peromyscus sp.) and one chipmunk were caught. As a result, seed protection, in the form of ¼ mesh wire cages, was adopted for one half of the seed spots. The lower edge of each cage was forced into the ground, and those used in the fall seeding operation were weighted with stones. The stones were removed at the time of the spring seeding. All cages were left in position during the first season (1949).

Plates 3 to 6 illustrate the preparation, seeding and protection of a seed spot.

EXPERIMENTAL DESIGN

The six types of seedbed treatment, three species, and season and method of sowing necessitated 72 treatment combinations on each aspect. One block, 160 × 180 links, was selected on each aspect, divided into four plots of equal size for replication of treatment, then subdivided into 288 milacre quadrats. The various treatment combinations were then applied randomly to the 72 quadrats in each plot, resulting in four replications of each treatment combination on each of the three aspects.

RESULTS

Germination and Survival (General)

During the first season following establishment (1949), germination and mortality were recorded each week. During the second season (1950) mortality was recorded in the spring and fall. In addition the height of the tallest seedling on each stocked spot was also recorded in the fall. Thereafter mortality and heights were recorded in the fall of each year up to and including the fall of 1955.

In 1949, germination commenced on May 13th, and reached its maximum rate during the first week of June (Fig. 1). A second minor surge in germination occurred during the first week of July. By the middle of July, 95 per cent of the total germination had occurred and by the second week of August initial germination was complete. Delayed germination occurring the following season (1950) accounted for a comparatively small portion (4 per cent) of the total.

There were two mortality maxima, the first during the second and third weeks of June and the second during the second week of July (Fig. 1). The mortality maxima both occurred during the week or two following the two surges in germination and reflect the extreme vulnerability of seedlings during the first few days after germination. Mortality was augmented during these periods by unfavourable weather conditions. On the 15th and 16th of June snow fell continuously with sufficient frost to crust it lightly. Following the snow many seedlings succumbed, particularly those that had germinated the previous week. Mortality was heavier among the spruce and pine than the fir. While no meteorological data were collected, the first part of July was considered to be one of the hottest and driest periods experienced during the summer. These conditions, following shortly after a period of germination, probably account for the surge in mortality during July.

The trend of mortality for all species over the entire study period is illustrated by year and aspect in Figure 2. The zero ordinate in this graph represents total 1949 germination. It is immediately apparent that the mortality has followed much the same pattern on all aspects. The greatest loss of seedlings occurred during the season of germination and the first and second year following. After this initial period of decimation, mortality continued but at a diminishing rate. By 1955 the majority of the seedlings remaining could be considered established.

Much of the mortality during the second year could be attributed to soil-heaving. At this time the type of soil treatment appeared to have little bearing on the severity of heaving. Frost-heaving was again observed during the third season but was notably less severe on those spots retaining vegetative cover. Very few seedlings were lost as a result of heaving during the third season, their root systems apparently being developed sufficiently to anchor them firmly.

Rodent Control

Caging of the seed spots to prevent loss to birds and rodents showed marked results for all species (Table 1). Seed protection is therefore considered an absolute necessity if regeneration success is to be realized.

Table 1

Comparative Results of Germination During the First Season

	Broadcast Seeding				Spot Seeding			
	Caged		Not Caged		Caged		Not Caged	
	No./Spot*	% Stocking**	No./Spot	% Stocking	No./Spot	% Stocking	No./Spot	% Stocking
Lodgepole pine	2.9	55.2	0.0	1.8	2.7	73.9	0.4	24.0
White spruce	1.0	27.1	0.1	6.2	1.6	35.8	0.2	12.7
Douglas fir	2.9	68.3	0.1	4.8	4.0	73.6	0.3	26.7
All species	2.4	52.3	0.1	4.6	2.8	60.8	0.3	21.0

*Number of seedlings per spot is the total number of seedlings divided by the total number of seed spots.

**Per cent stocking is the per cent of spots stocked to one or more seedlings in relation to the total number of seed spots.

The data presented in Table 1 further suggest that seed-spotting also reduced the loss of seed to rodents and at the same time slightly improved conditions for germination.

Observations made in the early spring of 1949 indicate little or no seed loss from the fall-sown seed, either broadcast or spot sown. This suggests that the loss was heaviest during the spring season after the disappearance of the snow.

Species

The results by species, presented in Table 2, show that Douglas fir was superior in initial germination, per cent survival, and per cent stocking in 1955.

Table 2

Germination and Survival by Species; All Caged Spots

Species	Average No. of Germinants per Spot	% Survival 1955	% Stocking 1955	Height of Tallest Seedling per Stocked Spot 1955
Lodgepole pine	2.9	17.0	17.3	4.8"
White spruce	1.4	1.7	1.6	1.9"
Douglas fir	3.7	26.4	34.0	3.1"

During the first season (1949) it was noted that the Douglas fir seedlings were generally more vigorous than the pine or spruce. By the third year, however, it was quite obvious that the pine seedlings were superior in this respect. This trend has continued and is reflected in Table 2 by the superior average height of the pine seedlings in 1955.

Although delayed germination contributed little to the total, it is interesting to note that 50 per cent of the seedlings resulting from delayed germination were Douglas fir, 46 per cent were pine and four per cent were spruce.

Aspect

The influence of aspect on germination and survival is shown by Table 3. Total germination of lodgepole pine bore little relationship to aspect. Per cent survival and subsequent per cent stocking, however, indicate that the most favourable conditions occurred on the NE. slope.

Per cent survival and stocking of white spruce have been so low in all cases as to be of little use in assessing the influence of aspect. Total germination of this species, however, was also favoured by the NE. aspect.

The superiority of the NE. aspect is further confirmed by Douglas fir. Germination, per cent survival and per cent stocking of this species were highest on the NE. slope. Conditions on the level proved to be more favourable than on the SW. slope.

Table 3

Germination and Survival by Species and Aspect; Caged Spots

Lodgepole Pine	NE. Aspect	Level	SW. Aspect
No. of germinants per spot	2.8	2.9	3.0
% Survival 1955	19.2	16.0	15.9
% Stocking 1955	21.2	15.4	11.5
White Spruce			
No. of germinants per spot	2.1	1.4	0.5
% Survival 1955	1.1	3.2	0.0
% Stocking 1955	2.3	2.3	0.0
Douglas Fir			
No. of germinants per spot	5.0	3.4	2.7
% Survival 1955	35.7	19.4	18.2
% Stocking 1955	51.0	32.7	18.4

Season of Sowing

The data presented in Table 4 indicate that, with the exception of spot-sown Douglas fir, better germination followed fall seeding.

Table 4

Total Germination by Species, Method of Sowing and Season of Sowing; Caged Spots

	Broadcast Sown		Spot Sown	
	Fall	Spring	Fall	Spring
Lodgepole Pine				
No. of Germinants per spot	4.8	0.2	3.7	2.2
White Spruce				
No. of Germinants per spot	1.9	0.3	2.3	1.0
Douglas Fir				
No. of Germinants per spot	3.1	2.6	3.2	5.7

Method of Sowing

The best method of sowing varied with the species and the season of sowing (Table 4). Broadcast sowing proved best for lodgepole pine if seed was fall-sown and spot seeding when seed was spring-sown. The best germination followed fall broadcast seeding.

The spot seeding of white spruce resulted in better germination whether spring or fall-sown. The difference in the results from fall spot and fall broadcast seeding, however, was negligible. The best germination for this species followed fall spot seeding.

As with white spruce, Douglas fir germinated best following spot seeding regardless of season of sowing. Again the difference in results between fall spot and fall broadcast is slight and probably not significant. The best germination for this species occurred following spring spot seeding.

Seedbed Treatment

The data illustrating the influence of seedbed treatment, (Table 5), suggest that seedbed treatment is beneficial to germination, but it is quite obvious that the degree of effectiveness varies with the treatment and the species.

Table 5

Effect of Seedbed Treatment on Germination and Survival; Caged Spots

	Vegetation Removed						Vegetation Not Removed						Stones Removed					
	Soil Cultivated			Soil Not Cultivated			Soil Cultivated			Soil Not Cultivated			Soil Cultivated			Soil Not Cultivated		
Species	No. Germ.	Srvl. 1955 (%)	Stk. 1955 (%)	No. Germ.	Srvl. 1955 (%)	Stk. 1955 (%)	No. Germ.	Srvl. 1955 (%)	Stk. 1955 (%)	No. Germ.	Srvl. 1955 (%)	Stk. 1955 (%)	No. Germ.	Srvl. 1955 (%)	Stk. 1955 (%)	No. Germ.	Srvl. 1955 (%)	Stk. 1955 (%)
Lodgepole pine	2.7	9.6	14.8	1.6	30.8	9.1	5.5	18.8	41.7	2.2	4.3	9.5	2.7	4.7	12.5	3.0	30.0	18.5
White spruce	1.2	0.0	0.0	1.2	4.0	4.8	0.8	0.0	0.0	0.7	0.0	0.0	4.6	0.0	0.0	1.0	7.2	3.7
Douglas fir	4.4	28.6	41.7	2.2	31.7	29.6	3.5	35.1	42.9	2.4	35.9	33.3	6.2	15.5	37.5	3.8	24.4	16.7

The best germination and subsequent stocking for lodgepole pine followed soil cultivation, without vegetation or stone removal. Removal of the vegetation does not appear to be beneficial on this site. There is a suggestion of benefit derived as a result of stone removal but the data are not conclusive.

Although survival of white spruce seedlings has been extremely low in all cases, initial germination suggests that all three treatments have been of benefit. The performance of Douglas fir suggests little or no benefit from vegetation removal. However, both soil cultivation and stone removal improved germination. Although soil cultivation appears to have improved germination, and thereby stocking per cent, per cent survival has been higher, in most cases, where the soil has not been cultivated.

SUMMARY OF RESULTS - EXPERIMENT 1

The results of Experiment 1 prompt the following conclusions.

1. Regardless of species, seed protection to prevent loss from birds and rodents is essential.
2. White spruce is not recommended for regenerating these difficult sites. Initial germination and subsequent per cent stocking was best with Douglas fir but the better vigour of lodgepole pine suggests that this species might eventually be the most satisfactory.
3. The most favourable conditions were found on the northeast aspect and on the southwest aspect the most severe.
4. With one exception, fall sowing gave the best results for all three species. The exception, spot seeded Douglas fir germinated best when spring sown.
5. The best method of sowing varied with the species and season of sowing. For lodgepole pine broadcast seeding proved most favourable when seed was fall sown and spot seeding proved best when seed was spring sown. The best pine germination and subsequent stocking followed fall broadcast seeding. Spot seeding resulted in the best germination for both white spruce and Douglas fir, whether spring or fall sown. However, fall spot seeding was favoured by white spruce while spring spot seeding gave the best results with Douglas fir.
6. The influence of seedbed treatment varied with the species and the type of treatment. Removal of the vegetation was of possible benefit to white spruce only, while soil cultivation improved the germination and subsequent stocking of all three species. Stone removal was beneficial to the germination of both white spruce and Douglas fir but did not prove to be of definite value to lodgepole pine.

EXPERIMENT 2

TREATMENTS

The preliminary results of Experiment 1 indicated several promising methods of seeding lodgepole pine and Douglas fir. Experiment 2 was initiated in 1952 to obtain further data based on a stronger statistical design.

The site of Experiment 2 is adjacent to that of Experiment 1 and is similar in all respects. Only the level aspect was included in Experiment 2, however, since preliminary results of Experiment 1 indicated no major difference in results could be attributed to aspect.

In view of the results of Experiment 1, all seed spots were caged to prevent loss to birds and rodents.

The variables chosen for study were:-

1. Species: Douglas fir and lodgepole pine
2. Fall vs. spring sowing
3. Broadcast vs. spot seeding
4. Seedbed treatment which included the following:

    A. Vegetation removed, stones removed, soil cultivated.
    B. Vegetation removed, stones removed, soil not cultivated.
    C. Vegetation removed, stones not removed, soil cultivated.
    D. Vegetation removed, stones not removed, soil not cultivated.
    E. Vegetation not removed, stones not removed, soil cultivated.
    F. Vegetation not removed, stones not removed, soil not cultivated. (control)
    G. Vegetation not removed, stones removed, soil cultivated.
    H. Vegetation not removed, stones removed, soil not cultivated.

Fall seeding was completed in September of 1952 and spring seeding in 1953. Fifteen apparently full seed were sown on each spot. Cutting tests indicated 93 per cent viability for lodgepole pine and 75 per cent viability for Douglas fir. All seed sown in the spring received a two-week cold soaking treatment prior to sowing.

EXPERIMENTAL DESIGN

Treatments were randomly applied in a split plot technique to three replicate blocks, each of which was divided into the appropriate number of quadrats. These quadrats were the ultimate treatment units (Figure 3).

RESULTS

Germination, mortality and heights were recorded once each season during 1953, 1954 and 1955.

In July of 1953, only 28 Douglas fir seedlings were found on the 96 seedspots as compared to 594 lodgepole pine. By July of 1955, eight Douglas fir and 236 pine were still surviving. For this reason species has not been considered as a variable in the analysis and all subsequent data pertain to lodgepole pine. The analysis of variance for the number of lodgepole pine seedlings alive in 1955 is shown in Table 6.

Table 6

Analysis of Variance of the Number of Seedlings Alive in 1955

Source	D.F.	Σ.S.	M.S.	F.	Sig.
Blocks	2	40.08	20.04	3.47	N.S.
Seedbed Treatment	7	80.33	11.48	1.99	N.S.
Error A	14	80.92	5.78		
Season	1	7.04	7.04	1.12	N.S.
Season x Seedbed Treatment	7	47.79	6.83	1.09	N.S.
Error B	16	100.67	6.29		
Method	1	126.04	126.04	45.01	H.S. (1%)
Method x Seedbed Treatment	7	36.79	5.26	1.88	N.S.
Method x Season	1	20.17	20.17	7.20	S. (5%)
Method x Seedbed Treatment x Season	7	44.34	6.33	2.26	N.S.
Error C	32	89.66	2.80		
Total	95	673.83			

The total number of seedlings alive in 1955, by seedbed treatment, season, and method of sowing, is shown in Table 7.

Table 7

Total Number of Lodgepole Pine Seedlings Alive in 1955 by Seedbed Treatment, Season, and Method of Sowing

		Seedbed Treatment							
		A	B	C	D	E	F	G	H
Broadcast Sown	Spring	19	11	23	7	13	8	6	4
	Fall	15	12	6	6	19	7	7	10
Spot Sown	Spring	3	4	1	1	--	2	3	--
	Fall	15	1	5	7	7	2	3	9
Total		52	28	35	21	39	19	19	23

Seedbed Treatment

The influence of the individual seedbed treatments is summarized in the subtotals presented below.

Vegetation Removed (A, B, C, & D)	Vegetation Not Removed (E, F, G & H)
136	100
Stones Removed (A, B, G & H)	**Stones Not Removed (C, D, E & F)**
122	114
Soil Cultivated (A, C, E & G)	**Soil Not Cultivated (B, D, F & H)**
145	91

Differences due to seedbed treatment were not significant statistically but, as in Experiment 1, the results are suggestive of a beneficial effect, particularly following soil cultivation, with lodgepole pine.

Season and Method of Sowing

Subtotals derived from the basic data of Table 7 summarize the effect of season and method of sowing (Table 8).

Table 8

Number of Lodgepole Pine Seedlings Alive in 1955

	Spring Sown	Fall Sown	Totals
Broadcast	91	82	173
Spot	14	49	63
Totals	105	131	236

Statistically, these data indicate that the level of influence of season of sowing is dependent upon the method of sowing. Apparently fall sowing is beneficial only if the seed is spot-sown. If the seed is broadcast, season of sowing is of little importance.

Although the converse is true with regard to method, broadcast sowing proved to be better than spot sowing regardless of season of sowing. The difference is of marked importance following spring seeding.

DISCUSSION

In comparing the results of the two experiments it must be remembered that Experiment 1 is not readily adaptable to statistical analysis, and as a result, the interactions between variables cannot be readily recognized. Also, the two experiments were initiated in different years and probably register the influence of different climatic conditions. Where inconsistencies occur between results, the better design of the second experiment has been considered in assessing results.

The performance of Douglas fir is puzzling. In Experiment 1 this species compared favourably with lodgepole pine in all measures except vigour. In Experiment 2 Douglas fir must be considered a failure. The only apparent explanation is a difference between weather conditions of the initial years of the two experiments. However, the use of Douglas fir on these severe sites cannot be recommended until considerably more information is available on the site requirements of this species in Alberta.

The site of these experiments is exposed and very dry and any treatment that increases the amount of available moisture will probably improve germination and survival.

The reaction of lodgepole pine to seedbed treatment was similar in both experiments in that soil cultivation proved to be of most value. Although germination and thereby per cent of stocking was improved, there is some indication that per cent survival may have suffered as a result of this treatment. The increase in germination may be attributed to better contact of the seed and seedling with the mineral soil during the critical spring germination period. The breaking and loosening of the soil, however, might have resulted in more rapid drying of the rooting medium during the hot dry periods of late spring and summer and thereby lessened the chances of survival. It is possible that scalping, without cultivation, might have been of equal or more value on this site.

The vegetation is not luxurious, and although a source of competition for the available moisture, it may provide some shelter for the young seedlings. In addition, frost-heaving was noted to be less severe on those spots retaining vegetative cover.

In so far as fall broadcast sowing gave the best results, the two experiments are in accord with respect to method and season of sowing. Although further comparisons are difficult due to interactions, the most glaring inconsistency is the very poor results following the spring broadcast sowing of Experiment 1. This combination proved among the best of Experiment 2. Again, these conflicting results may be due to different weather conditions. Until further information is available in this regard, fall seeding is recommended.

In considering the applicability of these findings it must be borne in mind that the experimental design does not lend itself to comparisons of the degree of success that may be expected from any practical application involving a combination of the experimental treatments. Also, the lithosols involved in the experiment are of little or no commercial interest from the standpoint of wood production and the justification for their reforestation lies in the need for water management. If in the future it is necessary to restock such areas for water management purposes a practical and cheap method must be employed. The results of this experiment indicate that a method incorporating the following features will give a reasonable degree of success:

1. Lodgepole pine by virtue of its adaptability to the site and the ease of seed collection is the most acceptable species for conditions in Alberta.

2. Protection of seed from rodent predation is essential. The most practical method will be to coat the seed with a durable poisonous coat, coloured to minimize the destruction of birds.

3. Seeding should take place in the fall.

4. Seedbed preparation is required. Where possible, mechanical equipment should be employed. A light tracked vehicle with a scraper blade should be employed to scalp a mineral soil seedbed which is distributed in patches over the area. This can best be accomplished by alternately lifting and dropping the blade. Provision should be made for releasing the seed mechanically on the scalped spots from a bin carried on the tractor. Pelleted seed should be released at a rate of 10,000 per acre. In the event that mechanical equipment cannot be employed because of the difficulty of terrain, the alternative would be hand-scalped spots prepared with a grub hoe and hand seeded. The individual spots should be not less than one foot square and should be established at a rate of 1,000 per acre or at roughly 6 1/2-foot spacings.

Although further research on the problem of artificially restocking areas by seeding is required, the experimental work should preferably be carried out first on the more productive sites and the findings should then be extended to the less important and unproductive stony sites. Future investigation should consider:-

(1) The testing of pelleting methods and the prevention of rodent predation on seed.

(2) The testing of other species, notably ponderosa pine and Douglas fir.

(3) The effects of seasonal variation in climate upon survival.

(4) The testing of various mechanical methods of seed-bed preparation.

(5) The development of suitable mechanical seeding equipment and its incorporation into the seedbed preparation equipment.

(6) Cost studies of the various methods which may be developed.

SUMMARY AND CONCLUSIONS

In 1948, investigations were initiated at the Kananaskis Forest Experiment Station, to develop successful methods of re-storing forest cover to denuded mountain lithosols. Due to the rocky nature of mountain lithosols and the resultant obstacles to planting, direct seeding was selected as the most practical method.

The variables investigated and the results obtained included:-

1. Species:

Lodgepole pine, Douglas fir, and white spruce. Until further knowledge is available, lodgepole pine is the only species of those tested that is recommended for restocking mountain lithosols in Alberta.

2. The influence of aspect:

The northeast aspect was found to favour both initial germination and subsequent survival. The southwest aspect was found to be the least favourable.

3. The influence of seed loss to birds and rodents:

Measures must be taken to prevent seed loss to birds and rodents if any degree of success is to be realized.

4. The value of seedbed treatment which included vegetation removal, soil cultivation and stone removal:

Soil cultivation was the only seedbed treatment of those tested which proved to be of definite value.

5. Season of sowing; spring or fall:

Method of sowing; broadcast or spot:

Although the level of influence of season and method of sowing were found to be interdependent, the results suggest that the most favourable combination for lodgepole pine is a broadcast sowing in the fall.

At the present stage the most practical treatment for unrestocked lithosols in Alberta, which incorporates the most favourable results of this experiment, would be to broadcast lodgepole pine seed, which has been pelleted with a rodenticide, during the fall season on seedbeds that have been lightly scarified with either mechanical equipment or hand tools.

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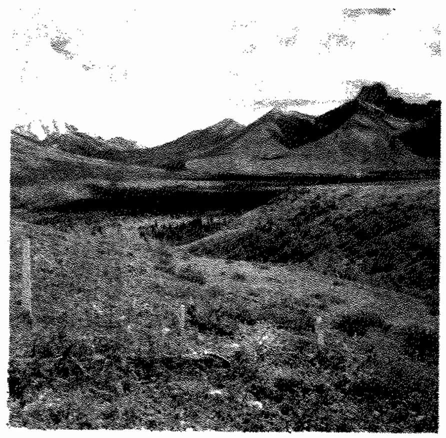

Plate 1. View of the experimental area (S.W. aspect).

Plate 2. Undisturbed seedbed of the experimental area.

Plate 3. Stones removed and piled on windward side. Vegetation removed and soil cultivated.

Plate 4. Depth guide in place and Douglas fir seed scattered.

Plate 5. Seed covered with mineral soil to level of depth guide.

Plate 6. Depth guide removed and cage placed.

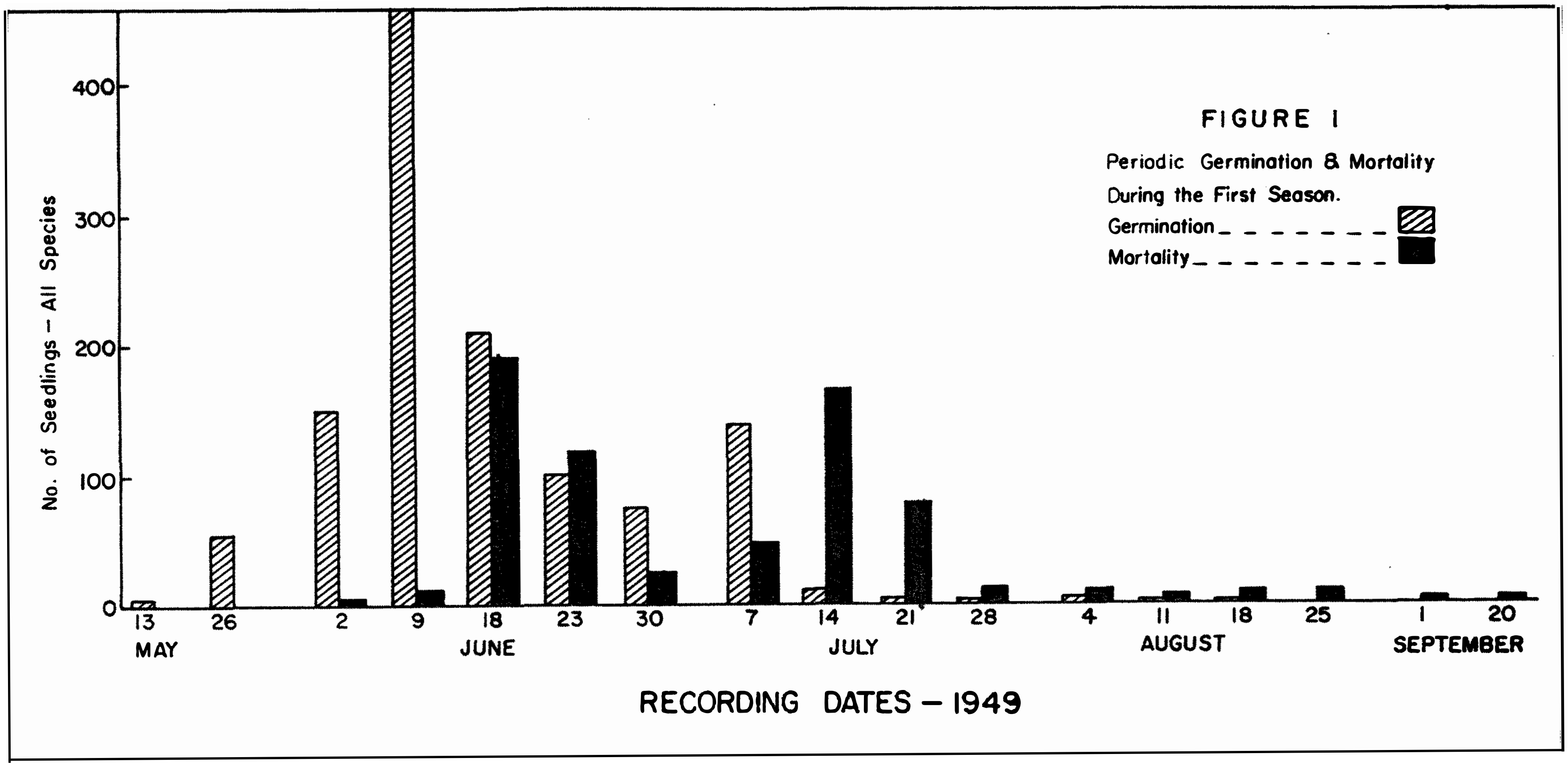
FIGURE I
Periodic Germination & Mortality
During the First Season.
Germination
Mortality
No. of Seedlings – All Species
400
300
200
100
0
13
26
MAY
2
9
18
23
30
JUNE
7
14
21
28
JULY
4
11
18
25
AUGUST
1
20
SEPTEMBER
RECORDING DATES – 1949

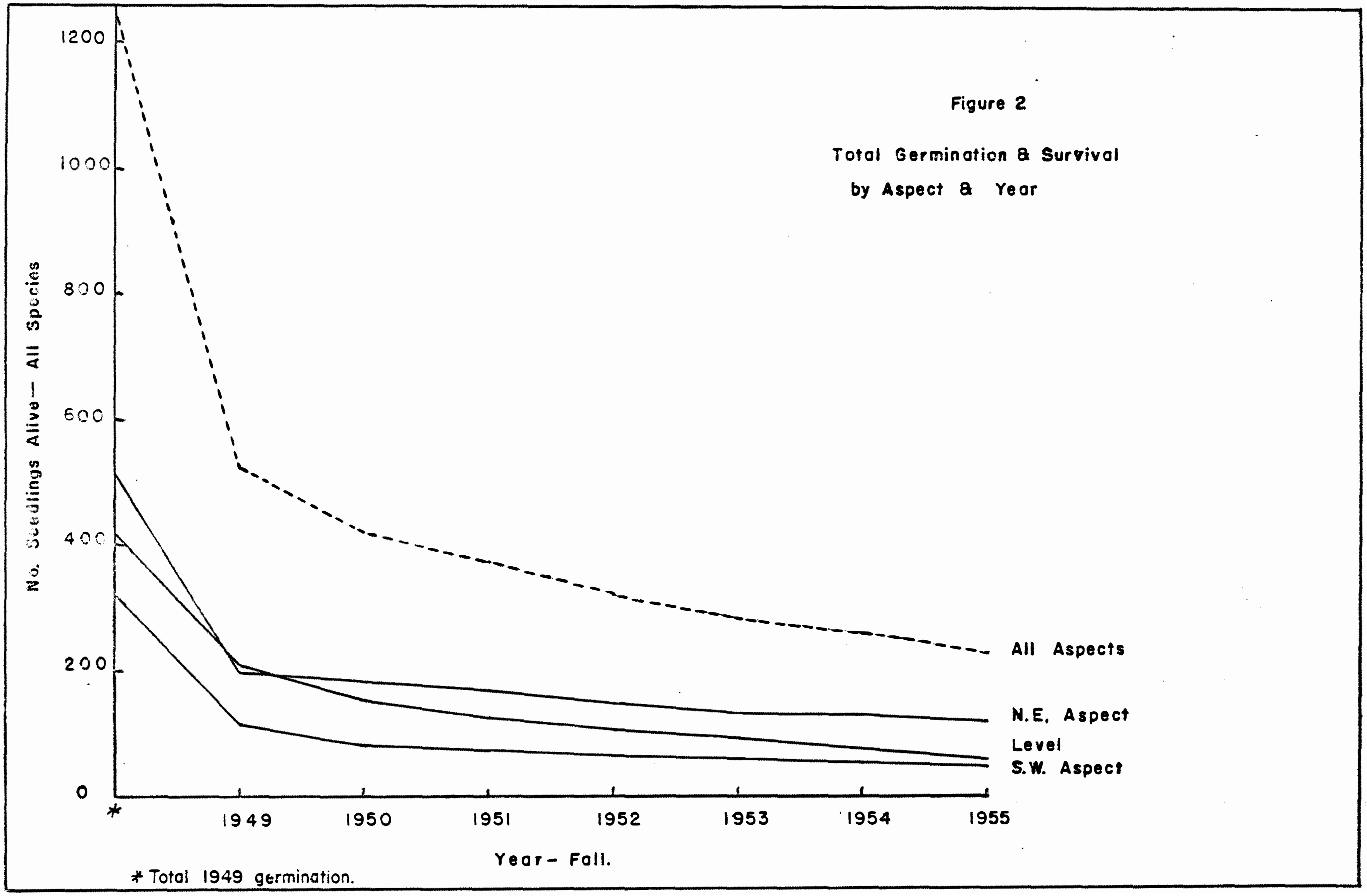
Figure 2
Total Germination & Survival
by Aspect & Year
No. Seedlings Alive— All Species
1200
1000
800
600
400
200
0
*
1949
1950
1951
1952
1953
1954
1955
Year— Fall.
All Aspects
N.E. Aspect
Level
S.W. Aspect
* Total 1949 germination.

Figure 3

Diagram Illustrating the Split Plot Technique Employed