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Operational Direct Seeding of Douglas-fir and Lodgepole Pine with Alternative Foods in British Columbia

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ABSTRACT

Direct seeding of cutovers in temperate coniferous forests of North America has often been hampered because of seed predation by rodents and birds. However, the use of alternative foods in direct seeding programs has been shown to improve the survival of conifer seed. Seed predation by rodents and birds was greatly reduced when alternative foods were used in experimental seeding trials with Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.) in British Columbia, Canada. This technique may further the use of direct seeding as an economical solution to certain reforestation problems. The methods may be adapted for both aerial and mechanized ground row-seeding applications on an operational basis.

Key Words

Seed predation, reforestation, forestry, rodents, direct seeding, British Columbia, Douglas-fir, lodgepole pine, deer mouse, alternative foods.

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INTRODUCTION

Direct seeding has been used for almost half a century as a method of regenerating cutover forest land in North America, but has never been used on the same scale as planting of nursery stock. It represents a valuable reforestation technique, particularly when conditions warrant an economical approach to forest regeneration and less emphasis on the attendant benefits of planting.

Consistently good direct seeding results are often hindered by one of the following: 1) seedbed condition; 2) seed damage by rodents and birds; and 3) moisture and temperature conditions during and immediately following the germination period. Type of seed, viability, amount applied, and method of application will also have a bearing on the success of direct seeding. Appropriate conditions for seed germination and seedling survival are always necessary for successful direct seeding. However, the first obstacle affecting sown conifer seed is predation by rodents. Much research has been done on seed (particularly Douglas-fir) damage by rodents and birds in coastal B.C., as well as related areas of the Pacific Northwest (Black 1969; Radwan 1970; Radvanyi 1973; Pank 1974; Sullivan 1979a).

This paper summarizes research on a biological technique utilizing alternative foods to reduce conifer seed predation by rodents and birds. The technique was developed for Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) seed in coastal regions (Sullivan 1979b) and for lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.) in interior regions (Sullivan and Sullivan 1982) of British Columbia. In addition, the adaptation of this method for operational use in both aerial and mechanized ground seeding applications is discussed.

STUDY AREAS

Douglas-fir

A technique for direct seeding Douglas-fir with alternative foods was developed from 1975 to 1977 on two relatively flat clearcut blocks in the University of British Columbia Research Forest, Maple Ridge, B.C. The study site was located in the Coastal Western Hemlock biogeoclimatic zone (Krajina 1965, 1969), Dry Subzone (Klinka 1976). One area was logged in the fall of 1973 followed by slash burning in 1974. This burn was uniform in some areas but patchy in others. The main cover was burned or unburned slash with bracken (Pteridium aquilinum), fireweed (Epilobium augustifolium), and several other less abundant successional herbs. The second area was also logged in the fall of 1973 but not burned. Cover included slash and a plant species composition similar to that of the burn. There was, however, more red alder (Alnus rubra), black raspberry (Rubus leucodermis), and salmonberry (Rubus spectabilis).

Lodgepole pine

A technique for combining alternative foods with lodgepole pine seed was developed during 1979 at three relatively flat study areas in the interior of British Columbia. The southernmost area was located 30 km northwest of Summerland adjacent to the Okanagan Valley in the Interior Douglas-fir biogeoclimatic zone (Krajina 1965, 1969). The dominant tree species, lodgepole pine, was logged in 1978. Ground cover included slash with pinegrass (Calamagrostis rubescens) and lupine (Lupinus spp.).

The second study area was located 53 km west of Williams Lake in the Douglas-fir - pinegrass Subzone (northern phase) of the Interior Douglas-fir biogeoclimatic zone (Annas and Coupé 1979). The forest was logged in 1977 and burned in 1978. Ground cover included burned slash, pinegrass, and a variety of early successional herbs.

The northernmost study area was situated 70 km southwest of Prince George in the Sub-boreal Spruce biogeoclimatic zone. The area was logged in 1978. Ground cover included slash and pinegrass with some successional herbs.

METHODS

Eight checkerboard grids were located on the two coastal clearcut blocks and four grids on the respective cut block of each interior study area. Each experimental grid, 91.2 m x 91.2 m, was systematically divided into 36 (15.2 m x 15.2 m = 231 m^2) plots. In each plot, a 0.61 m x 0.61 m quadrat was located in a suitable area for seed sampling and recovery.

Before each experiment, seed was weighed and packaged according to the amount desired per square metre of grid (area of grid = 8317 m^2). Several separate samples of 2500 Douglas-fir, 1000 lodgepole pine, 1000 sunflower seeds, and 1000 oat kernels were weighed with the mean value representing that given number of seeds. This value was used as a multiple to determine the number of seeds by weight for each of the 36 plots on a grid.

In all experiments, 25 quadrats were randomly chosen for sampling on each grid. A known density of seed was placed in each of four (0.093 m^2) units in a seed-sampling quadrat. Location of one or more seeds in a 0.093 m^2 unit was marked by wooden toothpicks. These markers were placed approximately 0.5 cm from each seed. Equal densities of seed were placed in adjacent 0.093 m^2 units, which contained no marked seeds. The remaining allotted seed was spread by hand as uniformly as possible over the rest of the plot area. Seed survival sampling was conducted at two-week (three-week for pine) intervals for six weeks (nine weeks for pine).

Ratios in numbers of sunflower seed to Douglas-fir seed were 7:1, 5:1, 3:1, and 0:1 (control). The combination of two alternative foods was in a ratio of 5:2:1 (sunflower:oats:Douglas-fir). The ratios of sunflower seed to lodgepole pine seed were 2:1 and 0:1 (control).

RESULTS

Douglas-fir

Results from experimental seeding of Douglas-fir with alternative foods (sunflower seeds and oats) are summarized in Figure 1. These data were compiled from spring 1977 seeding experiments and from similar trials in the late fall of 1976 and 1977. The fall seeding trials produced valid results on conifer seed predation which may be applied to spring conditions because of the similar responses and occurrence of small mammal species during these two seasons. For example, chipmunks are usually hibernating at these times and seed-eating birds are rare. The development of this direct seeding technique with respect to populations of seed-eating rodents and birds is discussed by Sullivan (1979b).

The 7:1 (sunflower to Douglas-fir) and 5:2:1 (sunflower to oats to Douglas-fir) ratios produced excellent survival of conifer seed (Figure 1). These results are also expressed as the potential number of germinants per ha (assuming the cutover area is direct-seeded with 0.11 kg Douglas-fir seed/ha, and that 80% of the seeds successfully) germinate.

Lodgepole pine

Results from experimental seeding with lodgepole pine and an alternative food (sunflower seeds) are summarized in Figure 2. These data were compiled from seeding experiments undertaken during the spring of 1979. At each of the three study areas, control (pine seed by itself) survival of pine seed was compared with the experimental (pine seed with sunflower) results for seeding trials on areas with comparable densities of rodents. The higher survival of pine seed at both the Cariboo and Prince George study areas was likely due to the lower populations of rodents in these areas than in the Okanagan. Details regarding the development and testing of this sunflower-lodgepole pine seed technique and its interaction with populations of seed-eating rodents are discussed by Sullivan and Sullivan (1982).

The 2:1 (sunflower to pine) ratio produced excellent survival of conifer seed at all three study areas (Figure 2). A lower amount of sunflower seed reduced seed damage by rodents in these pine seeding trials possibly because of the much greater size difference between pine and sunflower seeds than between Douglas-fir and sunflower. Rodents showed preference for larger seeds perhaps because their food value return per unit effort in gathering seeds is much greater. In addition, rodents such as the deer mouse may prefer Douglas-fir seed over pine (Douglas-fir would then require larger amounts of an alternative food) although this has not been experimentally verified.

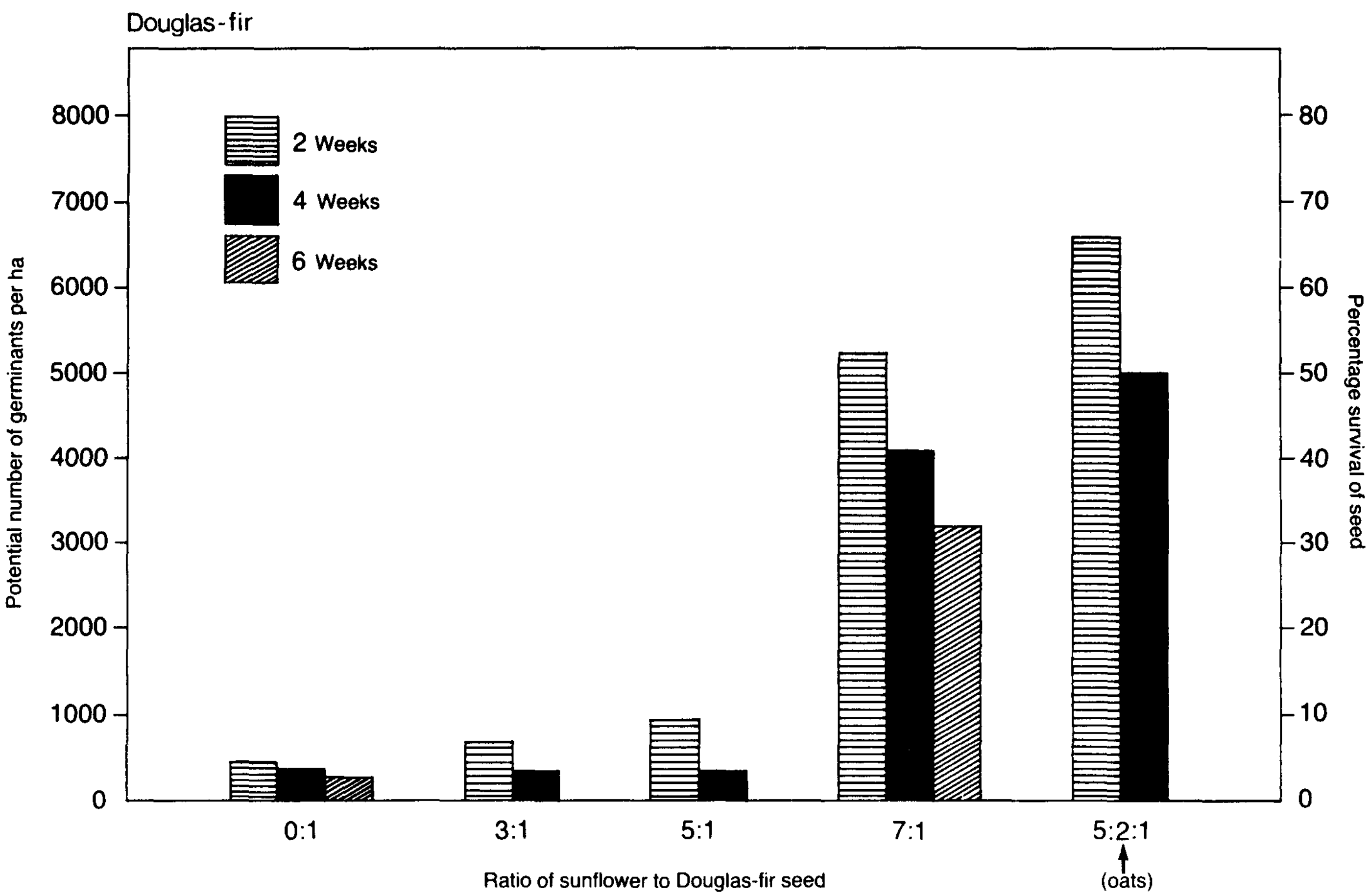

FIGURE 1. The success of different Douglas-fir seed to sunflower seed (and oats in 5:2:1 ratio) ratios (by numbers of seed) at two, four, and six weeks after seeding.

The open bars represent survival of Douglas-fir seed by itself and the closed bars represent survival of Douglas-fir seed when seeded with alternative foods. The potential number of germinants per ha is also illustrated for a seeding density of 0.11 kg (12 500 seeds) Douglas-fir seed per ha and assuming 80% germination.

Errata: Bars for 0:1 ratio of sunflower to Douglas-fir seed should have been 'open' and separately labelled for the 2, 4, and 6 week periods.

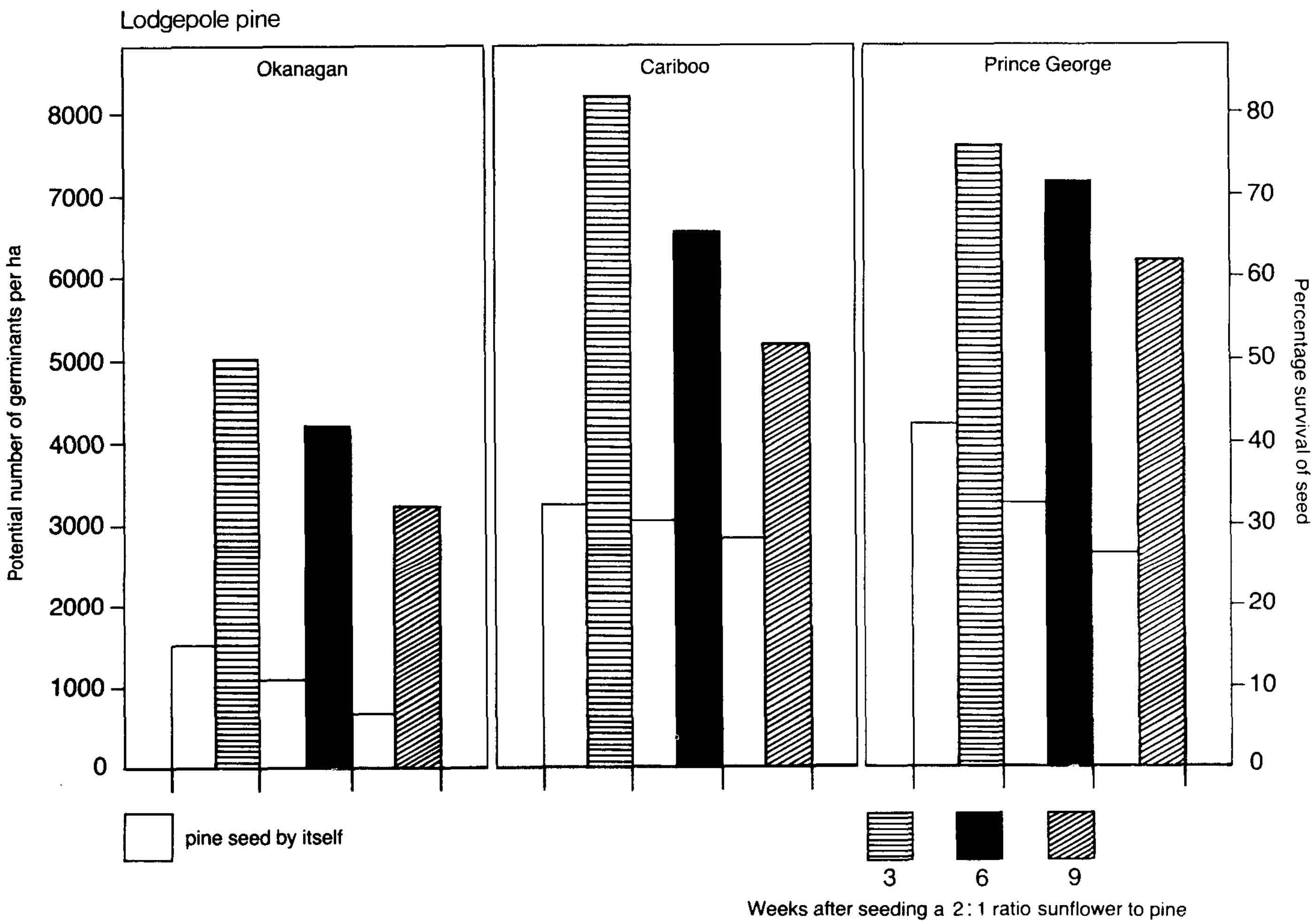

FIGURE 2. The success of lodgepole pine seed mixed with sunflower seed (2:1 ratio sunflower to pine) at three, six, and nine weeks after seeding at three study areas in the interior of British Columbia.

The open bars represent survival of lodgepole pine seed by itself and the closed bars represent survival of lodgepole pine seed when mixed with sunflower. The potential number of germinants per ha is also illustrated for a seeding density of 0.04 kg (12 500 seeds) lodgepole pine seed per ha and assuming 80% germination.

APPLICATION IN REFORESTATION PROGRAMS

Direct seeding with alternative foods should be undertaken in the late winter to early spring (March-April, depending on local snow conditions) in the year after an area is logged. Older clearcut areas which are heavily overgrown with shrubs and herbaceous weeds should have some degree of mechanical (scarification) or chemical (herbicide) site preparation. In areas with winter snow cover, most of this snow should be gone before seeding commences. This helps ensure the necessary seedbed moisture which is of paramount importance for germination (Arnott 1973). A site preparation technique should be selected which provides adequate mineral soil for germination and seedling establishment.

For Douglas-fir sites in the Coastal Western Hemlock and Coastal Douglas-fir biogeoclimatic zones, the following mixture is recommended: 0.11 kg (12 500) Douglas-fir, 46 kg sunflower, 5.5 kg whole oats; or 0.11 kg Douglas-fir and 64 kg sunflower per ha. For lodgepole pine sites, the following is recommended: 0.04 kg (12 500) lodgepole pine with 18 kg sunflower per ha.

The number (12 500) of conifer seeds in the recommended mixtures represents the minimum number of tree seeds required by this technique for successful stocking. The amount may be varied depending on seed supply factors or desired stocking level. However, the amounts of alternative foods should remain fixed to maintain adequate protection from rodent predation.

To promote prompt germination and vigorous seedling growth, the conifer seed should be stratified for at least three weeks and perhaps treated with suitable growth hormones. Seed thus treated may germinate within a two- to four-week period after seeding. This interval is well within the length of time (four weeks) in which Douglas-fir seed showed excellent survival when mixed with alternative foods (Figure 1). Similarly, lodgepole pine seed with sunflower survived very well up to nine weeks after seeding (Figure 2).

ECONOMIC AND LOGISTIC ASPECTS

The costs of spreading conifer seed and alternative foods in this reforestation technique are shown in Table 1. Costs of seed supplies are calculated per 1000 viable seeds. Stratification and hormone treatment are considered as phases of seed preparation; therefore the cost is negligible in these calculations whether for direct seeding or nursery sowing.

The cost of direct seeding Douglas-fir with alternative foods is $303/ha and for lodgepole pine is $249/ha. These costs include the expenses associated with site preparation but are still less than one-half of the range of expenses for planting ($698-846/ha). These total planting costs are average values and assume that 1150 trees are planted per ha.

Aerial application of the seed mixture by helicopter would cost $28/ha assuming several 50 to 100 ha clearcut blocks were seeded and the total area of these blocks was approximately 1000 ha (Conair Aviation Ltd., personal communication). This cost estimate assumes the helicopter base is nearby (minimum of three hours ferrying). It also includes two helicopter passes: one for the alternative foods and a second to distribute the conifer seed. The application cost may vary if the dimensions of one or more clearcut blocks increase the time to dispense seed. A Brohm seeder (Worgan 1973) would be used for distributing the conifer seed and a Chadwick spreader would disperse the alternative foods (sunflower seeds). This spreader has been used for dispensing large quantities of fertilizer at various sites in British Columbia. In addition, the distribution of the alternative foods is relatively simple logistically, compared with the sowing of conifer seed (Conair Aviation Ltd., personal communication). Because of the small quantity and size of the conifer seed, it can be very difficult to obtain a uniform distribution over the area of a clearcut block.

Mechanical ground application could be done using the Brackekultivatorn scarifier-seeder which scalps the ground with large digging teeth and then drops seed from an integral hopper onto the prepared seedspot (Parker 1972;

TABLE 1. Costs of seeding Douglas-fir seed and Lodgepole pine seed with alternative foods per hectare

	Direct seeding		Planting (1150 trees/ha)
	Douglas-fir	Lodgepole pine	
Conifer seed (12 500/ha)	$ 40.75	$ 26.67	$ 5.99
Sunflower seed ($1.37/kg)	63.02 (46 kg)	24.66 (18 kg)	-
Oats ($0.32/kg)	1.76 (5.5 kg)	-	-
Stratification and hormone treatment	-	-	-
Helicopter application	27.63	27.63	-
Site preparation	170.00	170.00	170.00
Actual planting	-	-	320.00
Range of average stock costs	-	-	201.00-345.00
Range of transportation costs	-	-	0.92-5.29
Totals	303.16	248.96	697.91-846.28

The range of planting costs assumes that an average of 1150 trees are planted per hectare. Site preparation cost is an average value and is considered to be representative for both seeding and planting. Information (1984) on seed and planting costs provided by the B.C. Ministry of Forests.

Winston and Schneider 1977). The Brackekultivatorn may be pulled by a skidder or caterpillar tractor. Conifer seed may be dispensed automatically at each seedspot or may be placed manually. In terms of operational use with alternative foods, lodgepole pine (or white spruce) with sunflower seed could be adapted for mechanical ground seeding via the Brackekultivatorn. A modified seeding apparatus may be required to dispense sunflower. However, the quantity of sunflower (18 kg/ha) is a reasonably small amount to be distributed compared with that (46-64 kg/ha) recommended for mixture with Douglas-fir in coastal areas. The obvious advantage of using this machine is its ability to prepare the site and dispense seed in one operation.

The furrow seeder is another mechanical method by which seed may be operationally distributed (Graber and Thompson 1967, 1969). This modified beet planter is coupled behind a fireline plow which is pulled by a small tractor. The tractor and plow produce a mineral soil seedbed and work well in stony, wooded lands. The seeder on this machine may also be adapted for the distribution of sunflower seeds, particularly in interior regions where lower amounts of alternative food are required. Furrow seeding has proven to be an efficient one-pass method well-adapted to forest terrain in the northeastern United States (Graber 1973). This machine prepares a suitable planting spot with minimum disturbance to the surrounding environment.

DISCUSSION

The ability to direct-seed lodgepole pine and Douglas-fir would be most advantageous on large areas burned naturally or intentionally, inaccessible areas which are too costly to plant or have had plantation failure; and in areas where natural regeneration may not be adequate. In addition, the alternative foods technique could be adapted to species other than the lodgepole pine and Douglas-fir already tested.

Direct seeding has generally failed as a reliable reforestation practice in most of North America. Perhaps one of the most important problems is the time of year when seeding has been done and how this relates to potential germination and populations of small mammals and seed-eating birds. Waldron (1973) reported that the majority of direct seeding in Canada has been done in the fall. However, sowing in April, May, and June has yielded, on the average, higher stocking than either autumn or early winter seeding. Similarly, in the Pacific Northwest of the United States, seeding has been mainly carried out in the fall (Gartz 1955; Carmichael 1957; and Lavender 1958). Why has most direct seeding been attempted in the fall at a time when populations of deer mice, chipmunks, and seed-eating birds are highest (Sullivan 1978, 1979c)? Conifer seed sown in the fall undergoes natural stratification during the winter and is then able to germinate in the spring. Laboratory stratification prevents seed from being exposed to small mammal depredations in the fall and winter. Late winter and early spring seeding programs in North America, although few in number, have proved to be more successful, at least compared with those at other seasons of the year (Carmichael 1957; Waldron 1973). Graber (1969), working in the northeastern states, found that more than one-half of pine seeds sown in the fall were lost after three weeks. He concluded that seeding should be avoided when small mammals are abundant and seeds are left exposed to predation. Similarly, Clark (1969) and Radvanyi (1971, 1973) concluded that late winter seeding with adequate snow cover for the conifer seed would reduce rodent predation and provide suitable conditions for germination in the spring.

The best results for direct seeding in North America have been obtained in the pine regions of the southeastern United States. One reason for this success is reduction of seed predation with endrin and arasan which act as repellents (Derr and Mann 1971). This provides a classic example of how direct seeding can be very successful if seed losses to rodents and birds are controlled. In addition, aerial row seeding has been developed in this part of the U.S. (Mann and Taylor 1969) and, along with ground row seeding, is a technique which would use less conifer seed and provide suitable distribution of trees (Vyse 1973). As outlined for the Brackekultivatorn and furrow seeder, alternative foods could also be incorporated into this latter method of seeding.

CONCLUSION

The use of alternative foods in direct seeding operations can significantly improve the survival of conifer seed. Damage to seed by rodents and birds has been greatly reduced for at least six weeks in seeding trials with Douglas-fir and lodgepole pine seed. Coupled with prompt germination and establishment, this technique of seeding offers a practical and economical approach to reforestation. Cost of seeding with alternative foods is generally half as expensive as planting trees. In addition, the ability to quickly reforest large areas by aerial and mechanical ground seeding could save much time, thereby avoiding costly regeneration delays.

Smaller amounts of conifer seed may be used with this technique than have been used in previous direct seeding operations. If the seed is properly distributed over the clearcut area and rodent damage is controlled, the chance of obtaining a uniform cover of seedlings is significantly increased. The success of any direct seeding project is related to the quality of site preparation and the technique described in this paper is no exception. Adequate mineral soil and some degree of shade-producing slash or minor vegetation must be available for successful germination and seedling establishment.

These techniques of aerial and ground row seeding with alternative foods could have an important role to play in reforestation. Successful direct seeding will complement planting as another tool to effectively regenerate cutover forest land.

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