DIRECT SEEDING OF DOUGLAS FIR WITH SPECIAL REFERENCE TO SURVIVAL

by

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A THESIS

submitted to

OREGON STATE COLLEGE

in partial fulfillment of
the requirements for the
degree of

MASTER OF SCIENCE

June 1957

DIRECT SEEDING OF DOUGLAS FIR WITH
SPECIAL REFERENCE TO SURVIVAL

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Date thesis is presented 6 May, 1957.

Typed by Anna McCook.

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ACKNOWLEDGEMENTS

Very special thanks are due to Dr. C.M. McKell, now with the Agricultural Research Service, U.S. Department of Agriculture, in co-operation with whom this study was conducted.

Acknowledgements are due to Dr. W.W. Chilcote, Department of Botany, for his enthusiasm and encouragement.

The guidance of Dr. J.R. Dilworth, School of Forestry, is acknowledged with thanks.

Mr. N.B. Kverno, Mr. M. McCormack, Mr. E. Hooven, Dr. M.C. Parker, all assisted in various aspects of the study, and their help is gratefully acknowledged.

Thanks are due to the Charles H. Lilly Company, Albany, Oregon, and to Mr. H. Rampton, Research Agronomist, Agricultural Research Service, who supplied the cover crop seed.

The photograph in Figure 10 was taken by Mr. H.H. Millsap, Agricultural Experiment Station, to whom thanks are due.

The following personnel of the Research Division, B.C. Forest Service, kindly reviewed the manuscript: Mr. R.H. Spilsbury, Mr. A.R. Fraser, Dr. A.L. Orr-Ewing, and Mr. R.L. Schmidt.

ACKNOWLEDGEMENTS (cont'd)

The financial assistance of the Weyerhaueser Timber Foundation is acknowledged with thanks.

DIRECT SEEDING OF DOUGLAS FIR

WITH SPECIAL REFERENCE TO SURVIVAL

INTRODUCTION

The decade since the end of the second world war has produced great advances in forest management in the Pacific Northwest. It has been shown that good forestry pays. Dana (8) states

> The remarkable advance in private forestry during the last decade, particularly among the larger owners, has been due chiefly to other factors than government threats or doles. Private owners have been genuinely interested in forestry because they have been convinced that it is both necessary and profitable.

In no aspect of forestry has this change in attitude been more apparent than in the desire for prompt restocking following logging, as if this is not immediately obtained, the next rotation is delayed. This can have a serious effect on the operations of a large company with big investments in integrated conversion plants which are dependent upon a regular supply of logs. The situation can be equally serious on National Forest land since many operators are dependent on National Forest timber sales for their logs, and mills are, in their turn, dependent upon a steady supply from the logging operator.

Delay in restocking may result in a brush problem which gets progressively worse with increasingly productive sites and makes eventual restocking more difficult and more expensive. Private owners still pay taxes on unproductive land and this simple fact is a great spur in encouraging owners to return their land to production following logging.

The main methods of attempting to attain this goal of prompt restocking have been:

(1) Changes in cutting practices to encourage natural regeneration.

(2) Increase in artificial regeneration by planting or direct seeding.

Patch logging has many advantages besides increasing the chances of natural regeneration and has become standard practice on many operations. Unfortunately good cone crops have been very scarce during the past ten years and patch logging has frequently failed to produce adequate restocking. Baiting to control seed eating rodents and protect natural seedfall has been tried experimentally and may prove a useful tool when methods are improved. However, in view of the uncertainty of natural restocking and the small chance of an adequate seedfall occurring immediately following slash burning, artificial regeneration has increased in importance during the past ten years. Planting is regarded by many as the best method of obtaining regeneration, but continually rising costs have forced many to look for cheaper methods. Direct seeding is much cheaper than planting but, at present, is limited by three factors, one of which varies from area to area and from year to year. The first two factors are the control of seed eating rodents and shortage of seed, especially that from high elevations. Spencer and Kverno (24) of the United States Fish and Wildlife Service have been working for some years on the rodent problem and have achieved substantial progress. Duffield (9.p.6) stresses that adequate seed supply of the correct provenance is a serious and ever-present problem which is becoming more serious as logging proceeds to higher elevations. At the lower elevations, second-growth stands suitable for cone collection are fairly numerous and some seed is available each year. At the higher elevations the only second-growth stands are those which regenerated following a fire and these are rather uncommon. In addition, little is known about the frequency, yield and quality of high elevation cone crops. The final factor, affecting both natural and artificial regeneration by seeding, is seedling mortality. This varies from year to year according to the weather and from area to area according to the site quality, aspect, slope, soil and ground vegetation. Many factors, either singly or in combination, may effect both germination and initial seedling survival. The chief factors are -

1. Unfavorable conditions for germination. This may cause either reduced germination or lack of germination.

2. Disease.

3. Insects or animals.

4. Heat.

5. Drought.

6. Competition from other plants.

All these causes of death should be considered as it is of little use attempting to correct one factor if the seedling will die from another one. There has been considerable interest, in recent years, in heat as a cause of the mortality of both natural and artificial regeneration and some work has been conducted to find out the factors causing mortality, the extent of these factors and possible methods of control. This study comprises an investigation on high temperature as a cause of seedling mortality.

OBJECTIVE

To create conditions favorable for the survival of Douglas fir seedlings by the use of a cover crop which will favorably modify soil surface temperatures in the weeks following germination.

REVIEW OF THE LITERATURE

The mortality of young seedlings by high temperatures has been recognized. Toumey and Neethling (28) have described heat injury to white pine seedlings growing on dry mineral soil but where soil moisture in the root zone was not deficient. Bates and Roeser (3) reported that in the Rocky Mountain region, soil surface temperatures as high as 160°F. may not be uncommon, and that direct injury to protoplasm occurs at 140°F. They found that

> maximum temperatures could be a critical factor preventing natural reproduction and where this was the case, planting might be necessary or the establishment of a given species might not be possible until the heating action of direct sunlight on the site had been somewhat modified.

Baker (2) states that an internal temperature of 137°F. causes injury to Douglas fir seedlings but that temperatures a few degrees below 130°F. can be endured for some time. He repeatedly recorded soil surface temperatures as high as 160°F. Bigelow (5) found that the effect of sustained high temperatures on the biological processes of seedlings is profound for, as the temperature increases in an arithmetic progression, the duration of time required to kill seedlings decreases approximately in a geometrical progression. Roeser (21) used heated sand to simulate field conditions and gave the following critical temperatures for Douglas fir seedlings of various ages:

Seedling age.	Highest temperature likely to be tolerated by all individuals.	Temperature likely to be fatal to all.
Days.		
39	125°F.	150°F.
71	124°F.	154°F.
91	131°F.	146°F.

He also stated that injured seedlings are more liable to attack by fungi.

The work of Isaac (18) is the most extensive in regard to Douglas fir and contains an excellent summary of the earlier investigations up to 1938. He found temperatures on black burned soil were 7°F. to 18°F. higher than on a yellow soil surface. He established three plots in the Wind River area. Area A which was very heavily burned, and was practically bare of any vegetation, Area B where the burn was of medium intensity and some herbaceous brush had established itself, and Area C in the adjoining undisturbed old-growth. The highest surface-soil temperature recorded was 164°F. on Area A, whereas at no time did the temperatures on Area C rise high enough to cause injury to seedlings. A surface-soil temperature of 123°F. for several days following germination was found likely to injure Douglas fir seedlings and one of 125°F. or more is likely to kill them. Dead shade was found to aid seedlings survival whereas live shade produced competition for moisture and nutrients. Since some degree of slash disposal is necessary to reduce hazard, Isaac recommended spot burning of accumulations except on south slopes where he felt no burning should take place, whenever practical. In later work (19), he emphasized the importance of slope and exposure on surface soil temperature and thus on seedling survival, and gives the following example based on a 35-day period in late summer in the Wind River area. Valley temperatures averaged 143°F., south exposure 150°F., east exposure 147°F., and the northwest exposure 137°F.

Garman (15.p.23) reported surface temperatures of 140°F. in May on burned areas at Cowichan Lake, B.C., and found that temperatures on such areas were frequently 15°F. higher than on unburned, exposed yellow mineral soil. He found that the greatest mortality due to heat often occurred when the seedlings were young but that this was not always the case and that in one experiment, in 1941, 13 percent of the total seedling losses occurred during a heat wave in July when the maximum air temperature on six successive days was over 90°F. Garman found that artificial shade increased survival 21 percent compared with the unshaded control.

Even in the northerly latitude of Finland, Vaartaja (31) recorded surface temperatures up to 145°F. and noted that temperatures were higher on a burned area than on a nearby unburned gravel. In another article (33), he recorded a surface-soil temperature of 152°F. at the Arctic Circle on a sunny day. In a third article (32), Vaartaja found that Scots pine (Pinus sylvestris, L.) seedlings were killed by fifteen minutes immersion in water of from 124°F. - 131°F. In artificial humus soil, temperatures of from 129°F - 149°F. proved critical to seedlings of the same species.

Smith (23) made a comprehensive investigation of surface temperature when studying seedbed conditions and regeneration of eastern white pine (Pinus strobus L.). He found that maximum surface temperatures on a litter seedbed were always higher than on mineral soil although the amount of direct sunlight was the same. The surface of pine litter attained 131°F. ten minutes after complete exposure, but mineral soil never reached this temperature. Smith(23 p.30) stated,

> these observations demonstrated that surface temperatures responded rapidly to variations in incipient solar radiation. They also showed clearly that surface temperature was in no way dependent on air temperature at conventional levels of measurement ... The temperature of any substance depends on the amount of heat absorbed, the rate at which heat is lost and the specific heat of the substance itself.

Silen (22) has used Tempil pellets in an attempt to find out what percentage of a clear-cut experiences lethal temperatures. Tempil pellets have an accuracy of $\pm$ 1 percent and are available over a considerable range of temperatures. He used pellets having melting points of 125°F., 138°F., and 150°F. and found that 125°F. was close to the threshold mortality for Douglas fir seedlings and that the melting of a 138°F. Tempil pellet indicated that a lethal temperature had been reached. He found that by July 1st, surface temperatures exceeded 138°F. on an average of 27.6 percent of the area on north slopes and 60.7 percent of the area on south slopes. Turner (29) has computed the actual amounts of direct solar radiation received for different latitudes and on different slopes at various times of the year. These graphs strikingly show the effect of aspect. At 50° north latitude on June 21st, for example, the amounts of solar radiation received were 1.37, 1.22, .72 gram calories per square centimeter per minute on 30° south slopes, level ground and 30° north slopes respectively. Maguire (20) has computed the solar radiation at a level station at 2700 feet elevation at Placerville, California, on the 21st day of each month throughout the year. Surface soil temperatures above 125°F. were recorded almost constantly between April 15 and October 15, using a Foxboro soil thermograph. The value of this experiment is shown by the fact that with adequate shading a 400 percent increase in seedling survival was achieved.

The experience of these experiments may be summarized:

1. Surface soil temperature of between 125°F. - 130°F. are the threshold of lethal temperatures for Douglas fir seedlings.

2. Lethal temperatures occur over widely differing latitudes.

3. Lethal temperatures may be of long duration.

4. Mortality increases sharply with increase in temperature above the lethal threshold.

5. Different soil surfaces are heated to different temperatures by an equal amount of solar radiation. Black surfaces are among the hottest.

6. South slopes are hotter than level ground which, in turn, is hotter than north slopes.

7. Lethal temperatures are widespread on many cutovers, especially on south slopes.

8. Seedlings injured by high temperatures are more susceptible to other damaging factors such as fungi and drought.

The use of a cover crop has been tried as a method of giving protection to young Douglas fir seedlings. Mustard has been sown as a cover crop on burned watersheds in California to combat erosion for some years. Gleason (16). In August 1951, a disastrous fire burned 28,000 acres in the Vincent Creek-Smith River drainage in west central Oregon. Parts of the area were so completely denuded that the Bureau of Land Management decided immediate rehabilitation measures were essential and seeded nearly 17,000 acres with brown mustard (Brassica juncea (L) Cos.), in the fall of that year.(17). Subsequently nearly 12,000 acres were baited for rodent control and 6,097 acres were seeded to Douglas fir. The primary aim of sowing mustard was to provide a vegetative cover to the bare ground and prevent soil erosion but out of the project came the idea of using mustard as a cover crop to increase Douglas fir survival. As a result, a co-operative research project was set up between the Bureau of Land Management and Oregon

State College and research work was carried out in 1954 and 1955. The requirements for a cover crop, as set forth by the Bureau of Land Management, are:

1. Seed must be available on short notice in large quantities at a reasonable cost.

2. Seed must be capable of very rapid germination on an unprepared seedbed without covering.

3. The plant must grow rapidly during periods of drought and considerable fluctuation in temperatures, giving full ground cover before heavy winter rains and low temperatures begin.

4. It must not persist longer than necessary to reduce run off and erosion and until native cover is reestablished, nor be a deterrent to tree regeneration.

5. It must not constitute a noxious weed menace, nor increase the fire hazard with inflammable fleshy fuel.

In connection with the latter requirement Wyckoff, formerly Director of the California Forest and Range Experiment Station, made this statement about mustard,

> Mustard is the most fire resistant plant with which I have ever worked. A wild fire running before a good wind was observed to stop and die when it ran into a heavy stand of dry mustard stems.

In the 1954 co-operative experiment, Pierovich (6) found increased Douglas fir survival on areas seeded to mustard compared to the control areas. However, the summer was wetter and cooler than average and he warned that the results may not be typical. Clarkson (6) found no seedling survival in experiments carried out during the hot summer of 1955 and concluded that competition for available moisture was the responsible factor. Further research work is required as the performance of mustard is confounded by uncontrollable external factors such as climate.

In 1952, the Weyerhaeuser Timber Company (25) seeded mustard on part of a 1,800-acre burn in the Millicoma Forest. It was found that the burn had not destroyed the native vegetation to the extent feared and that there was sufficient ground cover to make mustard unnecessary. The following beneficial effectsof mustard were noted:
(1) The long tap root which acts as an anchor or stake in preventing soil movement. (2) The rosette form of growth which persists all winter and covers a maximum of area per plant. (3) The single stem form of growth which occupies very little growing space per plant. It is suggested that a soil improving species such as a legume be tested, and the question of browsing is raised.

Another suggestion has been to sow Douglas fir seed into mustard stubble. This means a delay of one year and is an idea worthy of trial; however, it is interesting to note the findings of Geiger (15 p.272) concerning the high reflective ability of green vegetation. This property applies only to the infra-red wave-lengths which contribute more heat than the visible wave-lengths. Green vegetation reflects about 44 percent of the infra-red radiation compared to 2 - 11 percent for most bare soils, although they reflect more when dry than moist. Clark (7) has concluded that the unusual ability of green leaves to reflect infra-red radiation is caused by the presence of chlorophyll and is greatly diminished when the chlorophyll is destroyed. This might be of importance in choosing between a live cover crop and dead shade like mustard stubble.

Suggestions to overcome these disadvantages include manipulation of the time and rate of seedling the cover crop, trial of other cover crop species, and spraying with herbicides to control cover crop development. This latter idea has obvious disadvantages since it entails another operation which costs money. It is, however, an idea worthy of trial especially as mustard is extremely sensitive to 2,4-D and similar chemicals.

OUTLINE OF STUDY

This experiment is the third cooperative project between the Bureau of Land Management and Oregon State College and was conducted by C.M. McKell and J.M. Finnis.

The B.L.M. required a comprehensive experiment which included seed laboratory, greenhouse and field trials. The experiment was viewed as a pilot study which would serve as a basis for a more extensive two-year experiment. Thus it was not intended to make exhaustive investigations on any one phase but rather to obtain an overall impression. In view of the fact that seven cover crops were being tested for the first time, the exploratory nature of this experiment is perfectly logical.

Eight cover crops were tested. These are:

India Mustard	*Brassica juncea*. (L.) Coss.
Native Mustard	*Brassica campestris*. L.
Annual blue grass	*Poa annua*. L.
Velvet grass	*Holcus lanatus*. L.
Burnet	*Sanguisorba annua*. Nutt.
Common vetch	*Vicia sativa*. L.
Hairy vetch	*Vicia villosa*. Benth.
Hop clover	*Trifolium procumbens*. L.

For the sake of clarity, the experiments are divided into and described in three sections, after which a discussion on the entire study follows. The three sections are: (1) Seed laboratory experiment. (2) Greenhouse experiment. (3) Field trials.

SEED LABORATORY EXPERIMENT

OUTLINE

One of the requirements of a successful nurse crop is that germination should occur early in the spring and growth should be sufficiently advanced to provide adequate shade to the fir seedlings when the latter germinate. This means that the cover crop must be capable of germinating at relatively low temperatures and short day lengths. The first property was tested in the seed laboratory and the second in the greenhouse. Optimum germination conditions for all cover crop species except burnet are given in U.S.D.A. Agricultural Handbook No. 30 (30) and those for Douglas fir by Allen (1), but in this study it was necessary to find out the performance of the species under conditions far from optimum. It must be emphasized that throughout the experiment only one seed lot of each species has been used and the performance of the particular lot may not be typical for the species. Four replicates of 100 seeds of each species, except India mustard but including Douglas fir, were tested at the following temperatures:

1. 5°C.
2. 10°C.

3. 8 hours at 5°C. and 16 hours at 15°C.

4. 20°C.

RESULTS

Germination was recorded at intervals up to 55 days and detailed results are given in the Appendix. These results are summarized in Table 1.

Table 1. Summary of germination of eight species at four temperatures.

Species	Germination percent at temperatures of			
	5°C.	10°C.	5-15°C.	20°C.
Poa	16.00	54.75	90.75	92.75
Velvet grass	76.50	81.75	95.00	87.25
Hop clover	51.50	50.00	45.75	49.00
Native mustard	5.00	11.25	20.50	31.25
Common vetch	98.75	98.50	97.75	100.00
Hairy vetch	90.00	93.25	92.00	92.75
Burnet	79.75	84.25	86.25	88.25
Douglas fir	0.00	2.25	21.75	63.00

These figures show that low temperature had an adverse affect on the germination of annual blue grass, mustard and Douglas fir, but that the amount of germination of the other species was relatively little affected. These results are shown graphically in Figure 9.

However, the rate or speed of germination was affected by temperature for all species. This is an important factor as the ideal situation would be for a given cover crop species to germinate promptly at low temperatures so as to be tall enough to provide shade for the fir seedlings. If germination is slow then the cover crop may not be sufficiently advanced to perform this function. Figures 1 - 8 show cumulative germination percent plotted against time in days for the species tested. Since temperature affected amount of germination as well as speed of germination, it is difficult to place the species into any well defined groups. But examination of Figures 1 - 8 does show the following reactions for the various species.

1. Annual blue grass.

Germination at 20°C. is quick and complete. Germination at 5 - 15°C. is about 5 days slower, but not reduced in total amount. At 10°C., germination is slower and lower, while at 5°C. the adverse affect on both measurements is marked.

2. Burnet.

Germination at 5 - 15°C. and 10°C. is about 10 days and 19 days respectively slower than at 20°C. At 5°C., it

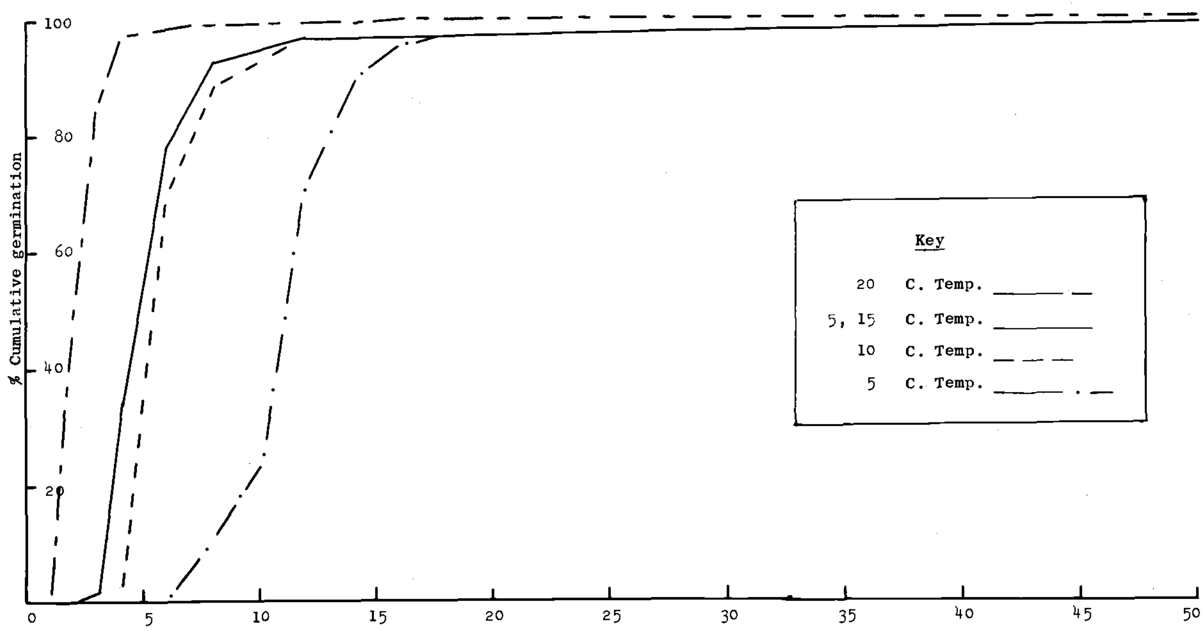


Figure 1. Germination of VICIA SATIVA

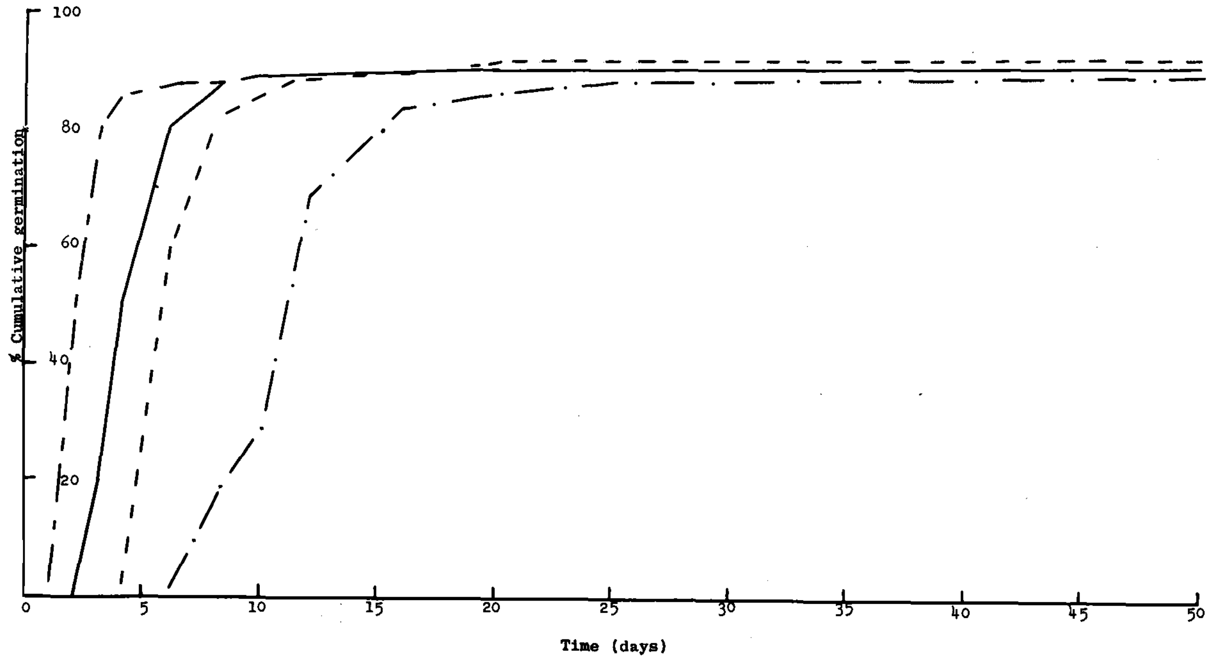


Figure 2. Germination of **VICIA VILLOSA**

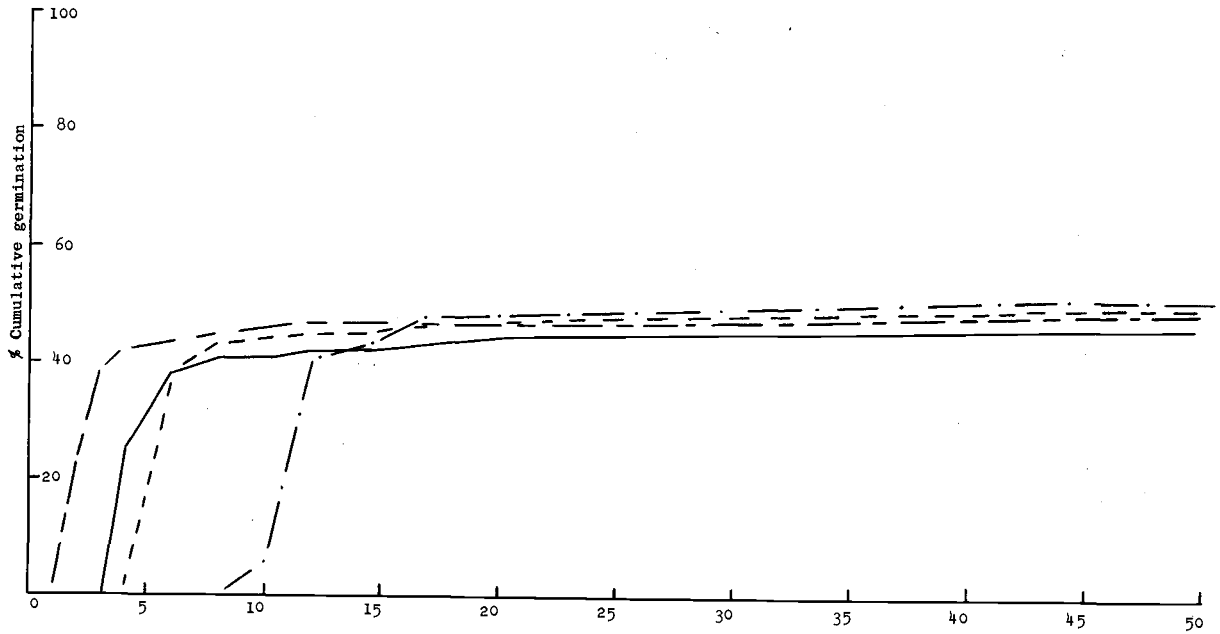


Figure 3. Germination of TRIFOLIUM PROCUMBENS

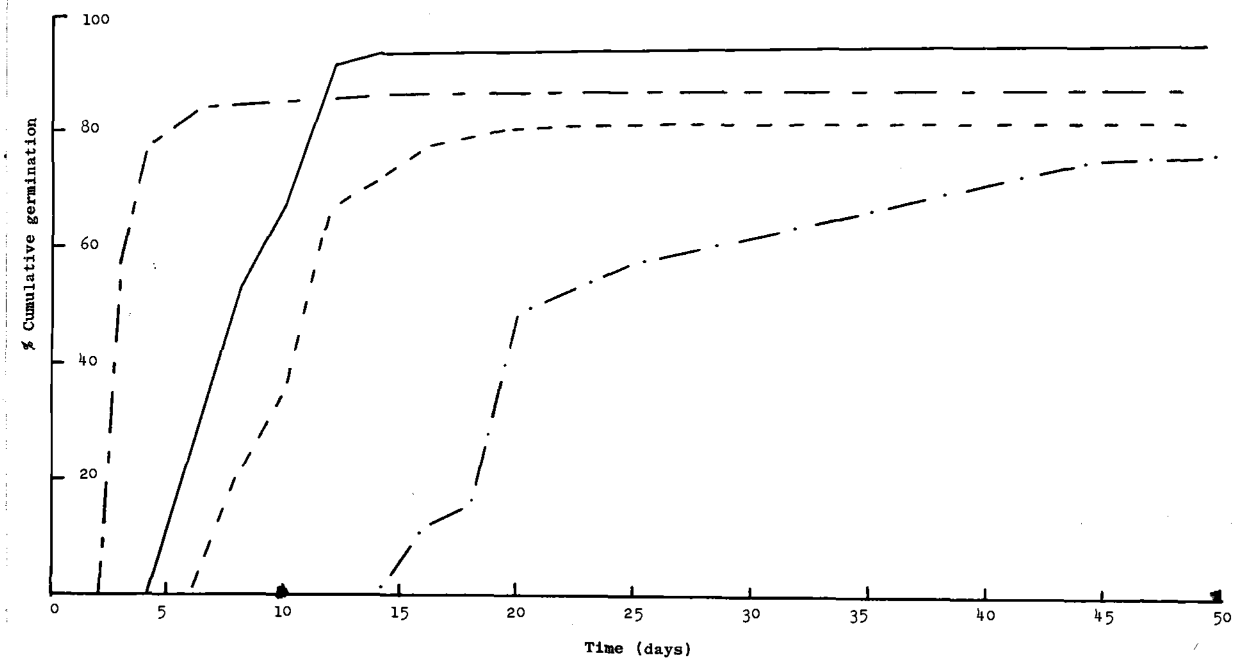


Figure 4. Germination of HOLCUS LANATUS

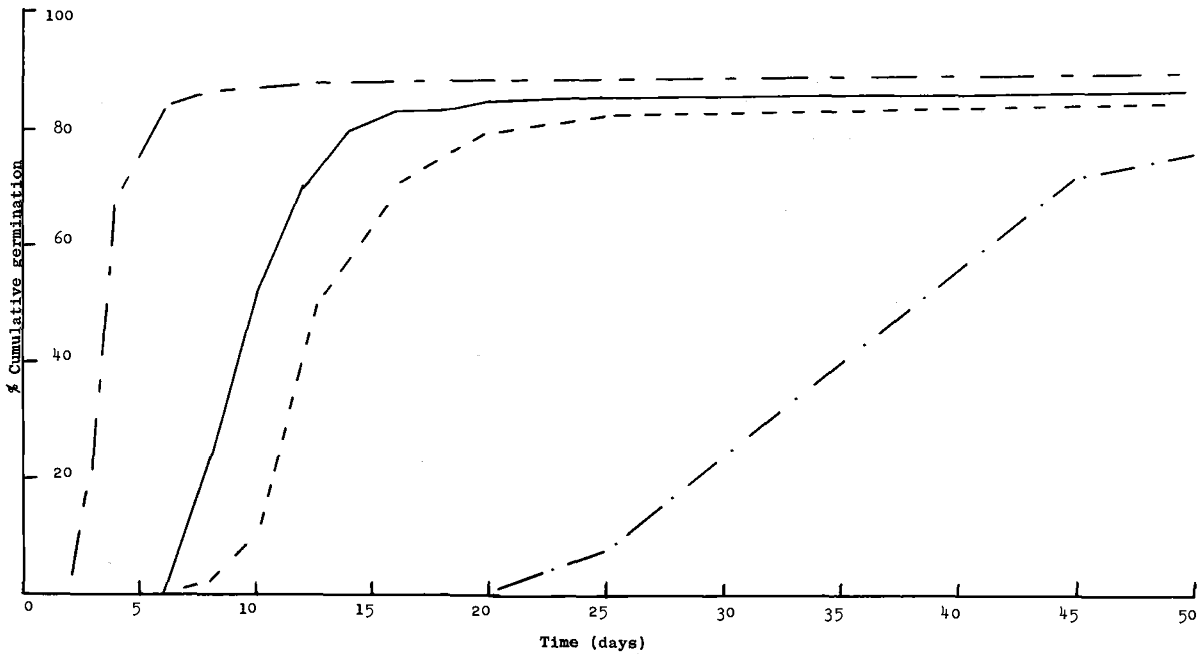


Figure 5. Germination of SANGUISORBA ANNUA

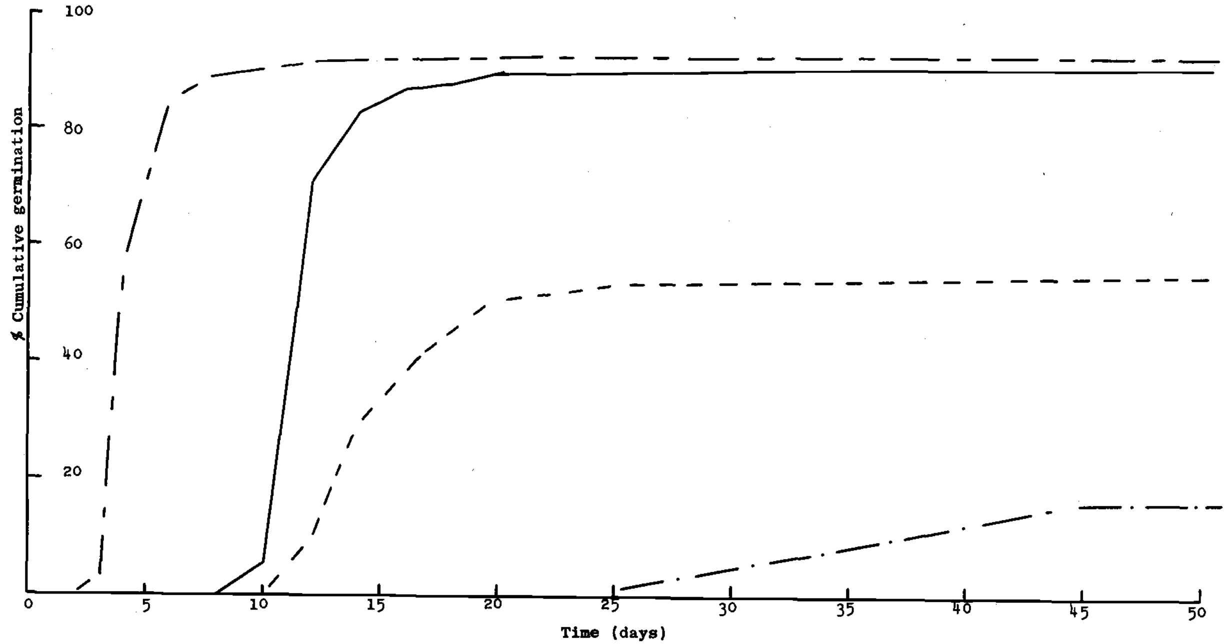


Figure 6. Germination of **POA ANNUA**

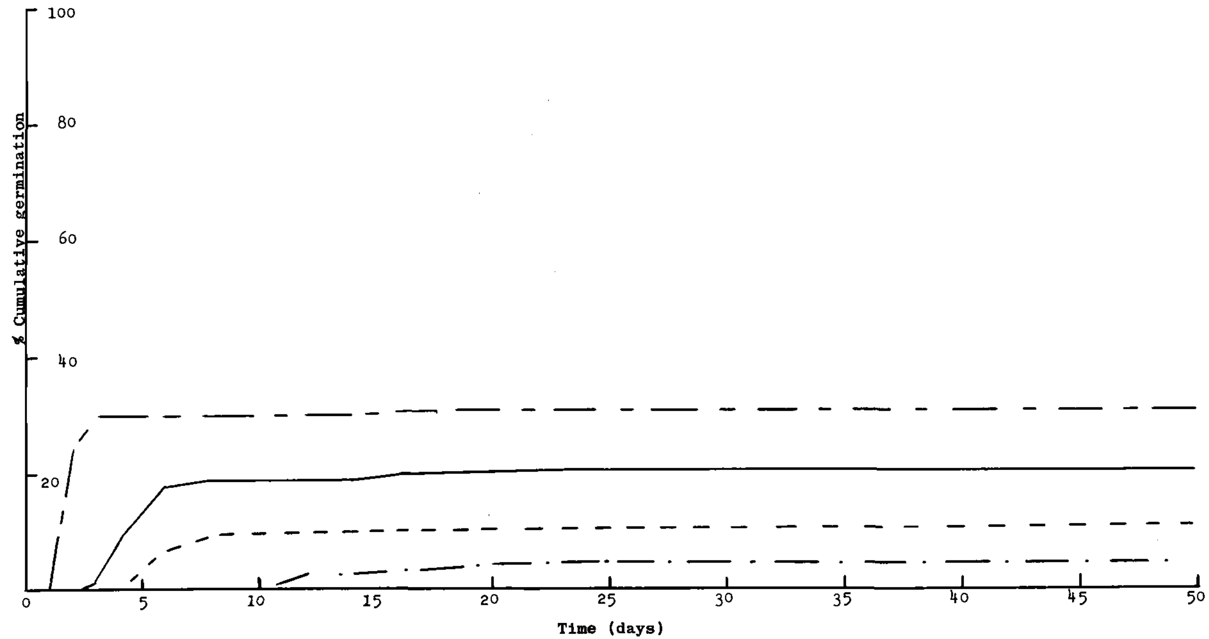


Figure 7. Germination of BRASSICA CAMPESTRUS

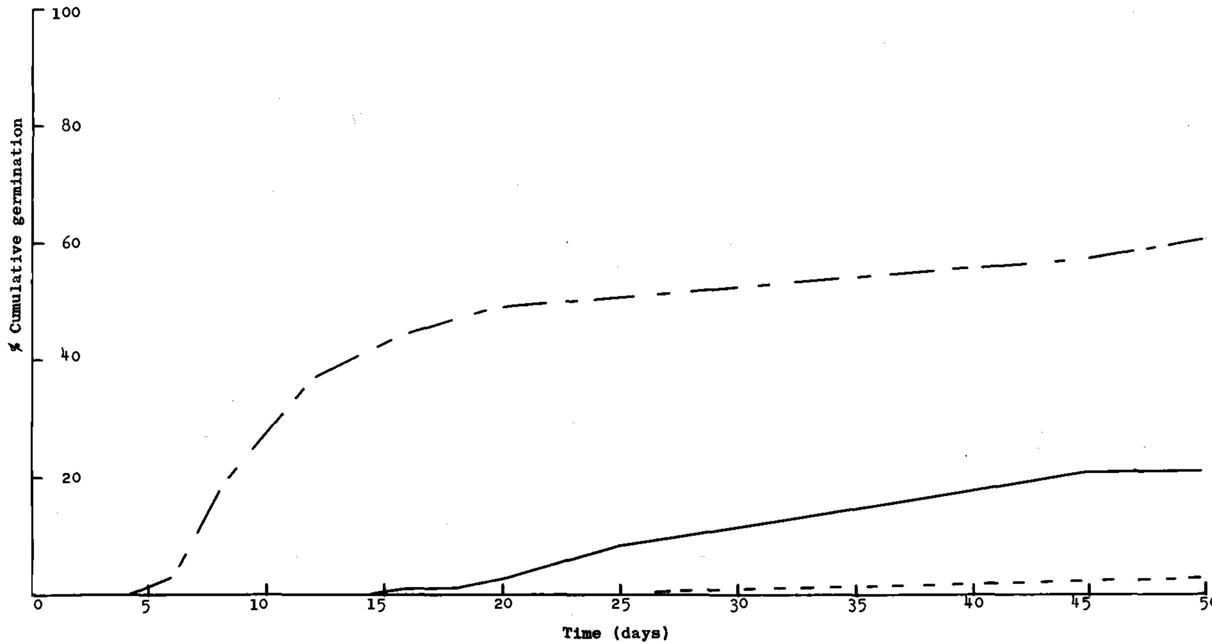


Figure 8. Germination of **PSEUDOTSUGA MENZIESII**

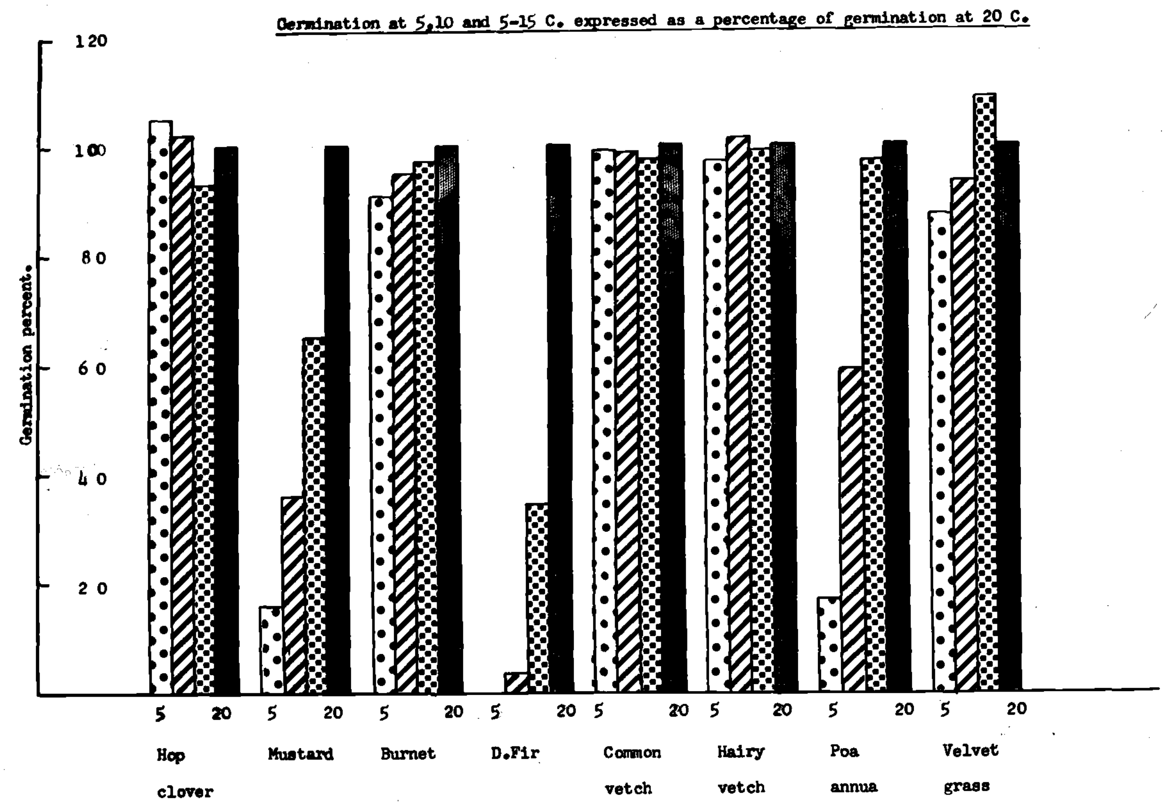


Figure 9. Germination of eight species at four different temperatures in the seed laboratory.

was 55 days before germination reached 90 percent of that recorded at 20°C.

3. Hop clover.

Temperature had little effect on amount or rate of germination. Germination at 5°C. was 8 days behind that at 20°C.

4. Velvet grass.

Temperatures of 10°C. and 5 - 15°C. resulted in a delay of 14 and 6 days respectively in reaching that recorded at 20°C. At 5°C., germination was very slow and it took 55 days to reach 87 percent of the germination recorded at 20°C.

5. Mustard.

Germination of the mustard was poor and it might be that this was a poor sample. For this particular lot, germination was reduced in amount and rate by increasingly lower temperatures.

6. Hairy vetch.

Germination was high at all temperatures. That at 10°C. was 6 days slower than at 20°C. and germination at 5°C. was a further 6 days delayed.

7. Common vetch.

The pattern was very similar to that of hairy vetch.

8. Douglas fir.

Temperature had a very marked effect on germination. None occurred at 5°C. and very little at 10°C. At 5 - 15°C. there was only 23.5 percent of the germination capacity at 20°C. This is very similar to results reported by Finnis (11 p.15). He found no germination at 10°C. and germination at 16°C. was limited, being just over 30 percent of that occurring at 24°C.

DISCUSSION

These laboratory tests show that all the cover crops tested germinate quicker and at lower temperatures than Douglas fir. Field tests are the crucial test, however, since moisture and temperature conditions vary in the field but were controlled in the laboratory test. Vaartaja (32) reported very poor root development of Scots pine and Norway spruce in dry weather even when there was plentiful moisture in the soil. Another interesting and possibly important factor concerns temperature. During germination time, there are warm, clear days, cool days and cloudy days with occasional warm periods of varying duration and intensity. The question arises as to whether short spells of warmth are cumulative in effect and build up to a required amount of heat to bring about germination. For these reasons laboratory tests can be little more than a guide.

GREENHOUSE INVESTIGATIONS

Work in the greenhouse was divided into two parts:

1. A study of the competition between Douglas fir seedlings and the various cover crops.

2. A study of the effect of photoperiod on the germination and growth of Douglas fir and the various cover crop species on burned and unburned forest soil.

COMPETITION EXPERIMENT

The objective in this experiment was: After plants of the various cover crop species and Douglas fir seedlings were established, to compare the survival of the different plants under drought conditions and to compare their root distribution.

Number 10 cans were filled with forest soil from one of the study areas on Mary's Peak which was tamped down to approximate as closely as possible the degree of compaction found in the field. Newly prepared and calibrated Bouyoucos blocks were placed in each can four inches from the soil surface. The top inch of the can was filled with soil from a recent slash burn. Thirty-two cans were used, four for each species, which were:

Native mustard.

India mustard.

Annual blue grass.

Velvet grass.

Hop clover.

Burnet.

Common vetch.

Hairy vetch.

Seeds of the appropriate cover crop and stratified Douglas fir seed were placed in each can on 17 December, 1955. The cans were watered regularly for four weeks until the plants were established and then no more water was given. Observations were made at intervals on the thriftiness of the Douglas fir seedlings and cover crops. Ohms-resistance readings were taken at the same time. When the Douglas fir seedlings in any pot looked dead, the pot was placed in a tray of water to see if the seedlings revived or were actually dead. At the end of the experiment the bottoms were cut out of a number of cans and the roots washed and notes made of the root systems of the plants.

RESULTS

A plant pathogen affected both mustard species and owing to their poor growth and development no conclusions can be drawn from them. Both vetches provided very severe competition for the Douglas fir and the seedlings were nearly all dead seven weeks after the last watering. Figure 10 shows the appearance of the different cover crops and Douglas fir seedlings on 1 March. Hop clover only grew into very small plants. They showed symptoms of drought fairly early and looked worse than the Douglas fir but had an ability to remain alive for a long time and to revive when placed in the water pan. Burnet was intermediate in its competitive affect, but outlasted the Douglas fir seedlings. The velvet grass showed signs of wilting but had a capacity to endure the conditions and revive and outlast the Douglas fir. The Douglas fir seedlings with annual blue grass lasted longest of all. The grass formed a sod on top of the can which was quite difficult to separate when washing out the roots. This characteristic might have value for erosion control. The blue grass flowered quite early and at the beginning of March the plants in all the pots were in flower. The last readings were taken in early May when all the Douglas fir seedlings had died and most of the blue grass. The few survivors were looking very sickly. This was six weeks later than Douglas fir mortality with vetch. The blue grass was the most shallow rooted of the cover crops and Douglas fir survival was best with blue grass. However, the plants are small and their form is such that they do not look as if they could give shade to the Douglas fir seedlings. This observation was later confirmed in the field.

The results are summarized in Table 2.

Table 2. Competition between Douglas fir seedlings and cover crop plants

Cover crop	Moisture depletion	First plants to die
Native mustard	moderate	?
India mustard	moderate	?
Annual blue grass	slowest	annual blue grass
Velvet grass	fairly rapid	Douglas fir
Hop clover	moderate	some of each
Burnet	moderate	Douglas fir
Common vetch	rapid	Douglas fir
Hairy vetch	rapid	Douglas fir

PHOTOPERIOD EXPERIMENT

Flats of the cover crop plants and of Douglas fir were grown under short day and long day conditions in burned and unburned forest soil. The burned soil was obtained from a recent slash burn on Mary's Peak. The short day treatment was the natural day length during the period February, March and April which increased from eleven to twelve hours during this time. The sixteen-hour day was obtained using a time-clock-operated tube light. If a cover crop would germinate, grow and mature under the short day conditions which prevail early in the year it would be an advantage. Unfortunately the greenhouse was maintained at about 70°F. and so that while the day length was typical of conditions early in the year, temperature was not.

The flats were seeded on 4 February, 1956, and watered regularly and the soil kept at approximately field capacity so that moisture was never a limiting factor. After five days under all conditions germination of India mustard, hop clover and velvet grass was well under way. Germination of native mustard and annual blue grass was starting. The radicles of the two vetches were emerging from the seed coat. However, there was no sign of activity of the burnet and Douglas fir. After one month the beneficial effect of the long day was becoming apparent. Plants were generally taller than those under the short day treatment. Douglas fir germination was markedly improved. There was some damping off on all four treatments. It is impossible to account for this or even know if it is due to

Figure 10. Competition experiment in the greenhouse.
1 March 1956.
L. to R. Native mustard, Poa, Hop clover, Common vetch, Velvet grass, Burnet, Hairy vetch, India mustard.

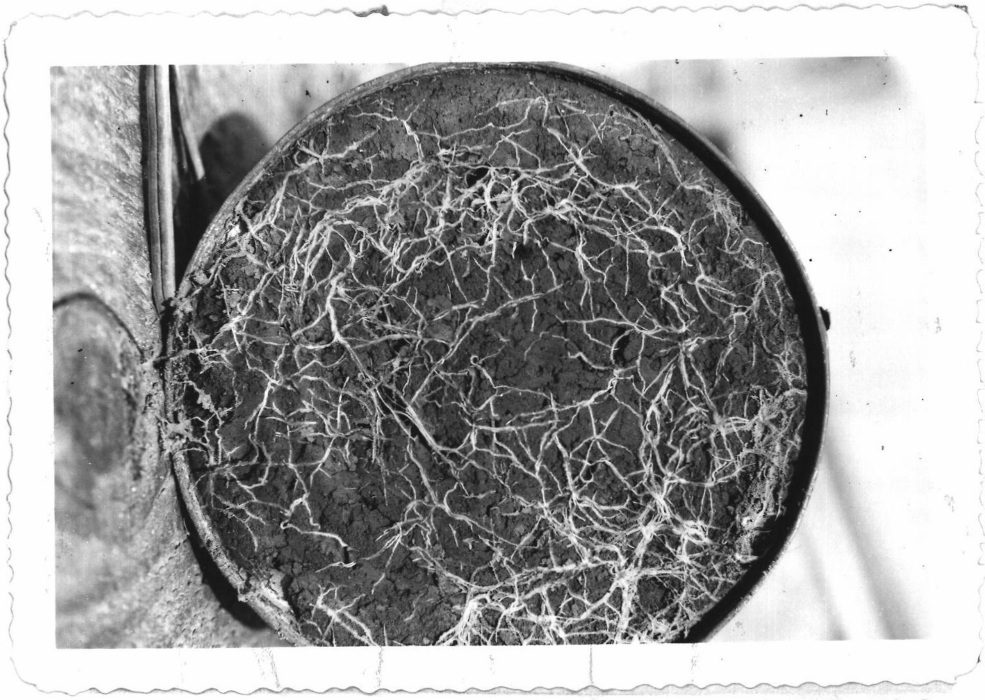


Figure 11. Bottom of can cut away to show extent of vetch roots. April 1956.

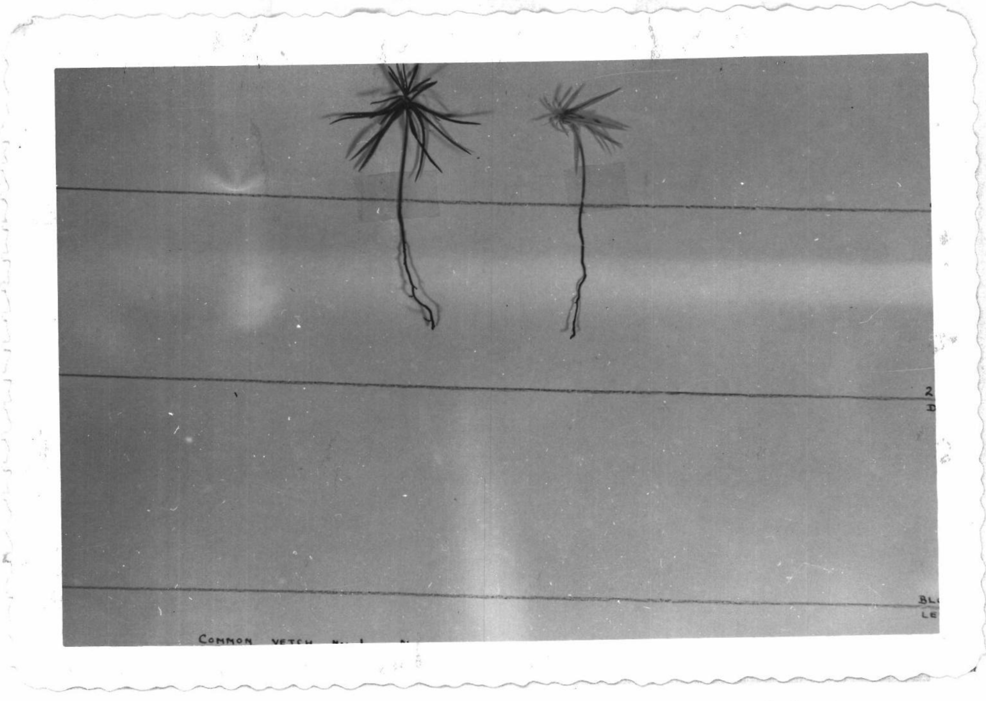


Figure 12. Development of Douglas fir roots when grown in competition with vetch. April 1956.

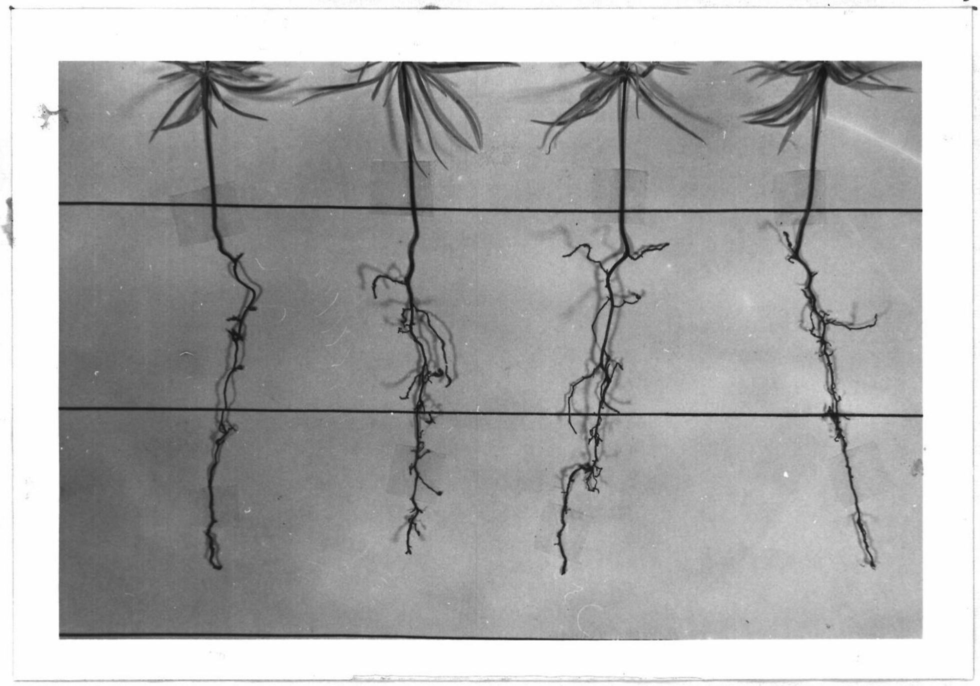


Figure 13. Development of Douglas fir roots when grown in competition with Poa. April 1956.

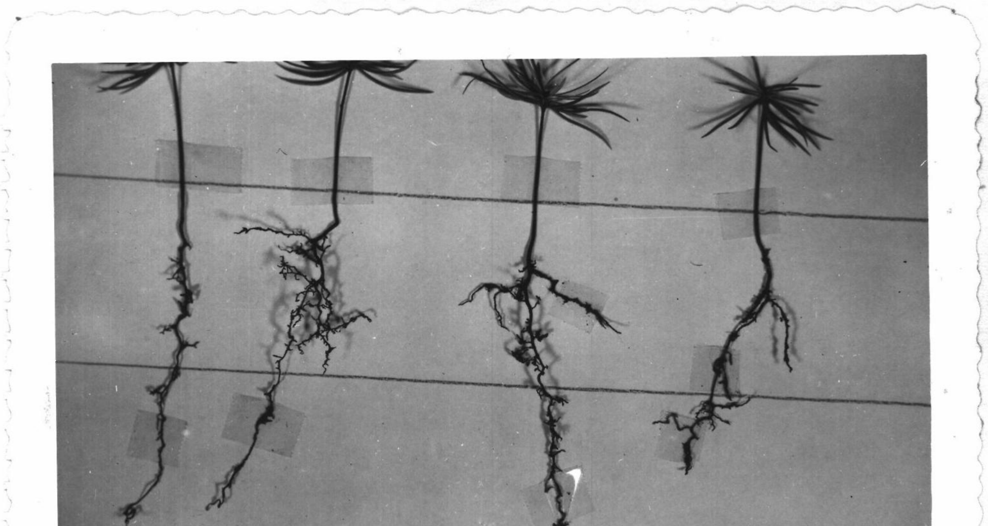


Figure 14. Development of Douglas fir roots when grown in competition with native mustard.

the conditions of the experiment or due to outside influences since the greenhouse is used by many people including pathologists doing inoculation experiments. Figures 15 - 22 show the long and short day plants on the burned soil on 7 April, 1956. Growth was greater under long day conditions but it is interesting to see that the annual blue grass flowered first under short day conditions but not under the long day, where flowering was about two weeks later. By the middle of April the native mustard, India mustard and common vetch were in flower under long day conditions. Later in the month the hop clover flowered. The native mustard flowered under short day conditions but this and the annual blue grass were the only species to flower under short day conditions before the experiment concluded in May even after running for over three months. The response to day length is summarized in Table 3.

Table 3. Response of cover crop species to day length after ten weeks.

Species	12-hour day	16-hour day
Native mustard	flowering	flowering
India mustard	not flowering	"
Annual blue grass	flowering	not flowering*
Velvet grass	not flowering	"
Hop clover	"	"*
Burnet	"	"
Common vetch	"	flowering
Hairy vetch	"	not flowering

*Flowering evident one week later, 24 April.

Growth of all species was better on burned soil than on unburned soil.

The performance of annual blue grass appeared promising in the drought study and the photoperiod study but the seed laboratory tests showed that low temperature limited germination.

FIELD TRIALS

Field trials were carried out in three areas. Two of the field trials were on the Mary's Peak area in the Siuslaw National Forest and one on O. and C. land southwest of Roseburg. For the sake of clarity, each area is described separately.

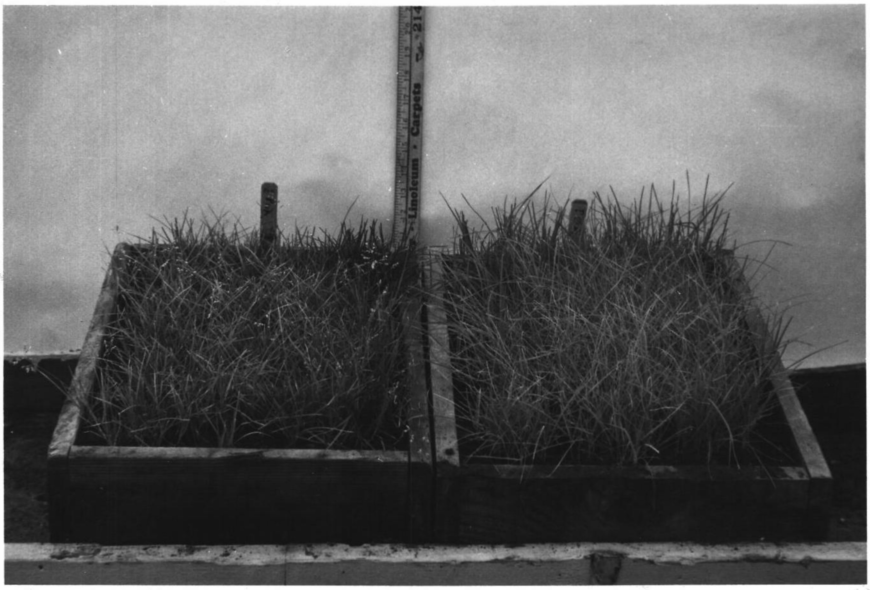


Figure 15. Annual blue grass. Note flowering of short day plants on the left. 7 April 1956.

Figure 16. Velvet grass.

Figure 17. Hairy vetch.

Figure 18. Common vetch.

Figure 19. India mustard. Note long day plants on the right in flower.

Figure 20. Native mustard. Long day and short day plants in flower.

Figure 21. Hop clover. Note greater growth of long day plants on the right.

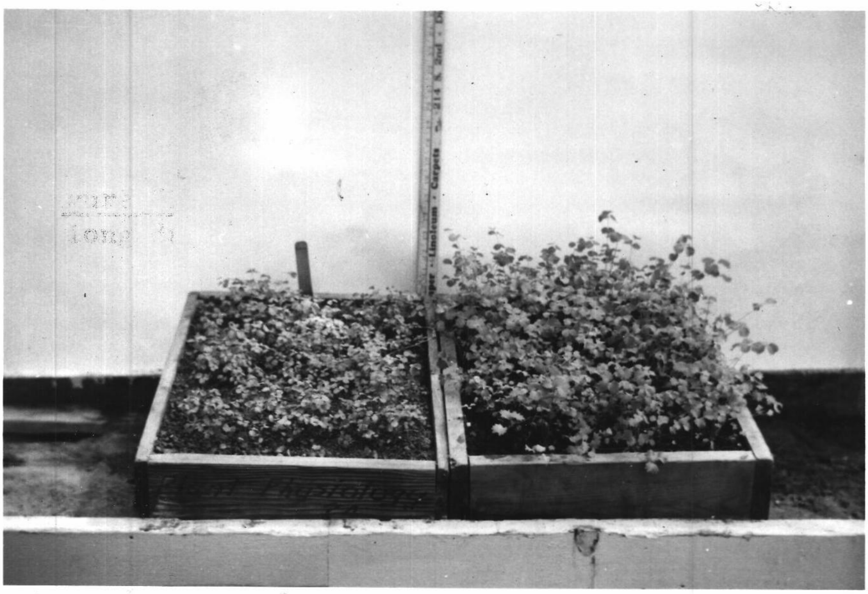


Figure 22. Burnet. Note greater growth of long day plants on the right.

PLOT LOCATION AND DESCRIPTION

1. Wilt Area: Known to the Forest Service as such after the operator who purchased the timber.

Location: Situated on the City of Corvallis watershed on the Siuslaw National Forest. T 12 S. R 7 W. Section 22.

Description: Small setting of about 20 acres at an elevation of 1700-1800 feet with an average slope of 18 percent. The plots were situated on a portion of the setting which had a gentle southerly aspect.

History: Douglas fir-Western hemlock stand logged in 1954-55. The slash was burned in September 1955 after a heavy rain. The burn was of moderate intensity (Tarrant 26).

Soil description: The soil is an Olympic clay which was formed from residual basalt and is relatively free from stones. An examination of the area was made by Dyrness (10). He found no soil erosion. There was 8.7 percent of stones, by weight, in the top two inches of soil. A survey showed the area covered by the burn to be:

Lightly burned	54.8 percent
Severely burned	16.1 percent
Unburned but disturbed	21.3 percent
Undisturbed	7.8 percent

This is a higher proportion of severely burned area than that reported by Tarrant (27) in a more extensive study.

However, on that portion of the area used in the experiment, severely burned portions were less frequent than on the rest of the setting and only occurred where the fire had burned hot under a log. The total organic matter, expressed as a percentage, was as follows:

Surrounding green timber	10.7
Severely burned	4.5
Lightly burned	10.4
Unburned	10.9
Undisturbed	12.2

This shows no important difference between the green timber, lightly burned and unburned areas.

The following plants formed the major part of the vegetation on the area:

Oregon grape	*Mahonia aquifolium* Pursh.
Thistle	*Cirsium edule* Nutt.
Salal	*Gaultheria shallon* Pursh.
Vine maple	*Acer circinatum* Pursh.
Grass	*Deschampsia elongata* (Hook) Munro.
Groundsel	*Senecio vulgaris* L.
Swordfern	*Polystichum munitum* (Kaufl.) Presl.
Bracken fern	*Pteridium aquilinum* (L.) Kuhn. var *pubescens* Underw.
Bedstraw	*Galium aparine* L.
Thimbleberry	*Rubus parviflorus* Nutt.
Golden chinquapin	*Castanopsis chrysophylla* (Hook). A. de Candolle.

2. Albertsen Area: Known to the Forest Service as such after the operator who purchased the timber.

Location: Situated just outside the City of Corvallis watershed on the Siuslaw National Forest. T 12 S R 7 W. Section 34.

Description: A small setting of about 20 acres at an elevation of 2200 feet. The landing is on a fairly level ridge running nearly halfway across the setting. The ground drops away sharply on three sides.

History: Douglas fir-Western hemlock stand logged in 1954-55. The slash was burned in October 1955. The burn was fairly complete and of light to moderate intensity except for the landing where the concentration of fuel produced a hard burn. No plots were in this area.

Soil description: The soil is an Olympic rocky clay loam. It is not too different from that on the Wilt Area.

Vegetation: This is very similar to that on the Wilt Area.

3. Roseburg Area:

Location: Situated about 10 miles southwest of Winston, on Suicide Creek on O. and C. land. T 28 S. R 8 W. Section 27.

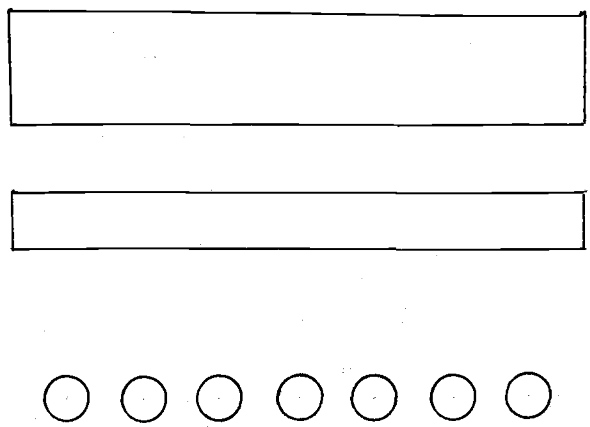
Description: A small setting of 15-20 acres at an elevation of 1400-1500 feet.

History: A predominantly Douglas fir stand with a volume of about 35 MBF/acre cat logged in 1954-55. The slash was burned on 28 September, 1955, and the burn was clean and of moderate intensity. Incense cedar, Libocedrus decurrens Torr, and sugar pine, Pinus lambertiana Dougl. are minor components of the stand. The soil is an Aiken clay loam with relatively few stones.

PLOT LAYOUT

The plot layout was essentially the same on each of the three areas. On each area, three strips 200 feet by 25 feet were staked out, and were seeded with treated Douglas fir seed and India mustard, Brassica juncea. Details are given in a later section. Ten circular milacre plots were established on each strip for detailed examination. These were established during the winter, some months before germination, in order to eliminate any possible personal bias. On the Wilt and Albertsen Areas, control strips 200 by 10 feet were laid out parallel to those seeded with mustard as shown below.

Figure 23. Diagrammatic representation of plot layout on Wilt and Albertsen Areas (not to scale).
This design was replicated three times on each area.



The control strips were seeded with treated Douglas fir seed but no mustard in order to provide a comparison between the two treatments. This layout was not necessary on the Roseburg Area as here the whole setting was seeded with treated Douglas fir seed.

Plots to test seven other possible cover crops were replicated three times on each experimental area. Each plot was circular with a radius of 4½ feet and within this was established a circular milacre plot, radius 3 feet 8.7 inches, with a margin about 9 inches wide to allow for any edge effects.

SEEDING

1. Wilt Area.

Two strips were seeded with India mustard at the rate of 35 lbs. per acre on 11 October, 1955. The third strip was seeded at the same rate on 4 November, at the time when a further supply of mustard seed was received from the B.L.M.

This area was seeded with Endrin* methocel rhoplex treated Douglas fir seed at the rate of 1½ lbs. per acre and an overlay of "1080"+ treated wheat on 24 January, 1956. Seeding was done with cyclone seeders on about four inches of snow.

The circular plots were seeded with poisoned Douglas fir seed and seed of the seven cover crop species, on 4 November.

2. Albertsen Area.

The three strips were seeded with India mustard at the rate of 35 lbs. per acre on 21 October, 1955. The same strips were seeded with Endrin* methocel rhoplex treated Douglas fir seed at the rate of 1½ lbs. per acre and an overlay of "1080" treated wheat on 31 January, 1956. Seeding was done with a cyclone seeder on about thirty inches of snow. The circular plots were seeded with poisoned Douglas fir seed and seed of the seven cover crop species on 21 November. The seed for the Wilt and Albertsen Areas was supplied by the B.L.M. and was collected in 1954 on the Siuslaw National Forest at 2000 feet elevation. The seed was treated by N.B. Kverno of the U.S. Fish and Wildlife Service.

3. Roseburg Area.

Ten acres were seeded with Endrin* methocel rhoplex treated Douglas fir seed at the rate of 1½ lbs. per acre on 29 October, 1955. The three strips were seeded with India mustard at 35 lbs. per acre on the same day. The circular plots were seeded with poisoned Douglas fir seed and seed of the seven cover crop species on 29 October. The seed was obtained from the Manning Seed Company and was collected in 1954 from T21 South, R1 East at 1000-2000 feet elevation. It was treated by N.B. Kverno.

*Endrin. active ingredient. Hexachloroepoxyoctahydro-endo, endo-dimethano naphthalene.

+Compound "1080". Sodium fluoroacetate.

TEMPERATURE AND MOISTURE MEASUREMENTS

Bouyoucos block were buried at four inch and twelve inch depths on milacres 2, 3, 4, 7, 8, and 9 on the mustard seeded plots and on the same numbered milacres on the control plots on all three areas in the early spring of 1956. Maximum thermometers were placed on milacres 2, 3, and 4 on the mustard and control plots. Results are discussed in a later section.

FIELD RESULTS

GERMINATION AND SURVIVAL

1. Wilt Area

The mustard germinated promptly in the fall of 1955, and by the middle of December the ground was almost completely covered by a green carpet of plants in the rosette stage. Some mortality and a certain amount of frost heaving was caused by the abnormal cold spell of early November and most of the surviving mustard plants were subsequently winter killed. Additional spring germination of mustard was poor and made a poorly stocked stand with little prospect of providing any shade for the fir seedlings. Consequently strip No. 3 was reseeded with mustard and all three strips reseeded with stratified poisoned Douglas fir seed with an overlay of "1080" treated wheat.

The reseeding of the mustard was again unsuccessful; mainly on account of poor germination, slow growth and browsing by deer. Figure 24 shows a typical part of the area in mid-June. The mustard plants had not matured and were still green at the end of the summer.

The germination of Douglas fir was also unsatisfactory; however, some delayed germination may occur in 1957. By the end of the summer of 1956, 146 Douglas fir seedlings had been tallied on the milacres with no mustard, and 108 on those with a mustard crop.

A survival count on 2 November, 1956, showed that early germinating seedlings survived better than the late germinates as is shown in Table 4.

Table 4. Date of germination of Douglas fir seedlings surviving on 2 November, 1956.

	Number of Douglas fir seedlings surviving on 2 November, 1956.									
	Mustard cover crop					No mustard				
Date of germination	May 18	May 29	June 9	June 18	Total	May 18	May 29	June 9	June 18	Total
Strip No.										
1	4	2	0	2	8	5	0	0	1	6
2	0	11	5	3	19	3	9	2	0	14
3	9	4	3	1	17	7	5	1	2	15
Total by dates	13	17	8	6	44	15	14	3	3	35

OTHER COVER CROPS

Results obtained from the seeding of the other cover crops were likewise disappointing. On 12 December, 1955, there was some scattered germination of hop clover, native mustard and velvet grass but no germination of common vetch, hairy vetch, annual blue grass or burnet. By the 19th of April, the two grasses were producing a fair covering but were too small to provide any shade. There were only a few small scattered plants of the other species. As the first sowing of poisoned Douglas fir seed and cover crop seed was a failure, all the plots were reseeded on the 27th of April with stratified poison Douglas fir seed and soaked seed of the various cover crops. The situation on 18th June was as follows.

Common vetch. A few small scattered plants, some of which had been browsed.

Hop clover. A considerable number of plants ranging from very small seedlings to plants five inches high and in flower, but not producing a stand that gave sufficient cover.

Annual blue grass. A fair stand, mostly in flower and giving a little cover.

Native mustard. Quite a good distribution of plants but very small with some browsing.

This shows that none of the tested species produced a stand capable of providing adequate cover for the Douglas fir seedlings with the possible exception of annual blue grass; of prime importance is the fact that all cover crops developed much too late to shade the Douglas fir seedlings, many of which had germinated over a month previously.

2. Albertsen Area.

This plot is at a higher elevation than the Wilt plot and the mustard was seeded later in the fall and consequently there was very little germination by mid-December, 1955. By mid-April, 1956, there was very little germination of the mustard, although mustard seed could be seen on the ground. The green-dyed poisoned wheat and aluminum-colored poisoned Douglas fir seed were easily visible and the distribution appeared good. None of the latter had germinated. The mustard was very slow developing and did not produce a good stand until well into the summer. The germination and growth of the Douglas fir on this area was very poor and warrants further investigation. This may be due to the late development of the mustard cover crop which allowed drying out of the seedbed. Only 15 Douglas fir seedlings were found on the 30 milacres on the three mustard seeded strips and the same number on the control strips. As seeds were seen on the ground through the spring and summer, it can safely be assumed that rodent depredation was not responsible. The seed was of good quality and of the correct provenance. Climatically, the year was not abnormal. Much of the current logging in the Pacific

Northwest is at elevations similar to this area and in many ways the area can be classed as "typical", yet at a relatively high rate of seeding, the resulting stocking was very poor.

The results of the seeding of the other cover crops on the circular plots was also poor. By mid-April, the two grasses were starting to germinate but the two vetches and the burnet had only a few seedlings each and there was nothing on the native mustard and hop clover plots. All the circular plots were reseeded with poisoned stratified Douglas fir seed and soaked cover crop seed in early May, but no worthwhile results were subsequently obtained.

3. Roseburg Area.

The strips were covered by a well distributed cover of mustard plants one to three inches tall at the end of March. The plots are on a moderately steep south slope as can be seen in the various photographs, especially Figure 33 which gives an overall view of the three strips. Although the annual rainfall in this region is just over thirty inches, the winter of 1955-56 was characterized by excessively heavy rainfall with disastrous floods. Twice during the winter, there were rainfall intensities of over five inches in a twenty-four hour period and although the slash fire the previous September produced a clean burn, the mustard showed no sign of washing. This is an interesting point which could have great significance.

The mustard grew rapidly during April and on the 21st of April averaged about one foot high as can be seen in Figure 30. By the end of the month it was two to three feet high and flowering. On the 5th of May, one-half of each strip of mustard was sprayed with the butyl ester of 2,4-D at the rate of three-quarters of a pound per acre. One half of each strip with no mustard was also sprayed at the same concentration on the same day. A good kill of mustard was obtained and the dead mustard stand provided some dead shade with no competition for soil moisture during the rest of the summer as is shown in Figure 30.

The Douglas fir seed germinated rapidly during the last two weeks of April and the first week of May. Detailed counts on each milacre are given in the Appendix (Tables 27 and 28). A summary of germination on the mustard and no mustard plots is given in Tables 5 and 6 below.

Table 5. Roseburg Area. Summary of Douglas fir germination on the strips seeded with mustard.

Date of exam.	Seedling Condition				Total germ. to date	Live seedlings per ma.
	Thrifty last exam.	Dead	New	Thrifty this date		
14 April	-	-	-	94	94	3.1
21 April	94	24	79	149	173	4.9
5 May	149	19	95	225	268	7.5
19 May	225	54	17	188	285	6.3
31 May	188	19	10	179	295	5.9
16 June	179	28	6	157	301	5.2

Table 6. Roseburg Area. Summary of Douglas fir germination on the strips without mustard.

Date of exam.	Seedling Condition				Total germ. to date	Live seedlings per ma.
	Thrifty last exam.	Dead	New	Thrifty this date		
14 April	-	-	-	66	66	2.2
21 April	66	16	28	78	94	2.6
5 May	78	14	15	79	109	2.6
19 May	79	16	1	64	110	2.1
31 May	64	14	0	50	110	1.7
16 June	50	5	0	45	110	1.5

Two important and interesting factors can be seen in these two tables.

1. The amount of germination is nearly three times as much under mustard as without a cover crop.

2. Germination of Douglas fir is earlier in the open without mustard. These factors require further research. A possible explanation may be that the seeds in the open receive more heat quicker and so germinate early. Soil surface temperatures are given in Table 13. However, if the weather remains hot, as it was in April, the seeds which have not already germinated, dry out before they can germinate and return into a type of dormancy. They will probably germinate later under the correct combination of conditions. By contrast the seeds under the mustard cover are slower to obtain the heat required for germination and are also less susceptible to excess drying.

Table 7 below shows the percentage of final germination of Douglas fir that had occurred at various dates with and without a cover crop.

Table 7. Roseburg Area. Percentage of total Douglas fir germination by dates with and without a cover crop.

Date of examination	Percent of total germination	
	Mustard cover	No mustard
14 April	31.1	60.0
21 April	26.3	25.5
5 May	31.6	13.6
19 May	5.7	0.9
31 May	3.3	0.0
16 June	2.0	0.0

Survival up to mid-summer, that is during the period when seedling losses due to isolation might be expected to be most severe, was better under mustard than in the open.

Table 8. Roseburg Area. Seedling survival with and without mustard up to 16 June.

Seedbed condition	Total germ.	Mortality	Live seedlings	Percent survival
Mustard cover	301	144	157	52.1
No mustard	110	65	45	40.9

It was important to test the effect of the 2,4-D on the young Douglas fir seedlings. It was rather difficult to assess this as it was not possible to separate losses due to spraying from losses due to other causes. If it can be assumed that the mustard cover crop would intercept most of the spray, then if the spray was harmful, the Douglas fir seedlings with no cover crop would suffer much heavier mortality from the herbicide than those seedlings under the cover crop, but the figures do not show this to be true. Field observations showed no obvious effect of the 2,4-D on the Douglas fir seedlings but the mustard plants literally curled up and died. Survival of sprayed and unsprayed Douglas fir seedlings to 16 June, with and without mustard cover, is given in Table 9.

Table 9. Roseburg Area. Survival of sprayed and unsprayed seedlings with and without mustard cover.

	Number of live Douglas fir seedlings					
	Mustard cover			No mustard		
	5 May	16 June	Percent survival	5 May	16 June	Percent survival
Sprayed	119	63	52.9	51	24	47.0
Unsprayed	106	94	88.6	28	21	75.0

The above figures indicate that spraying had more effect on tree seedling survival than presence or absence of a cover crop.

Survival over the whole summer was poor. A survival count was made in mid-September and the results are given in Table 10, which shows that mortality under unsprayed mustard was very high. This point is discussed further under moisture measurements. It shows very forcefully the potential danger of a cover crop. The situation is analogous to seeding a high site where weed growth is heavy. Survival under the other three conditions was also poor. The plots with sprayed mustard ended up with the greatest number of seedlings due to their initial higher stocking. If this advantage could have been maintained, it would have resulted in greatly increased stocking at the end of the first year.

Table 10. First year survival of Douglas fir seedlings on sprayed and unsprayed plots, with and without mustard cover.

	Mustard cover		No mustard	
	Sprayed	Unsprayed	Sprayed	Unsprayed
Total germ.	151	150	72	38
No. survivors	20	2	12	6
Percent survival	13.2	1.3	16.6	15.7

Detailed observations on the seven different cover crops tested on the circular plots are given in the Appendix.

In general, none of the plants tested appeared too promising. Both vetches produced only a few straggling plants which gave no shade. In view of their behaviour in the greenhouse tests, a stand of vetch thick enough to give any shade would probably be very competitive for soil moisture.

Burnet produced only a few scattered plants giving no cover, and hop clover was very similar. Annual blue grass did provide a little cover locally, but it is such a small plant that it would have to be very thick to give any shade and if it was that thick it might provide too much competition.

Velvet grass looks very promising in Figure 32, but it was very late growing and was not advanced enough to give the fir seedlings shade when they really needed it. Its bunchy habit of growth might be a disadvantage. Also, it is very vigorous and had nearly doubled in area by the following year so would be very competitive with the Douglas fir seedlings.

Native mustard appeard to be the most promising species. It has a branching habit of growth which gives more overhead cover per stem. Figure 36 shows the typical form of native mustard in contrast to the typical form of India mustard as shown in Figure 34. Native mustard will seed itself and establish another crop the following year while India mustard will not do this. Observations on the seven plants on the circular plots and on the India mustard on the strips are given in Table 11 below.

Table 11. Field observations and evaluation of the cover crops tested.

Species	Early vegetative growth	Provides good cover	Early maturity	Shallow rooted
India mustard	Uniformly early	Yes	Moderate	Moderate 8-10 in.
Native mustard	Growth early but not uniform	Yes	Moderate	No. 9-12 in.
Annual blue grass	Uniform early growth	Cover too low	Yes	Yes. 4 in.
Velvet grass	Slow	Cover tends to be in bunches	No	Moderate
Burnet	Moderate in early growth	Cover is patchy	No	No
Hop clover	Slow	No cover, patchy stand	Moderate	Moderate 7-9 in.
Hairy vetch	Moderate in early growth	Cover too open	Moderate	Moderate 8-9 in.
Common vetch	Moderate in early growth	Cover too open	No	Moderate 8-9 in.

An important point to consider in choosing a cover crop is its acceptance by rodents. The cover crop is sown at a time when natural food is becoming scarce and if it is readily eaten, all its other advantages are of no account. This phase of the investigation was undertaken by Mr. Edward

Hooven, Research silviculturist, Oregon State Board of Forestry. Results of these tests are summarized in Table 12.

Table 12. Acceptance of cover crop seeds by the white footed deer mouse (*Peromyscus maniculatus*.)

Plant species	Mouse response
India mustard	Rejected for other food.
Native mustard	" " " "
Annual blue grass	Eaten readily.
Velvet grass	" "
Burnet	" "
Hop clover	" "
Hairy vetch	Uneaten. Too large or too hard.
Common vetch	" " " "

Mr. Hooven added that the vetch seed might become acceptable after it was softened by weathering. This phase was prompted by the finding of hulled burnet seed on the Albertsen Area in December. The hulling was characteristic of white footed deer mouse activities. Probably the seed of other species had been hulled but their small size made them difficult to find in the field.

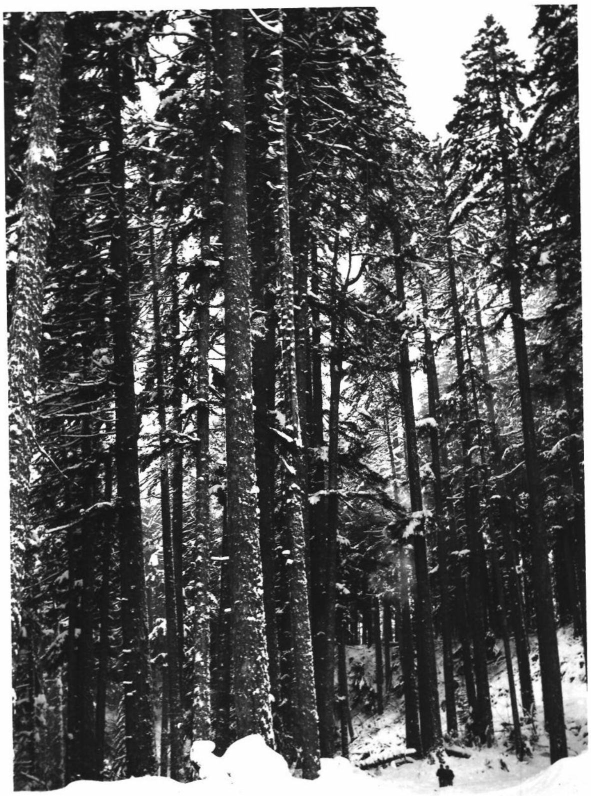


Figure 24. Surrounding green timber. Albertsen Area. January, 1956.

Figure 25. Wilt Area. Slow development of mustard. 18 June, 1956.

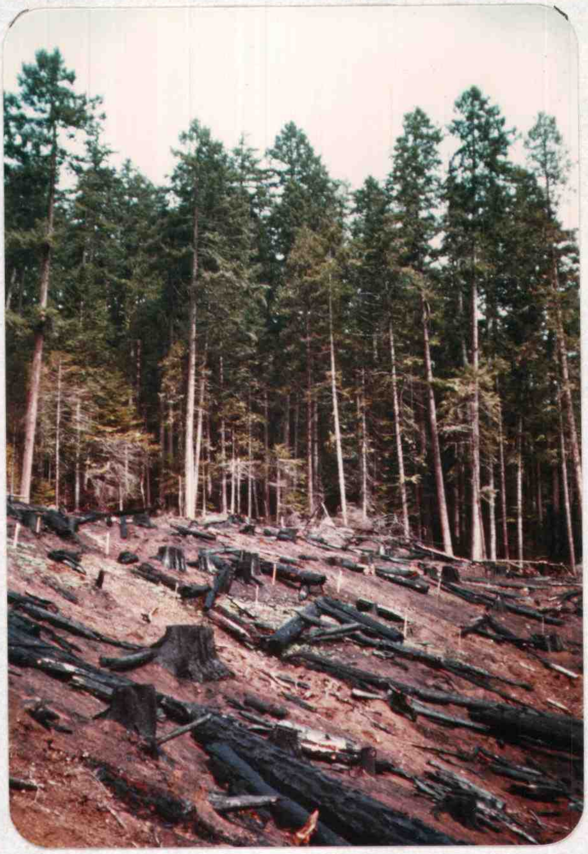


Figure 26. Surrounding green timber. Roseburg Area. 14 April, 1956.

Figure 27. Mustard in early April on the Roseburg Area.

Figure 28. Roseburg Area. 21 April, 1956. 9 marked seedlings on bare ground. No mustard.

Figure 29. Roseburg Area. 21 April, 1956. Typical bare seedbed. No mustard.

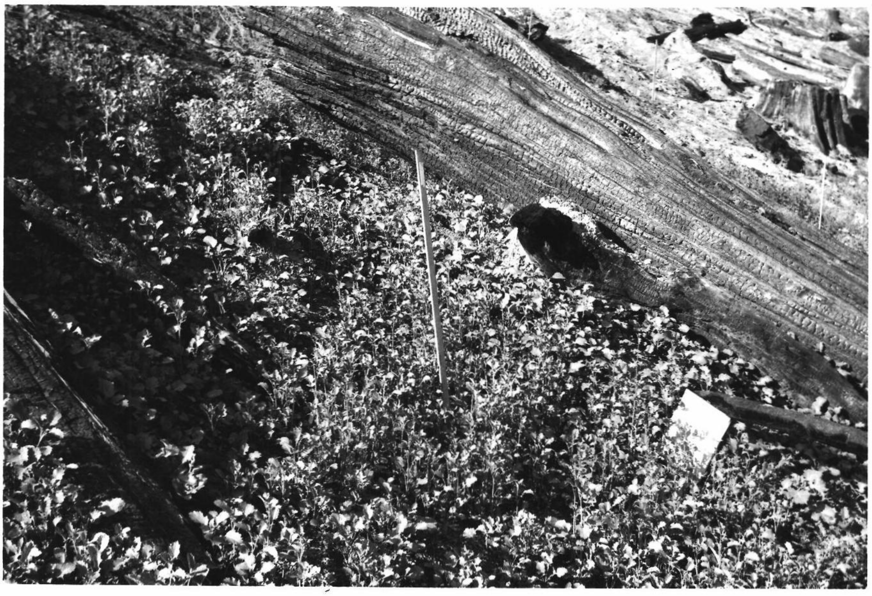


Figure 30. Growth of mustard in late April on the Roseburg Area. 21 April, 1956. (notebook is 10 inches high).

Figure 31. Native mustard in April on the Roseburg Area. 21 April, 1956. (stake is about 3 feet high).

Figure 32. Roseburg Area. 21 April, 1956. Annual blue grass. Plants are too small and too scattered to shade the Douglas fir seedlings.

Figure 33. Roseburg Area. 5 May, 1956. Mustard in flower on the three strips.

Figure 34. Thick stand of mustard in flower on the Roseburg Area. 19 May, 1956.

Figure 35. Seedling on typical burned seedbed with no mustard cover. Roseburg Area. 19 May, 1956.

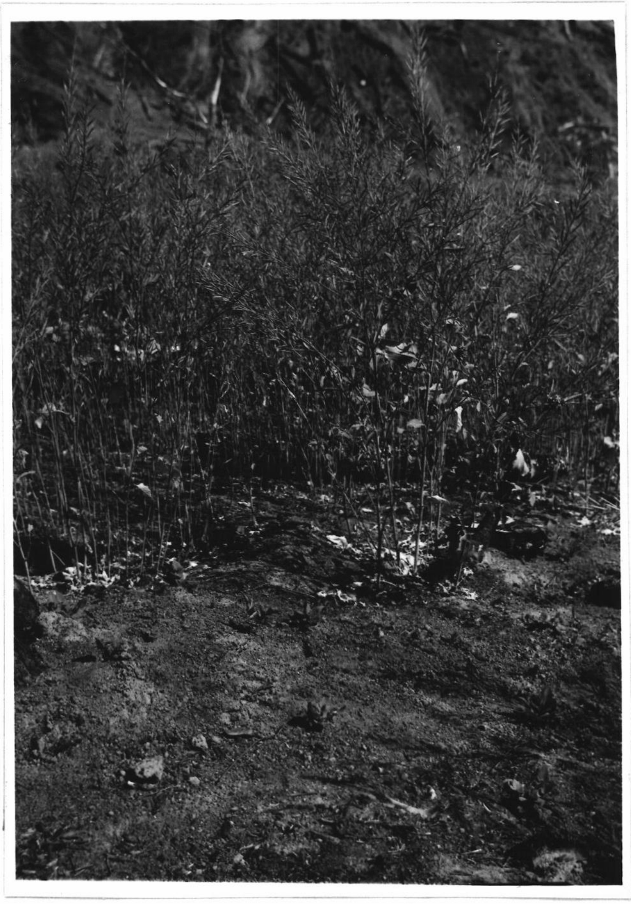


Figure 36. Native mustard on the Roseburg Area. Note branching habit of growth. 16 June, 1956.

Figure 37. (below) Sprayed India mustard on the Roseburg Area. 16 June, 1956.

TEMPERATURE AND MOISTURE MEASUREMENTS

1. Wilt Area

There was not sufficient mustard growth on the Wilt Area to give any shade and so provide any comparison between soil surface temperatures under mustard and in the open. However, the readings obtained are interesting as they give an idea of the temperatures which occur on a typical logged and burned setting. The temperatures given in Table 13 below are maximums reached since the previous reading. These were obtained by laying maximum thermometers flush on the ground and always replacing them in the same place after reading them.

Table 13. Maximum soil surface temperature in degrees Fahrenheit.

Date	Under mustard	No mustard
16 May	136.2 (6)	136.2 (8)
18 May	139.9 (8)	145.4 (9)
29 May	132.3 (9)	137.8 (9)
18 June	120.4 (9)	118.4 (7)
11 Sept.	153.2 (9)	158.2 (8)

Figures in parenthesis indicate the number of readings on which the average is based.

These readings show that temperatures in the lethal range occurred in the third week of May when newly germinated seedlings would be tender. The fact that low temperatures occurred in the succeeding few weeks is immaterial if the seedlings have already been killed. Much higher temperatures were recorded later in the summer but by that time the seedlings are probably much tougher and can endure them. At this stage the problem is complicated by drought, and the interaction of these two factors requires further investigation.

2. Albertsen Area.

On the Albertsen area an average soil surface temperature of 141.2°F., based on 18 readings, was obtained on 22 May. Owing to the poor germination and growth on this area, as reported in an earlier section, the thermometers were removed and used elsewhere.

3. Roseburg Area.

Maximum soil surface temperatures were recorded at fortnightly intervals during the two month period from mid-April to mid-June. Average maximum temperatures, based on nine instruments, are given in Table 14 below.

Table 14. Roseburg Area. Maximum soil surface temperatures under mustard and in the open from April to June, 1956.

Soil Surface Temperature in °F			
Date	Under mustard	No mustard	Difference
14 Apr.	109	115	6
21 Apr.	117	131	14
5 May	123	124	1
19 May	134	149	15
31 May	130	139	9
16 June	142	143	1
16 June	134*		9

* Under mustard sprayed with 2,4-D on 5 May.

These figures show that the temperature was consistently lower under the mustard cover than in the open. Figures 28, 29 and 35 show typical examples of bare ground without mustard. If 138°F. is considered a lethal temperature for young fir seedlings, it is interesting to note the number of readings above that level under mustard and in the open. These are given in Table 15.

Table 15. Roseburg Area. Number of times soil surface temperature exceeded 138°F.

Date	Under mustard	No mustard
14 April	0	0
21 April	0	2
5 May	0	1
19 May	3	9
31 May	3	5
16 June	7	6

These figures are difficult to interpret. During the period 5 May - 16 June, when the temperature exceeded 138°F. twenty-one times on the plots without mustard compared with thirteen times on the mustard plots, there was no marked difference in the seedling mortality under the two conditions. The temperature readings were on the unsprayed portion of the plots so there was no effect due to spraying. Either the sample was insufficient to give any accurate indication or seedlings can withstand higher temperatures than was previously expected. This aspect requires further investigation. The reliability of using mercury in glass thermometers to measure soil surface temperatures is also open to question.

A cover crop is likely to be a two-edged weapon. While it may give shade to newly germinated seedlings and protect them from injury by insolation, it is also likely to be a serious competitor for soil moisture. This problem is likely to get more serious as summer advances and soil moisture reserves are depleted. As previously stated, Bouyoucos blocks were buried at four and twelve-inch depths in the spring on a number of milacres. No soil moisture readings were made on the Albertsen Area and only a few on the Wilt Area. Owing to the slow growth of the mustard and the constant browsing on the latter area, there was not sufficient growth of mustard to show any difference between treatments and these readings are not included. However, the excellent mustard stand on the Roseburg Area produced interesting results, where an ohms-resistance reading of 600-900 ohms indicates the range of field capacity, 900-75,000 ohms indicates the range of available moisture, and over 75,000 ohms, the permanent wilting point ending in seedling mortality.

Moisture appeared to be readily available at four and twelve-inch depths on the Roseburg plots during April and the first three weeks of May as is shown in Table 16. But by the end of May, moisture reserves under mustard at a depth of four inches were depleted and remained so during June and July. This did not occur in the open without the mustard cover crop.

Table 16. Mean ohms-resistance readings at 4" and 12" depths under mustard and without mustard from 14 April to 25 July, 1956, on plots not sprayed with herbicide.

Date	No mustard		Under mustard	
	4"	12"	4"	12"
14 April	800	850	1,028	830
21 April	853	660	2,700	960
5 May	800	720	7,500	6,730
19 May	670	570	27,200	17,300
31 May	3,320	620	185,870	43,670
16 June	2,300	1,700	161,300	86,000
25 July	72,000	13,690	754,000	114,000

Each reading is an average based on 9 observations.

Precipitation occurred immediately before spraying with 2,4-D on May 5 so that subsequent moisture depletion with and without mustard should have started from an equal level. Readings taken three and a half weeks later on May 31 show the effectiveness of the herbicide treatment in reducing soil moisture losses due to the cover crop. Moisture was in greater abundance on mustard plots sprayed with 2,4-D than on unsprayed plots as is shown in Table 17. Even on plots without mustard the 2,4-D spray killed competing weeds which resulted in less soil moisture depletion.

Table 17. Effect of 2,4-D spray on ohms-resistance readings at 4" and 12" depths on 31 May.

	Herbicide treatment	Under mustard		No mustard	
		4"	12"	4"	12"
Strip 1	Control	36,000	20,100	4,200	680
"	Sprayed	17,600	5,300	1,300	620
Strip 2	Control	89,000	60,300	4,000	600
"	Sprayed	13,000	2,300	1,100	650
Strip 3	Control	144,000	80,600	1,600	590
"	Sprayed	15,000	21,780	2,800	580

Each reading is an average based on 3 observations.

Readings taken on the 25th of July on sprayed and unsprayed mustard as well as on the plots without mustard, show very clearly the value of killing the cover crop. The readings on the unsprayed mustard are very high and well within the range of permanent wilting, as is shown in Table 18. Proof of the effect of the heavy moisture depletion under mustard is seen in the poor survival of Douglas fir seedlings under unsprayed mustard (Table 10).

Table 18. Effect of 2,4-D on ohms-resistance readings at 4" and 12" depths on 25 July.

Treatment	Under mustard		No mustard	
	4"	12"	4"	12"
Not sprayed	754,300	114,300	72,000	13,690
Sprayed	119,500	43,630	13,000	4,350

Each reading is an average based on 9 observations.

DISCUSSION

The germination study in the seed laboratory showed that both species of vetch would germinate quickly at low temperatures but the greenhouse experiment showed them to be very severe competitors. Hop clover, burnet and velvet grass germinated fully at low temperatures although the rate of germination was slower, but field trials showed all three to be unsatisfactory although velvet grass might be called the best of a poor collection. India mustard and native mustard were undoubtedly the most promising of the cover crops tested and the only ones worth trying again.

The Albertsen plot was a complete failure. A relatively heavy sowing of seed treated with a proven treatment, Endrin, failed to produce adequate stocking. The seed was of the correct provenance and of good quality, and the weather was not abnormal. Plenty of unhulled seeds were visible on the ground so the trouble lies in factors affecting germination and is not due to seed-eating rodents. The situation requires further investigation.

Results were better on the Wilt Area but still not good enough. Possibly mustard of a suitable origin could be found that would better withstand the winter. Browsing was a serious problem here and while this area is part of a game reserve, browsing is a serious problem in many parts of the Pacific Northwest. Much ungerminated Douglas fir seed was visible on the ground during the summer and it will be interesting to see if there is any delayed germination in 1957. Finnis (11) reported considerable delayed germination in one experiment. Two plots broadcast seeded with poisoned seed were 6.6 percent and 28.6 percent stocked the first year and 46.3 percent and 57.0 percent stocked the following year. Several years later in another trial (12) he found that 66.3 percent of the total germination occurred in the second year.

The Roseburg plots produced many interesting results. There was nearly three times as much germination under mustard as in the open, and this is definitely a point in favor of mustard. The problem is to maintain that initial superiority and in this instance this was not achieved and the situation subsequently deteriorated. Seedling mortality was very heavy under unsprayed mustard. It is unwise to draw definite conclusions or make hard and fast recommendations from such limited evidence but it appears that no cover crop is preferable to an unsprayed cover crop. If good Douglas fir and mustard stands had been produced on all three areas, conclusions would have been based on 180 milacres instead of on 60 milacres. The spraying had a significantly harmful effect on seedling survival. It might be that further research will find sprays that will kill the mustard without damaging the Douglas fir seedlings. There remains the cost of herbicide spray. It is difficult to see how ground spraying could be done at less than $5.00 an acre. The labor involved in spraying is considerable if good coverage and kill is to be obtained. Water has to be packed, spray mixed and back-packs refilled and all of this is hard work. Aerial spraying is a possibility but nowadays most settings are small and the use of a fixed-wing plane or helicopter would not be economically justified. On large areas, such as catastrophic fires, the situation is different but, fortunately, such areas are not typical. Here aerial spraying might be possible but aerial seeding of mustard on such areas is a problem as a seeding rate of 35 lbs. per acre means few acres seeded per sortie. The extra cost of spraying a cover crop might be more than the difference between planting and seeding and with the chance of better survival from planting, this tips the scale in favor of planting. If the use of cover crops is to become a part of direct seeding technique, then great improvements must be made. At present, the use of cover crops raises as many new problems as it attempts to solve. This does not necessarily mean that there is no future for cover crops. It is certainly worth further investigation.

The conclusions of the field study may be summarized as follows.

1. Mustard was winter killed on the Wilt Area.

2. Spring germination of mustard was poor on the Wilt and Albertsen Areas.

3. Growth of mustard on the Wilt Area was poor.

4. Mustard was heavily browsed on the Wilt Area.

5. Germination of Douglas fir was poor on the Wilt and Albertsen Areas.

6. There was increased germination of Douglas fir under mustard on the Roseburg Area.

7. Soil surface temperatures were lower under mustard on the Roseburg Area.

8. Douglas fir seedlings were damaged by 2,4-D spray on the Roseburg Area.

9. There was heavy soil moisture depletion under mustard on the Roseburg Area.

10. Survival of Douglas fir seedlings under unsprayed mustard was very low on the Roseburg Area.

11. Overall survival of Douglas fir seedlings on the Roseburg Area was low.

The following recommendations are made for further study.

1. Trial of strains of mustard which are winter hardy.
2. Trial of sprays and rates of application which will effectively kill the cover crop without damage to the Douglas fir seedlings.
3. A study of the sites on which a cover crop might be beneficial.
4. A study of field germination of Douglas fir.
5. A study of the resistance to heat injury of Douglas fir seedlings.
6. An economic study of the relative merits of direct seeding and planting.
7. Experiments with seedspotting where seed is placed in locations where the seedlings would have the best chance to survive and become established. This would eliminate the necessity for a cover crop.

No mention has been made of rodent control as this phase of the work is being intensively covered by a number of government and private agencies throughout the Pacific Northwest.

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APPENDIX

Table 19. Germination of *Vicia Sativa.*

Common vetch.
Test started 25 Nov. 1955.
Medium: Moist blotting paper and moist blotting cover.

100 seeds per replicate.

Rep:	Number of germinates after (days)															
	1	2	3	4	6	8	10	12	14	16	18	20	22	25	45	55	Total
Temp: 5°C.																	
1	0	0	0	0	0	7	13	52	12	9	2	1		0	2	0	98
2	0	0	0	0	0	14	14	45	19	6	2	0		0	0	0	100
3	0	0	0	0	0	11	12	52	17	6	1	0		0	0	0	99
4	0	0	0	0	0	9	13	45	23	3	0	0		2	2	1	98
	0	0	0	0	0	41	52	194	71	24	5	1		2	4	1	395
Temp: 10°C.																	
1	0	0	0	0	76	11	2	6	0	3	0	0		0	0	0	98
2	0	0	0	0	71	21	3	2	0	0	0	1		0	1	0	99
3	0	0	0	0	70	20	6	2	0	0	0	0		0	0	0	98
4	0	0	0	0	62	21	10	3	0	2	0	0		0	1	0	99
	0	0	0	0	279	73	21	13	0	5	0	1		0	2	0	394
Temp: 5°C. and 15°C.																	
1	0	0	2	25	44	17	2	3	0	1	0	0		0	1	0	95
2	0	0	3	32	42	14	3	5	0	0	0	0		0	1	0	100
3	0	0	2	34	44	17	0	1	1	0	0	0		0	0	0	99
4	0	0	0	30	54	12	1	0	0	0	0	0		0	0	0	97
	0	0	7	121	184	60	6	9	1	1	0	0		0	2	0	391
Temp: 20°C.																	
1	0	56	31	12	0	1	0	0	0	0	0	0		0	0	0	100
2	0	50	35	12	0	2	0	1	0	0	0	0		0	0	0	100
3	0	42	38	16	2	1	0	0	0	1	0	0		0	0	0	100
	0	200	137	54	3	4	0	1	0	1	0	0		0	0	0	400

Table 20 . Germination of Vicia Villosa.

100 seeds per replicate.

Hairy vetch.
Test started 25 Nov. 1955.
Medium: Moist blotting paper and moist blotting cover.

Rep:	Number of germinates after (days)																
	1	2	3	4	6	8	10	12	14	16	18	20	22	25	45	55	Total
	Temp: 5°C.																
1	0	0	0	0	0	15	13	39	2	8	3	3		1	1	1	86
2	0	0	0	0	0	17	11	41	6	9	0	3		1	1	1	90
3	0	0	0	0	0	17	8	46	8	8	1	3		1	0	0	92
4	0	0	0	0	0	19	15	35	14	5	0	1		2	1	0	92
	0	0	0	0	0	68	47	161	30	30	4	10		5	3	2	360
	Temp: 10°C.																
1	0	0	0	0	61	21	4	2	1	0	0	2		0	1	0	92
2	0	0	0	0	62	23	3	3	0	2	0	1		0	1	0	95
3	1	0	0	0	56	30	5	3	0	3	0	0		0	1	0	98
4	0	0	0	0	57	21	4	4	1	1	0	0		0	0	0	88
	0	0	0	0	236	95	16	12	2	6	0	3		0	3	0	373
	Temp: 5°C. and 15°C.																
1	0	0	22	30	22	8	3	2	0	0	0	0		0	1	0	88
2	0	0	21	34	34	1	1	1	0	0	0	0		0	1	1	94
3	0	0	19	33	27	11	1	1	0	1	0	0		0	0	0	93
4	0	0	18	29	35	6	2	1	0	2	0	0		0	0	0	93
	0	0	80	126	118	26	7	5	0	3	0	0		0	2	1	368
	Temp: 20°C.																
1	0	46	35	7	1	0	0	0	0	1	1	1		0	2	0	94
2	0	45	37	5	5	0	0	0	0	0	1	0		0	1	1	95
3	0	36	38	7	2	1	1	1	0	0	0	0		0	1	1	88
4	0	58	26	4	2	0	0	1	1	1	0	0		0	1	0	94
	0	185	136	23	10	1	1	2	1	2	2	1		0	5	2	371

Table 21. Germination of *Trifolium Procumbens.*

100 seeds per replicate.

Hop clover.
Test started 25 May 1955.
Medium: Moist blotting paper.

	Number of germinates after (days)																
	Temp: 5°C.																
Rep:	1	2	3	4	6	8	10	12	14	16	18	20	22	25	45	55	Total
1	0	0	0	0	0	0	2	34	2	5	1	0		4	1	1	50
2	0	0	0	0	0	0	8	32	0	3	1	1		0	2	0	47
3	0	0	0	0	0	0	7	37	0	5	0	1		0	2	0	52
4	0	0	0	0	0	0	7	36	5	4	1	1		2	0	1	56
	0	0	0	0	0	0	24	139	7	17	3	3		6	5	2	206
	Temp: 10°C.																
1	0	0	0	0	37	2	0	0	1	0	0	1		2	1	2	46
2	0	0	0	0	43	4	1	3	1	2	2	0		0	0	1	57
3	0	0	0	0	35	8	2	1	1	1	2	1		0	0	0	51
4	0	0	0	0	40	3	1	0	0	0	1	0		1	0	0	46
	0	0	0	0	155	17	4	4	3	3	5	2		3	1	3	200
	Temp: 5°C. and 15°C.																
1	0	0	2	23	11	3	0	1	0	0	1	0		0	1	0	42
2	0	0	0	23	17	2	0	0	0	2	0	1		0	0	0	45
3	0	0	1	29	14	4	0	0	0	2	0	0		0	0	0	50
4	0	0	0	23	12	3	0	1	1	0	0	2		1	3	0	46
	0	0	3	98	54	12	0	2	1	4	1	3		1	4	0	183
	Temp: 20°C.																
1	0	29	12	3	2	2	0	1	0	1	0	0		0	2	0	52
2	0	18	21	0	0	2	1	2	1	0	0	0		0	0	0	45
3	0	19	16	5	0	2	1	1	0	0	0	0		0	2	0	46
4	0	26	13	6	4	2	0	0	1	0	0	0		0	1	0	53
	0	92	62	14	6	8	2	4	2	1	0	0		0	5	0	196

Table 22 . Germination of Holcus Lanatus.

100 seeds per replicate.

Velvet grass.
Test started 25 Nov. 1955.
Medium: Moist blotting paper.

	Number of germinates after (days)																
	Temp: $5^{o}C$.																
Rep:	1	2	3	4	6	8	10	12	14	16	18	20	22	25	45	55	Total
1	0	0	0	0	0	0	0	0	0	12	3	35		6	13	0	69
2	0	0	0	0	0	0	0	0	0	13	5	30		9	18	0	75
3	0	0	0	0	0	0	0	0	0	14	1	34		10	24	1	84
4	0	0	0	0	0	0	0	0	0	9	4	36		9	18	2	78
	0	0	0	0	0	0	0	0	0	48	13	135		34	73	3	306
	Temp: $10^{o}C$.																
1	0	0	0	0	0	28	19	14	3	5	1	2		1	0	0	73
2	0	0	0	0	0	20	12	41	6	4	1	1		1	0	0	86
3	0	0	0	0	0	18	10	38	6	8	1	2		0	2	0	85
4	0	0	0	0	0	17	16	33	4	9	1	1		1	1	0	83
	0	0	0	0	0	83	57	126	19	26	4	6		3	3	0	327
	Temp: $5^{o}C$. and $15^{o}C$.																
1	0	0	0	0	1	52	12	20	2	1	0	0		0	1	0	89
2	0	0	0	0	1	48	13	26	3	2	2	2		0	0	0	97
3	0	0	0	0	0	50	14	27	2	0	0	0		0	0	1	94
4	0	0	0	0	2	56	19	22	0	0	1	0		0	0	0	100
	0	0	0	0	4	206	58	95	7	3	3	2		0	1	0	380
	Temp: $20^{o}C$.																
1	0	0	58	15	5	0	0	0	1	0	0	0		1	0	0	80
2	0	0	59	12	11	0	0	0	0	0	0	0		0	0	0	83
3	0	0	62	20	3	1	0	0	1	2	0	0		0	0	1	90
4	0	0	53	29	10	4	0	1	0	0	0	0		0	0	0	97
	0	0	232	76	29	5	0	1	2	2	0	0		1	0	1	349

Table 23. Germination of Sanguisorba Annua.

100 seeds per replicate.

Burnet.
Test started 25 Nov. 1955.
Medium: Moist blotting paper.

Rep:	Number of germinates after (days)															
	1	2	3	4	6	8	10	12	14	16	18	20	22	25	45	55	Total
	Temp: 5°C.																
1	0	0	0	0	0	0	0	0	0	0	0	3		5	60	5	73
2	0	0	0	0	0	0	0	0	0	0	0	0		10	63	6	79
3	0	0	0	0	0	0	0	0	0	0	0	0		7	62	15	84
4	0	0	0	0	0	0	0	0	0	0	0	0		6	68	9	83
	0	0	0	0	0	0	0	0	0	0	0	3		28	253	35	319
	Temp: 10°C.																
1	0	0	0	0	0	5	13	36	14	12	1	3		2	0	0	86
2	0	0	0	0	0	0	4	28	18	13	4	6		2	5	0	80
3	0	0	0	0	0	2	8	33	15	13	6	2		6	2	0	87
4	0	0	0	0	0	1	8	24	17	19	6	6		1	2	0	84
	0	0	0	0	0	8	33	121	64	57	17	17		11	9	0	337
	Temp: 5°C. and 15°C.																
1	0	0	0	0	0	22	31	18	4	6	0	1		0	1	0	83
2	0	0	0	0	0	21	26	26	8	2	0	1		0	2	0	86
3	0	0	0	0	0	22	26	27	5	3	0	1		1	0	0	85
4	0	0	0	0	0	27	31	0	24	2	2	2		1	2	0	91
	0	0	0	0	0	92	114	71	41	13	2	5		2	5	0	345
	Temp: 20°C.																
1	0	0	21	46	12	3	0	3	0	0	0	0		0	0	0	85
2	0	0	26	40	20	0	0	0	0	0	0	0		0	0	0	86
3	0	0	32	39	17	2	0	1	0	0	0	1		0	0	0	92
4	0	0	24	41	19	4	2	0	0	0	0	0		0	0	0	90
	0	0	103	166	68	9	2	4	0	0	0	1		0	0	0	353

Table 24 . Germination of Poa Annua

100 seeds per replicate.

Annual blue grass.
Test started 25 Nove. 1955.
Medium: Moist blotting paper.

Rep:	1	2	3	4	6	8	10	12	14	16	18	20	22	25	45	55	Total
	Number of germinates after (days)																
	Temp: 5°C.																
1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	17	0	18
2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	17	0	18
3	0	0	0	0	0	0	0	0	0	0	0	0	0	3	11	0	14
4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	13	0	14
	0	0	0	0	0	0	0	0	0	0	0	0	0	6	58	0	64
	Temp: 10°C.																
1	0	0	0	0	0	0	0	17	19	5	4	2		2	3	0	52
2	0	0	0	0	0	0	0	13	16	9	5	1		3	0	0	47
3	0	0	0	0	0	0	0	7	17	9	10	9		4	0	0	56
4	0	0	0	0	0	0	0	2	24	14	10	10		3	1	0	64
	0	0	0	0	0	0	0	39	76	37	29	22		12	4	0	219
	Temp: 5°C. and 15°C.																
1	0	0	0	0	0	0	4	66	12	5	2	1		1	1	0	92
2	0	0	0	0	0	0	3	69	14	3	2	1		0	1	0	93
3	0	0	0	0	0	0	4	68	15	4	0	1		1	1	0	94
4	0	0	0	0	0	0	6	66	5	2	0	3		1	1	0	84
	0	0	0	0	0	0	17	269	46	14	4	6		3	4	0	363
	Temp: 20°C.																
1	0	0	2	56	25	4	1	2	1	0	0	0		0	0	0	91
2	0	0	6	58	27	3	1	1	0	0	0	0		1	0	0	97
3	0	1	2	56	23	7	0	0	0	0	1	0		1	0	0	91
4	0	0	2	48	32	7	1	2	0	0	0	0		0	0	0	92
	0	1	12	218	107	21	3	5	1	0	1	0		2	0	0	371

Table 25. Germination of Brassica. campestris. Mustard.

Test started 25 Nov. 1955.

100 seeds per replicate. Medium: Moist blotting paper.

Rep:	Number of germinates after (days) 1	2	3	4	6	8	10	12	14	16	18	20	22	25	45	55	Total
Temp: 5°C.																	
1	0	0	0	0	0	0	0	2	0	0	0	1		0	1	0	4
2	0	0	0	0	0	0	0	4	0	0	0	0		0	0	0	4
3	0	0	0	0	0	0	0	3	0	0	2	0		0	1	0	6
4	0	0	0	0	0	0	0	4	0	0	1	1		0	0	0	6
	0	0	0	0	0	0	0	13	0	0	3	2		0	2	0	20
Temp: 10°C.																	
1	0	0	0	0	7	1	0	0	0	0	0	0		0	0	0	8
2	0	0	0	0	8	1	0	1	0	1	0	0		0	0	0	11
3	0	0	0	0	9	0	2	2	0	0	0	0		0	1	0	14
4	0	0	0	0	7	2	1	1	0	0	0	0		0	1	0	12
	0	0	0	0	31	4	3	4	0	1	0	0		0	2	0	45
Temp: 5°C. and 15°C.																	
1	0	0	2	10	10	1	0	1	0	0	0	0		0	0	0	24
2	0	0	3	6	9	0	0	0	0	1	0	0		1	0	0	20
3	0	0	0	4	14	0	1	0	0	1	0	0		0	0	0	20
4	0	0	2	7	5	4	0	0	0	0	0	0		0	0	0	18
	0	0	7	27	38	5	1	1	0	2	0	0		1	0	0	82
Temp: 20°C.																	
1	0	33	5	0	1	0	0	0	0	0	0	0		0	0	0	39
2	0	19	4	0	0	0	0	0	0	0	1	0		0	0	0	24
3	0	23	6	0	0	0	0	0	0	2	0	0		0	0	0	31
4	0	23	8	0	0	0	0	0	0	0	0	0		0	0	0	31
	0	98	23	0	1	0	0	0	0	2	1	0		0	0	0	125

Table 26. Germination of Pseudotsuga Menziesii. Douglas fir.
100 seeds per replicate. Test started 25 Nov. 1955.
Source: Siuslaw 1954 - 2000ft. elevation. Medium: Moist blotting paper.

Rep:	1	2	3	4	6	8	10	12	14	16	18	20	22	25	45	55	Total
	Number of germinates after (days)																
Temp: 5°C.																	
1	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0
Temp: 10°C.																	
1	0	0	0	0	0	0	0	0	0	0	0	0		0	2	1	3
2	0	0	0	0	0	0	0	0	0	0	0	0		0	1	1	2
3	0	0	0	0	0	0	0	0	0	0	0	0		0	1	1	2
4	0	0	0	0	0	0	0	0	0	0	0	0		0	0	2	2
	0	0	0	0	0	0	0	0	0	0	0	0		0	4	5	9
Temp: 5°C. and 15°C.																	
1	0	0	0	0	0	0	0	0	0	2	0	3		9	4	0	18
2	0	0	0	0	0	0	0	0	0	1	0	0		1	15	0	17
3	0	0	0	0	0	0	0	0	0	0	0	2		5	18	2	27
4	0	0	0	0	0	0	0	0	0	1	0	2		8	13	1	25
	0	0	0	0	0	0	0	0	0	4	0	7		23	50	3	87
Temp: 20°C.																	
1	0	0	0	0	1	12	11	10	5	3	1	0		0	7	5	55
2	0	0	0	0	2	15	8	10	7	4	0	2		1	6	10	65
3	0	0	0	0	7	16	12	11	5	2	4	4		5	3	2	71
4	0	0	0	0	3	17	9	4	1	4	4	3		3	7	6	61
	0	0	0	0	13	60	40	35	18	13	9	9		9	23	23	252

Table 27. Record of seedling counts on individual milacres. Mustard cover.

Date of examination											
14 Apr.				21 Apr.				5 May			
M.A.	Good	Dead	Total	Good last exam	Dead	Good now	T. germ this date	Good last exam	Dead	Good now	T. germ this date
Transect No. 1											
1	9	0	9	9	2	15	17	15	1	16	19
2	8	0	8	8	3	12	15	12	1	12	16
3	1	0	1	1	0	1	1	1	1	5	6
4	0	0	0	0	0	1	1	1	0	5	5
5	0	0	0	0	0	0	0	0	0	0	0
6	2	0	2	2	1	6	7	6	3	5	9
7	0	0	0	0	0	3	3	3	0	4	4
8	4	0	4	4	1	7	8	7	0	13	14
9	2	0	2	2	2	2	4	2	0	3	5
10	2	0	2	2	0	3	3	3	0	8	8
	28	0	28	28	9	50	59	50	6	71	86
Transect No. 2											
1	5	0	5	5	0	8	8	8	0	14	14
2	1	0	1	1	0	2	2	2	0	4	4
3	12	0	12	12	3	13	16	13	2	18	23
4	1	0	1	1	0	1	1	1	0	6	6
5	3	0	3	3	0	3	3	3	0	4	4
6	2	0	2	2	0	2	2	2	0	4	4
7	9	0	9	9	2	11	13	11	1	17	20
8	1	0	1	1	0	1	1	1	0	4	4
9	2	0	2	2	0	3	3	3	0	7	7
10	4	0	4	4	0	6	6	6	0	9	9
	40	0	40	40	5	50	55	50	3	87	95
Transect No. 3											
1	4	0	4	4	2	2	4	2	0	4	6
2	1	0	1	1	1	0	1	0	0	1	2
3	8	0	8	8	3	5	8	5	1	7	11
4	2	0	2	2	0	2	2	2	1	6	7
5	3	0	3	3	2	2	4	2	0	4	6
6	0	0	0	0	0	2	2	2	0	4	4
7	1	0	1	1	1	2	3	2	0	2	3
8	2	0	2	2	0	2	2	2	0	2	2
9	1	0	1	1	0	10	10	10	2	12	14
10	4	0	4	4	1	22	23	22	6	25	32
	26	0	26	26	10	49	59	49	10	67	87
G.T.	94	0	94	94	24	149	173	149	19	225	268

Table 27. (continued)

Date of examination											
19 May				31 May				16 June			
Good last exam	Dead	Good now	T. germ this date	Good last exam	Dead	Good now	T. germ this date	Good last exam	Dead	Good now	T. germ this date
Transect No. 1											
16	2	14	19	14	0	14	19	14	0	16	21
12	1	11	16	11	0	11	16	11	0	11	16
5	0	6	7	6	0	6	7	6	0	6	7
5	0	5	5	5	0	5	5	5	1	4	5
0	0	0	0	0	0	0	0	0	0	0	0
5	1	5	10	5	2	3	10	3	0	4	11
4	0	5	5	5	0	6	6	6	0	6	6
13	2	13	16	13	1	12	16	12	2	10	16
3	1	2	5	2	0	2	5	2	0	2	5
8	3	5	8	5	1	4	8	4	1	3	8
71	10	66	91	66	4	63	92	63	4	62	95
Transect No. 2											
14	2	13	15	13	1	13	16	13	0	13	16
4	0	5	5	5	0	5	5	5	1	4	5
18	2	19	26	19	2	21	30	21	6	16	31
6	0	6	6	6	0	6	6	6	1	5	6
4	0	4	4	4	0	5	5	5	1	4	5
4	2	2	4	2	0	2	4	2	0	2	4
17	1	18	22	18	1	17	22	17	1	16	22
4	3	1	4	1	1	0	4	0	0	0	4
7	3	4	7	4	0	4	7	4	3	1	7
9	5	4	9	4	2	2	9	2	1	1	9
87	18	76	102	76	7	75	108	75	14	62	109
Transect No. 3											
4	0	4	6	4	1	3	6	3	1	3	7
1	0	1	2	1	0	1	2	1	0	1	2
7	0	7	11	7	1	6	11	6	2	4	11
6	1	6	8	6	0	6	8	6	3	3	8
4	2	6	10	6	1	5	10	5	1	4	10
4	1	3	4	3	0	5	6	5	1	4	6
2	0	2	3	2	1	1	3	1	0	1	3
2	0	2	2	2	1	2	3	2	0	3	4
12	3	9	14	9	3	6	14	6	2	4	14
25	19	6	32	6	0	6	32	6	0	6	32
67	26	46	92	46	8	41	95	41	10	33	97
225	54	188	285	188	19	179	295	179	28	157	301

Table 28. Record of seedling counts on individual milacres. No mustard.

	Date of examination										
	14 Apr.			21 Apr.				5 May			
M.A.	Good	Dead	Total	Good last exam	Dead	Good now	T. germ this date	Good last exam	Dead	Good now	T. germ this date
Transect No. 1											
1	0	0	0	0	0	0	0	0	0	1	1
2	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	1	1
4	0	0	0	0	0	0	0	0	0	1	1
5	0	0	0	0	0	0	0	0	0	1	1
6	1	0	1	1	0	2	2	2	0	2	2
7	3	0	3	3	1	4	5	4	1	4	6
8	10	0	10	10	3	9	12	9	1	8	12
9	2	0	2	2	1	2	3	2	0	3	4
10	1	0	1	1	0	1	1	1	0	1	1
	17	0	17	17	5	18	23	18	2	22	29
Transect No. 2											
1	6	0	6	6	3	6	9	6	0	6	9
2	3	0	3	3	0	4	4	4	1	3	4
3	3	0	3	3	0	3	3	3	0	5	5
4	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	2	2	2	0	2	2
6	1	0	1	1	0	1	1	1	0	1	1
7	0	0	0	0	0	0	0	0	0	0	0
8	5	0	5	5	2	6	8	6	1	8	11
9	3	0	3	3	0	4	4	4	1	3	4
10	0	0	0	0	0	0	0	0	0	0	0
	21	0	21	21	5	26	31	26	3	28	36
Transect No. 3											
1	1	0	1	1	1	0	1	0	0	0	1
2	1	0	1	1	1	1	2	1	1	1	3
3	6	0	6	6	1	5	6	5	1	4	6
4	2	0	2	2	0	2	2	2	1	1	2
5	1	0	1	1	0	2	2	2	0	2	2
6	3	0	3	3	2	2	4	2	1	1	4
7	3	0	3	3	0	3	3	3	1	3	4
8	5	0	5	5	0	10	10	10	2	10	12
9	2	0	2	2	1	2	3	2	1	1	3
10	4	0	4	4	0	7	7	7	1	6	7
	28	0	28	28	6	34	40	34	9	29	44
G.T.	66	0	66	66	16	78	94	78	14	79	109

Table 28. (continued)

Date of examination											
19 May				31 May				16 June			
Good last exam	Dead	Good now	T. germ this date	Good last exam	Dead	Good now	T. germ this date	Good last exam	Dead	Good now	T. germ this date
Transect No. 1											
1	0	1	1	1	0	1	1	1	0	1	1
0	0	0	0	0	0	0	0	0	0	0	0
1	0	1	1	1	1	0	1	0	0	0	1
1	0	1	1	1	0	1	1	1	0	1	1
1	1	0	1	0	0	0	1	0	0	0	1
2	0	2	2	2	1	1	2	1	1	0	2
4	0	4	6	4	2	2	6	2	0	2	6
8	3	6	13	6	3	3	13	3	1	2	13
3	1	2	4	2	0	2	4	2	1	1	4
1	1	0	1	0	0	0	1	0	0	0	1
22	6	17	30	17	7	10	30	10	3	7	30
Transect No. 2											
6	1	5	9	5	0	5	9	5	0	5	9
3	1	2	4	2	0	2	4	2	0	2	4
5	1	4	5	4	0	4	5	4	0	4	5
0	0	0	0	0	0	0	0	0	0	0	0
2	0	2	2	2	0	2	2	2	0	2	2
1	1	0	1	0	0	0	1	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0
8	1	7	11	7	1	6	11	6	1	5	11
3	0	3	4	3	3	0	4	0	0	0	4
0	0	0	0	0	0	0	0	0	0	0	0
28	5	23	36	23	4	19	36	19	1	18	36
Transect No. 3											
0	0	0	1	0	0	0	1	0	0	0	1
1	0	1	3	1	1	0	3	0	0	0	3
4	0	4	6	4	1	3	6	3	0	3	6
1	0	1	2	1	0	1	2	1	0	1	2
2	0	2	2	2	0	2	2	2	0	2	2
1	0	1	4	1	0	1	4	1	0	1	4
3	1	2	4	2	0	2	4	2	0	2	4
10	3	7	12	7	0	7	12	7	1	6	12
1	0	1	3	1	0	1	3	1	0	1	3
6	1	5	7	5	1	4	7	4	0	4	7
29	5	24	44	24	3	21	44	21	1	20	44
79	16	64	110	64	14	50	110	50	5	45	110

Table 29. Roseburg. Summary of seedling counts. Mustard cover crop.

Date of exam.	Transect No.	Good last exam.	Dead	New	Good this date	Total germ. to date	Live seedlings per milacre
1956							
14 Apr.	1	-	-	-	28	28	2.8
	2	-	-	-	40	40	4.0
	3	-	-	-	26	26	2.6
Total		-	-	-	94	94	3.1
21 Apr.	1	28	9	31	50	59	5.0
	2	40	5	15	50	55	5.0
	3	26	10	33	49	59	4.9
Total		94	24	79	149	173	4.96
5 May	1	50	6	27	71	86	7.1
	2	50	3	40	87	95	8.7
	3	49	10	28	67	87	6.7
Total		149	19	95	225	268	7.5
19 May	1	71	10	5	66	91	6.6
	2	87	18	7	76	102	7.6
	3	67	26	5	46	92	4.6
Total		225	54	17	188	285	6.27
31 May	1	66	4	1	63	92	6.3
	2	76	7	6	75	108	7.5
	3	46	8	3	41	95	4.1
Total		188	19	10	179	295	5.97
16 June	1	63	4	3	62	95	6.2
	2	75	14	1	62	109	6.2
	3	41	10	2	33	97	3.3
Total		179	28	6	157	301	5.23

Table 30. Roseburg. Summary of seedling counts. No mustard.

Date of exam.	Transect No.	Good last exam.	Dead	New	Good this date	Total germ. to date	Live seedlings per milacre
1956							
14 Apr.	1	-	-	-	17	17	1.7
	2	-	-	-	21	21	2.1
	3	-	-	-	28	28	2.8
Total		-	-	-	66	66	2.2
21 Apr.	1	17	5	6	18	23	1.8
	2	21	5	10	26	31	2.6
	3	28	6	12	34	40	3.4
Total		66	16	28	78	94	2.6
5 May	1	18	2	6	22	29	2.2
	2	26	3	5	28	36	2.8
	3	34	9	4	29	44	2.9
Total		78	14	15	79	109	2.63
19 May	1	22	6	1	17	30	1.7
	2	28	5	0	23	36	2.3
	3	29	5	0	24	44	2.4
Total		79	16	1	64	110	2.13
31 May	1	17	7	0	10	30	1.0
	2	23	4	0	19	36	1.9
	3	24	3	0	21	44	2.1
Total		64	14	0	50	110	1.66
16 June	1	10	3	0	7	30	0.7
	2	19	1	0	18	36	1.8
	3	21	1	0	20	44	2.0
Total		50	5	0	45	110	1.5

Table 31. Roseburg Plots. Fir seedling count and description.
Hairy vetch. Seeded 29 Oct. 1955.

	Fir seedling count						
Date of exam.	Plot No.	Good last exam.	Dead	New	Good now	Total germ.	Condition
21 Apr.	49	-	-	-	3	3	Very scattered plants.
5 May		3	-	-	3	3	
19 May		3	1	0	2	3	1-21 Apr. dead. Open stand.
31 May		2	0	0	2	3	Sprawling plants, in flower, giving some cover now, but not at time of fir germination.
16 June		2	0	0	2	3	Sprawling plants in flower.
21 Apr.	53	-	-	-	1	1	Scattered plants.
5 May		1	0	2	3	3	
19 May		3	2	0	1	3	1-21 Apr; 1-5 May dead. Large scattered plants.
31 May		1	0	0	1	3	Sprawling plants, in flower, giving some cover now, but not at time of fir germination.
16 June		1	0	0	1	3	Sprawling plants in flower. Ground moist under foliage.
21 Apr.	57	-	-	-	5	5	A very few small scattered plants providing no cover.
5 May		5	0	1	6	6	Good cover of natural lathyrus. No cover by hairy vetch.
19 May		6	1	0	5	6	As on 5 May.
31 May		5	0	0	5	6	No cover provided by hairy vetch.
16 June		5	2	0	3	6	2-21 Apr. dead. A few scattered plants. Some cover from natural vegetation.

Table 32. Roseburg Plots. Fir seedling count and description.
Common vetch. Seeded 29 Oct. 1955.

	Fir seedling count						
Date of exam.	Plot No.	Good last exam.	Dead	New	Good now	Total germ.	Condition
21 Apr.	47	-	-	-	1	1	Very scattered plants.
5 May		1	0	0	1	1	
19 May		1	0	0	1	1	Open stand.
31 May		1	0	0	1	1	As 52.
16 June		1	0	0	1	1	Open stand of straggly plants.
21 Apr.	52	-	-	-	10	10	Thin stand of scattered plants.
5 May		10	3	2	9	12	3-21 Apr. dead.
19 May		9	0	1	10	13	Photographed. Large scattered plants.
31 May		10	0	0	10	13	Sprawling plants, now in flower, and quite large, but too late to give shade during germination.
16 June		10	0	3	13	16	As before.
21 Apr.	62	-	-	-	3	3	A few scattered plants giving no cover.
5 May		3	1	0	2	3	1-21 Apr. dead. No cover provided.
19 May		2	0	0	2	3	Open sparse stand.
31 May		2	0	0	2	3	A few scattered plants giving no cover.
16 June		2	0	0	2	3	Six scattered plants giving no cover.

Table 33. Roseburg Plots. Fir seedling count and description.
Burnet. Seeded 29 Oct. 1955.

	Fir seedling count					
Date of exam.	Plot No.	Good last exam.	Dead	New	Good now	Total germ.	Condition
21 Apr.	48	-	-	-	7	7	A few scattered plants. Blackberry and other native vegetation more common.
5 May		-	-	-	-	-	Not examined.
19 May		7	1	2	8	9	1-21 Apr. dead.
31 May		8	1	0	7	9	1-21 Apr. dead. Sparse scattered stand giving no cover.
16 June		7	1	0	6	9	1-21 Apr. dead. As before.
21 Apr.	54	-	-	-	6	6	Sparse scattered stand.
5 May		6	0	1	7	7	
19 May		7	1	0	6	7	1-21 Apr. dead. Photographed. A few scattered plants giving no cover.
31 May		6	0	0	6	7	Cover crop as last exam; survival of seedlings not affected by burnet.
16 June		6	0	0	6	7	As before.
21 Apr.	59	6	2	5	9	11	A few scattered plants. No cover provided.
5 May		9	1	2	10	13	" " " " " "
19 May		10	0	0	10	13	" " " " " "
31 May		10	0	0	10	13	Very sparse stand. Most plants nearly in flower.
16 June		10	0	0	10	13	Open stand giving no cover.

Table 34. Roseburg Plots. Fir seedling count and description.
Velvet grass. Seeded 29 Oct. 1955.

	Fir seedling count						
Date of exam.	Plot No.	Good last exam.	Dead	New	Good now	Total germ.	Condition
21 Apr.	46	-	-	-	0	0	Good cover on 2/3 plot. Plants 4 ins. high.
5 May		0	0	0	0	0	
19 May		0	0	0	0	0	
31 May		0	0	0	0	0	Plants about 10 ins. high. Nearly in flower. Plants thick at base.
16 June		0	0	0	0	0	Plants about 2 ft. high and in flower. Now giving good cover but would provide competition.
21 Apr.	55	-	-	-	2	2	Quite good stand. No plants in flower.
5 May		2	0	0	2	2	
19 May		2	0	0	2	2	Photographed. Even stand.
31 May		2	0	0	2	2	Plants 10 ins. high. Nearly in flower. Plants thick at base, little lateral spread.
16 June		2	0	0	2	2	Plants about 2 ft. high and in flower, now giving good cover.
21 Apr.	61	-	-	-	8	8	Variable stand. Quite thick in places. Some cover locally.
5 May		8	4	1	5	9	4-21 Apr. dead. Some shade on part of area.
19 May		5	2	0	3	9	2-21 Apr. dead.
31 May		3	0	0	3	9	Plants 1-1½ ft. tall. Nearly in flower. Plants thick at base.
16 June		3	1	0	2	9	1-21 Apr. dead. Plants 2-2½ ft. tall and in flower, giving good cover now.

Table 35. Roseburg Plots. Fir seedling count and description.
Annual blue grass. Seeded 29 Oct. 1955.

	Fir seedling count						
Date of exam.	Plot No.	Good last exam.	Dead	New	Good now	Total germ.	Condition
21 Apr.	45	-	-	-	4	4	Seed washed off area which is very steep. Plants patchy. In flower.
5 May		4	0	0	4	4	
19 May		4	3	1	2	5	3-21 Apr. dead. Open stand. Flowering.
31 May		2	0	0	2	5	Scattered open stand. No cover.
16 June		2	1	0	1	5	1-21 Apr. dead. As before.
21 Apr.	51	-	-	-	2	2	Photographed. Some cover. In flower.
5 May		2	1	0	1	2	1-21 Apr. dead.
19 May		1	0	0	1	2	Photographed. Fair degree of cover.
31 May		1	0	0	1	2	Plants 6 - 8 ins. tall. Some cover locally.
16 June		1	1	0	0	2	1-21 Apr. dead. As before.
21 Apr.	58	-	-	-	4	4	Very short scattered plants. In flower. No cover.
5 May		4	0	0	4	4	Very short plants about 1 in. tall. Scattered and providing no cover.
19 May		4	0	0	4	4	Few scattered plants.
31 May		4	1	0	3	4	1-21 Apr. dead. As before.
16 June		3	1	0	2	4	1-21 Apr. dead. Very small scattered plants giving no cover.

Table 36. Roseburg Plots. Fir seedling count and description.
Native mustard (*B. campestris*). Seeded 29 Oct. 1955.

	Fir seedling count						
Date of exam.	Plot No.	Good last exam.	Dead	New	Good now	Total germ.	Condition
31 Mar.	43	-	-	-	-	0	¾ stocked. ¼ empty. Many plants 4-5 ins. across and 3 ins. tall. Four plants in bud.
21 Apr.		0	0	0	0	0	Good cover on ¾ of m.a. Plants 2-3 ft. high. Flowering. Photo.
5 May		-	-	-	-	-	Not examined. In flower.
19 May		0	0	0	0	0	Plants 2-3 ft. tall and flowering.
31 May		0	0	0	0	0	Nearly finished flowering. 3-4 ft. tall. Branching habit.
16 June		0	0	0	0	0	Plants gone to seed.
31 Mar.	56	-	-	-	-	0	Open scattered stand. No flowering.
21 Apr.		3	1	5	7	8	Large irregularly spaced plants. Some in flower. 15 ins. high. No cover.
5 May		7	0	1	8	9	Plants 2-3 ft. high.
19 May		8	0	0	8	9	Photographed.
31 May		8	0	0	8	9	Plants about 4 ft. tall and flowering. Branching habit.
16 June		8	0	0	8	9	Plants nearly finished flowering, branching habits.
31 Mar.	60	-	-	-	-	-	Spotty irregular stand. Some seeds now germinating. Should thicken up.
21 Apr.		7	0	1	8	8	Scattered plants 8 ins. high. A little local cover.
5 May		8	0	1	9	9	2-2½ ft. high. Scattered plants. Fair stocking. Some shade.
19 May		9	2	0	7	9	2-5 May. dead.
31 May		7	0	1	8	10	Branchy habit of growth. Good shade provided.
16 June		8	1	0	7	10	About 3 ft. high mostly finished flowering.

Table 37. Roseburg Area. Fir seedling count and description.
Hop clover. Seeded 29 Oct. 1955.

	Fir seedling count						
Date of exam.	Plot No.	Good last exam.	Dead	New	Good now	Total Germ.	Condition
31 Mar.	44						
21 Apr.		0	0	0	0	0	Mostly bare. A few small clumps of plants.
5 May							Not examined.
19 May		0	0	1	1	1	Open stand. Mostly in flower.
31 May		1	1	0	0	1	1-19 May. dead. Very few plants. No cover provided.
16 June		0	0	0	0	1	As before.
21 Apr.	50	3	1	1	3	4	A few small scattered plants. No cover.
5 May		3	1	1	3	5	" " " " " " "
19 May		3	0	0	3	5	Photographed. Few scattered plants.
31 May		3	1	0	2	5	1-21 Apr. dead. Few scattered plants. No cover.
16 June		2	0	0	2	5	As before.
21 Apr.	63	2	0	3	5	5	A few scattered small plants. No cover.
5 May		5	0	4	9	9	No cover at all.
19 May		9	0	1	10	9	A few plants, all in flower. No cover provided.
31 May		10	0	0	10	10	" " " " " " " " "
16 June		10	3	0	7	10	1-21 Apr., 2-5 May. dead. No cover provided.