Aerial Seeding

Research Bulletin No. 7

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RESEARCH BULLETIN NO. 7

AERIAL SEEDING

The

Methods and Techniques Employed

by the

Oregon State Board of Forestry

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INTRODUCTION

In the spring of 1943 the Oregon State Board of Forestry initiated a small-scale direct seeding research program. Previous experiments in the field had shown that the greatest deterrant to successful direct seeding was consumption of seeds by rodents. Accordingly, the initial efforts in the Board of Forestry program were directed to the development of rodent control techniques.

Mr. A. W. Moore, biologist with the U. S. Fish and Wildlife Service, had for many years been studying the habits and possible means of controlling seed-eating rodents. He generously contributed the results of his past experiments and cooperated in the development and testing of new rodent control techniques. Largely as a result of his work, a highly satisfactory poison bait and baiting technique were developed.

In the preliminary experiments seed was applied either by hand broadcasting or by spot seeding with a specially designed tool. During the late fall of 1945 and early winter of 1946 an experiment in airplane seeding was conducted on a 600 acre tract in Tillamook County. The success of this experiment clearly demonstrated the excellent possibilities of this method of reforestation (C).

After July 1947, funds made available through the Research and Experimental Tax Act were used to expand the direct seeding research program. New rodent baits were tested through both aerial and ground experiments; special seed treatments including stratification and soaking were tried; and through several large scale aerial experiments the advantages of the helicopter were demonstrated. By the fall of 1949 when the Tillamook Burn Rehabilitation Program was begun, aerial seeding techniques had been developed to the extent that this method could be used on a project basis on the reforestation phases of the program.

The interest in aerial seeding displayed by foresters and forest land owners has prompted this brief description of the methods and techniques developed by the Oregon State Board of Forestry and now in current use.

Aerial seeding is rapidly becoming a more and more attractive method of artificial regeneration. It is not only attractive from the standpoint of cost, but also from the standpoint of ease of execution. A denuded forest area approximately 5,000 acres in size and adaptable to aerial seeding can be baited and seeded for as little as $6.00 per acre. The entire job can be completed in five or six days and acceptable results expected.

The helicopter has become the accepted type of aircraft to handle the job. Its ability to land and take off from a small clearing and maintain a relatively constant speed at a constant elevation over rough terrain places the helicopter in a class by itself.

There is more to aerial seeding; however, than just bait, seed and helicopters. It is the purpose of this bulletin to outline generally the steps that should be followed in setting up an aerial seeding project; to offer certain recommendations on specifications; and to report on the major aerial seeding projects that have been carried out under Oregon's forest rehabilitation program.

There is no doubt that as more work is done in the field of aerial seeding, techniques will change and improve. Therefore, this bulletin is by no means the final word, but a temporary tool to aid those interested in the gigantic problem of forest regeneration.

ADAPTABILITY OF AREA

The adaptability of aerial seeding to a specific problem of artificial regeneration depends upon a number of important factors (8) and their interrelations. These factors are size of area, seed source, natural stocking, cover, soil condition, degree of burn, exposure and slope.

Aerial seeding at the present time can not be economically undertaken on tracts of land less than 500 acres in size. Proven methods of rodent control indicate that this is the smallest area that can be baited economically because of the requirement of a 1/4 mile buffer strip around the seeding block to prevent rodent drift. To determine the land status in regard to the remaining factors, a detailed survey should be conducted.

The Preplanting Survey

The preplanting survey is the accepted method whereby these factors can be evaluated.

Seed Source

The presence of seed source on the area under survey should be recorded. It is assumed that little or no seed source will be present where a reforestation problem exists.

Stocking

Stocking should be determined by using whatever method is accepted by the agency involved. A recommended method (7) for determining stocking consists of running two parallel lines, equally spaced, through each forty along which stocking and other conditions are evaluated on 4 mil-acre plots established at two chain intervals.

Cover

Probably one of the most important factors influencing aerial seeding is the cover type and the amount of ground area it occupies. Vegetation is also an important indicator of soil condition. Results of various experiments and

three years of project work in aerial seeding indicate that 60% of ground area occupied by vegetation and matted leaves is the upper limit within which direct seeding is effective. Light to moderate cover appears to be the most favorable to seedling establishment and survival. See Plates I, II and III for general examples of cover conditions.

Soil Condition

Soil condition can be examined and rated according to whatever degree of intensity is desired. Special attention should be given to such problem areas within the survey unit as rock outcrops, talus slopes, poorly drained soils and rocky soils.

Degree of Burn

Any burned over forest areas where seeding is contemplated should be examined and classified as to degree of burn. Classifications should describe the burn influence observed at the time of the survey rather than the intensity of the original fire, since time elapsed after burning permits return of vegetation, build up of humus and physical changes within the soil itself. See Plates IV, V and VI for general examples of degrees of burn.

Exposure

The relative area in each exposure will influence the establishment and survival of seedlings to a marked degree. It can generally be expected that north exposures will be the most favorable, east exposures favorable, south exposures least favorable (6) and west exposures slightly less favorable than east exposures.

Slope

The factor of slope should be considered along with cover, soil conditions and exposure, since its importance depends upon its interrelation with these three factors. For example, steep slopes with rocky soil and little vegetation may be subject to excessive erosion and therefore not too favorable

Plate I. Light Cover

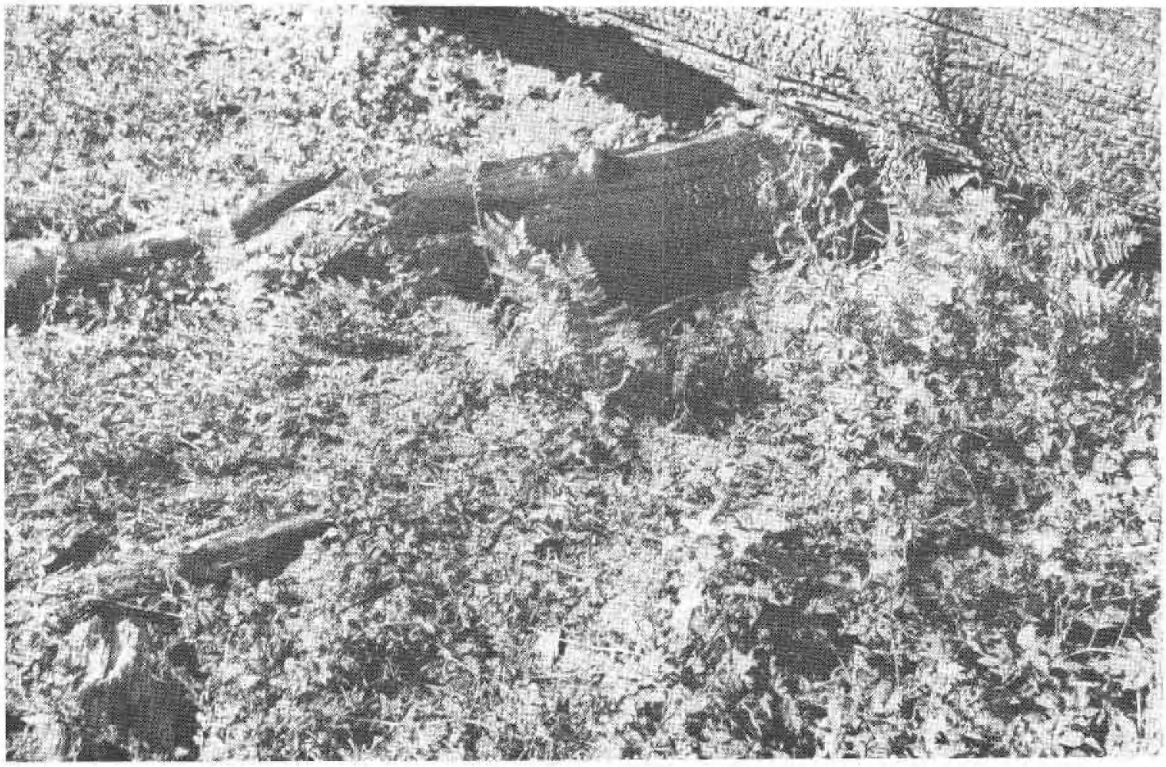


Plate II. Moderate Cover

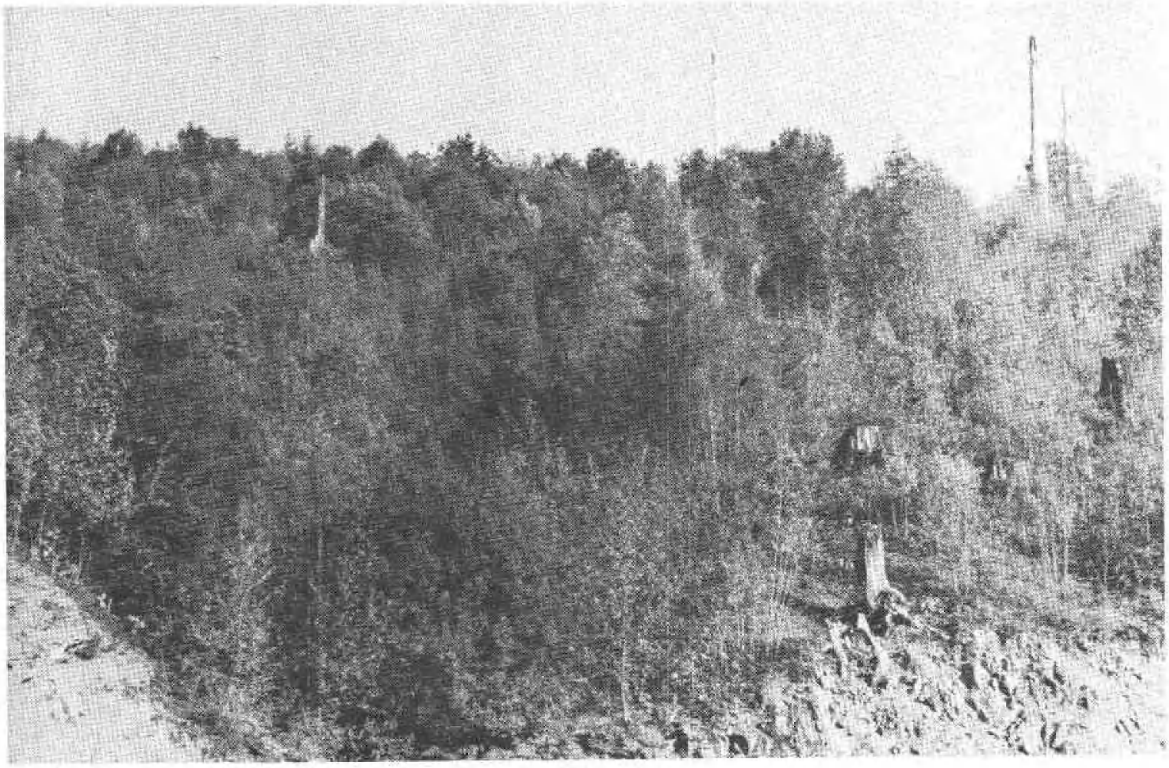


Plate III. Heavy Cover

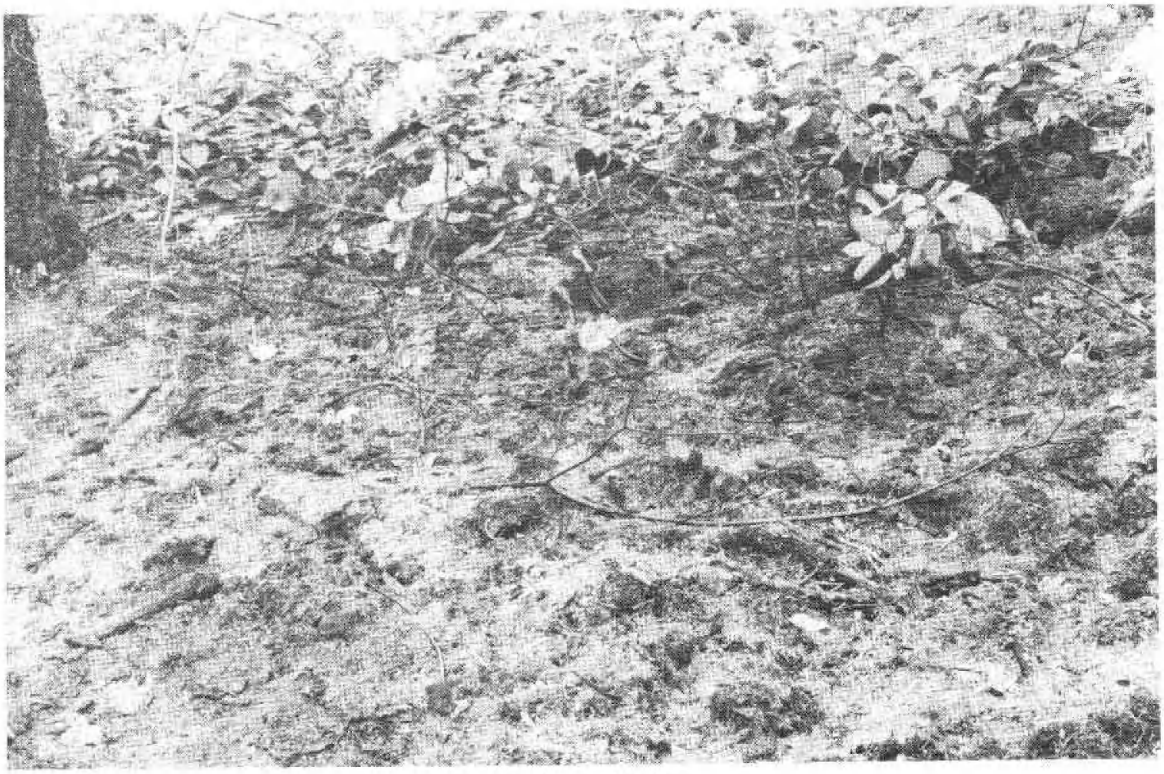


Plate IV. Light Burn

Plate V. Moderate Burn

Plate VI. Hard Burn

for seeding. Steep slopes with southern exposures are extremely unfavorable.

Compilation and Analysis of Data

After field surveys are complete data should be compiled and analyzed to determine whether the land is better adapted to aerial seeding or to some other method of reforestation.

Land Adaptability

Provided the major portion of the area appears to be adaptable to seedling establishment and no extensive unfavorable conditions such as south slopes, heavy brush cover and excessively rocky soil are present, aerial seeding can be undertaken and acceptable results expected.

Selection of Tree Seed Species

Choice of seed should be based primarily on the species reaching optimum development in the original stands (4). Such choice may be subject to other considerations which may favor one species over another. These must also be taken into consideration when choosing a seed species or a combination of seed species to use.

DELINEATION OF SEEDING AREA

After it has been decided that a given area is to be aerial seeded, it is necessary that the boundaries be designated and the seeding unit divided into seeding blocks. Division of the unit into seeding blocks facilitates apportioning of bait and seed and control over distribution. It also permits lay out of unit in logical blocks from the standpoint of a predetermined flight pattern.

Ground reconnaissance is necessary to determine the boundaries. Selection of a landing area for the helicopter can be made at the same time. An old logging landing or a wide truck road, either of which is level and not in use, will suffice. The ideal landing area should be on a ridge and permit land-

ing or take-off from at least two directions. Prevailing winds at time of baiting and seeding should be considered. The area should be free of any obstructions that might interfere with take-off or landing of helicopter.

Recent aerial photographs are invaluable in properly laying out the unit. Either an accurate map or an aerial photograph mosaic should be available on which to designate seeding boundary, block boundaries, and baiting boundary. Mosaics have proven very successful on aerial seeding operations, since pilots can study the road and drainage system of each block prior to flying over the area in the company of a guide.

If possible, boundaries should be made up of main stream drainages, prominent ridges and well defined main traveled roads. In many cases such a delineation is not possible because of land ownership boundaries. Where natural boundaries are not distinct or land ownership boundaries are used, the seeding unit and component blocks should be flagged. Markers made from .002 aluminum foil, 3 feet wide and 10 feet long, are readily visible from the altitudes at which the helicopter operates. Past experience indicates that markers need be placed only where needed along seeding boundaries and block boundaries. No markers are required to indicate outside boundary of bait buffer strip, since it can be covered by a series of parallel flights based on the effective swath width of the helicopter.

As aluminum markers are set out they should be recorded on map or mosaic. Large down logs lying along the boundary line offer the best place to set out a marker. The aluminum can be tacked to the log with a stapling hammer. Small pieces of cardboard should be placed where a staple is driven in so as not to tear the aluminum. Crinkling the aluminum between staples causes it to catch and reflect more light, thus making it more visible from the air. When logs are not available the aluminum can be crinkled slightly, placed on the ground along the boundary and held in place by chunks of wood and rocks.

The proper delineation and marking of the seeding unit is of great importance, since on its accuracy depends the correct distribution of bait and seed.

TREE SEED

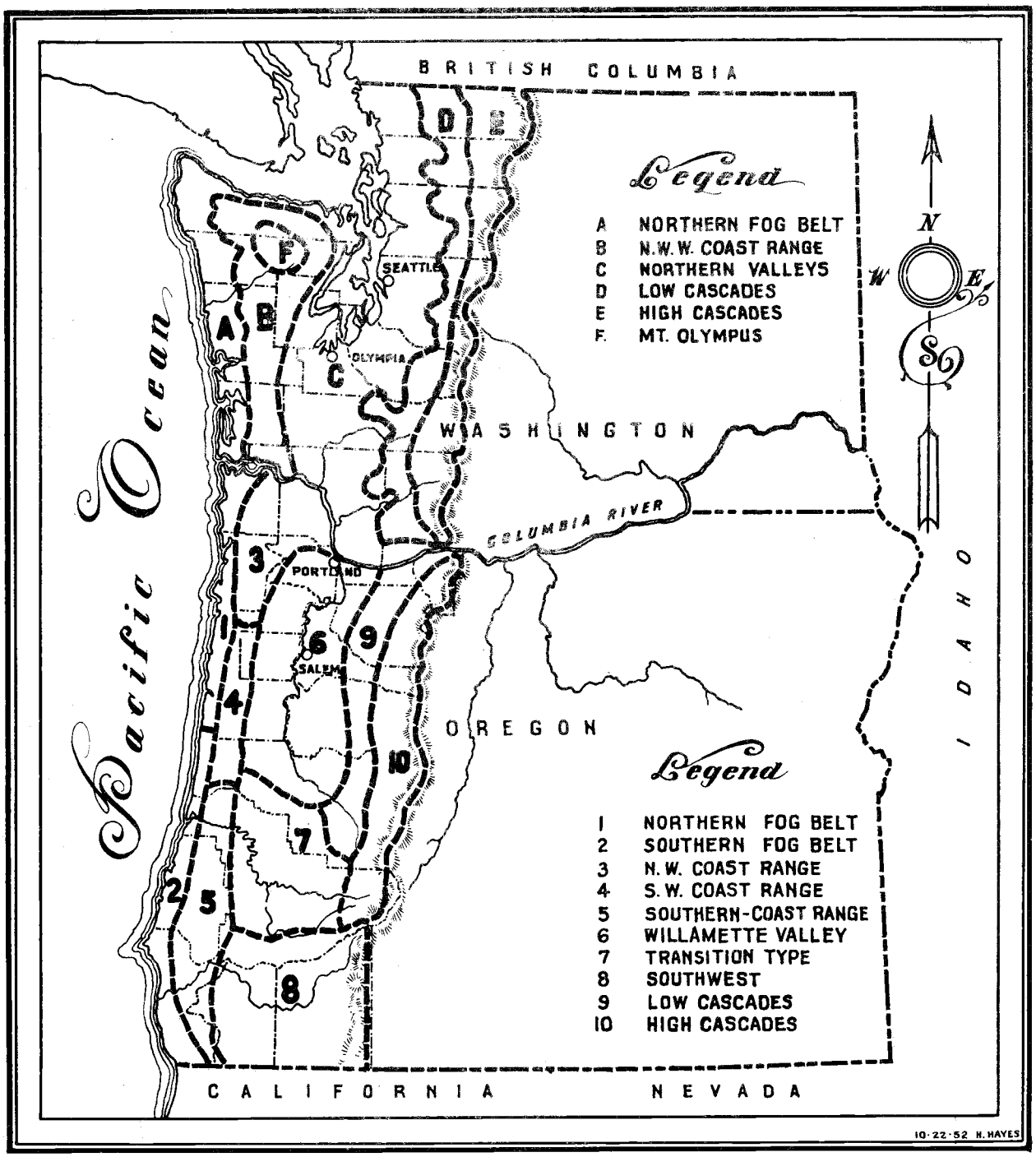
The selection of the seed to be used on a specific aerial seeding project should be based first on the species native to the area. Other factors may enter into the picture, such as, desirability of species from standpoint of germination and establishment, adaptability of site and desired end product.

After a choice of seed species has been made, it is desirable that every precaution be taken in procurement. Local seed from natural stands should be obtained if available. Climatic condition and mean elevation of collection and seeding site should be similar. If local seed is not available, it may be possible to obtain seed from an area having a similar growing season, latitude and elevation (4). To insure the proper classification of seed according to source, a zone system such as appears in Figure 1 is used. Seed suppliers are furnished with the map, and seed shipments are designated by zone of origin on certification form shown in Figure 2.

Procurement of Seed

The Oregon State Board of Forestry has compiled specifications covering the procurement of forest tree seed generally used in western Oregon for reforestation purposes. Figure 3 presents the specifications for Douglas-fir.

Specifications on other coniferous seed species are drawn up in a similar manner. However, there are certain variations in specifications. Purity of western redcedar seed does not require dewinging and allows 3% by weight of foreign matter. Minimum cutting test is 85% based on 100 seeds per 50 pound parcel; no germination test is required. Western hemlock seed must be thoroughly dewinged and contain no more than 3% foreign matter. Cutting test is same as western redcedar; no germination test. Port Orford white-cedar must be



SEED ZONES OF OREGON AND WASHINGTON

0 30 SCALE IN MILES

Figure 1.

Figure 2

Oregon State Board of Forestry
Certificate of Origin-Forest Tree Seed

Supplier_____Address_____

Species-common name_____Scientific name_____

Parcel or sack No.___Weight of parcel____lbs. Purity_____

Cutting test_____Drying temperature_____degrees Fahrenheit

SOURCE

State_____County_____Zone_____

Elevation_____Age of stand_____

Vigor_____General exposure_____

CERTIFICATION

State of_____County of_____

I,_____, of the City of_____

State of_____, on this _____day of_____,19___

do hereby certify that I am the supplier above named, that the cones from which the seeds were extracted were collected during the period_____

to_____,19___, under my direction and supervision, that all

cones were grown and matured during the year 19___, and that I have read the above material and all the statements made therein are true and correct.

SIGNATURE_____

Figure 3

Oregon State Board of Forestry
Forest Tree Seed Specifications
Douglas-fir

To furnish 2,000 pounds of Douglas-fir seed according to the following specifications and requirements:

Source: Pseudotsuga taxifolia viridis from the Douglas-fir region of Western Oregon or Western Washington. Elevations from which collected to be from 1,000 feet to a maximum of 2,500 feet.

Crop: Seed to be from the 1952 crop.

Purity: Seed to be thoroughly dewinged and to contain no more than 3% by weight of needles, cone particles, pitch or other foreign matter.

Cutting Test: Minimum requirement of cutting test to be 95% and based on 100 seeds per 50 pound parcel.

Germination: Minimum requirement of germination test to be 70% and based on tests made by the Oregon State College seed testing laboratory. In the event that initial results are below 70%, a second germination test will be run before final settlement is made. Samples of 1,000 seeds each will be furnished the testing laboratory for each 500 pounds of seed delivered.

Drying Temperature: Maximum permissible drying temperature to be 110 degrees Fahrenheit.

Container: Seed container to be composed of two sewn sacks of 50 pound capacity. The inner sack to be of cloth or canvas and the outer sack to be of burlap or canvas. Sacks to be new and free of holes. Sacks are to be marked with stencil on both sides in the following manner: (1) Numbered consecutively (2) Supplier's name or trademark (3) Quantity of seed (4) Year collected (5) Species (6) Elevation.

Certification: Seed certification to consist of a statement on a standard form. Certification to be placed in shipping tag envelope and fastened to each seed sack. Certification forms and shipping tag envelopes will be furnished to the successful bidder by the Oregon State Board of Forestry.

Delivery Date: Seed to be delivered to the Oregon Forest Nursery, Corvallis, Oregon on or before December 1, 1952. Bidder to quote only on the amount on which he can guarantee delivery.

Payment: Ninety percent of payment will be made within 30 days after delivery of order and receipt of invoice. The 10% balance will be paid after germination tests are received and meet specifications.

Figure 3 (Cont.)

In the event that specifications are not met, after germination tests, adjustment will be made on a percentage basis either in terms of money or seed. Orders under 500 pounds must be delivered and invoiced in one lot. Orders of 1,000 pounds or more must be delivered and invoiced in lots of 500 pounds or more.

Quotation: Bidders are invited to quote on all or any part of the above amount of seed.

Terms: Cash discounts of less than 20 days cannot be accepted.

cleaned as thoroughly as possible. Foreign particles should not exceed seed size. No cutting or germination tests are required. The purity requirement for Sitka spruce is the same as western hemlock. Cutting test must be 90% based on 100 seeds per 50 pound parcel; germination test must be at least 60%.

Care and Storage of Seed

If seed is to be purchased and set aside for future use, care should be taken to see that it is thoroughly dry. Seed can be stored in glass or metal containers or in burlap sacks. It is advisable that the seed be placed in cold storage at a temperature of 0° Fahrenheit. Variations in temperature as much as 5 to 15° F. should not affect viability; however, the safest course is to maintain the temperature as close to 0° F. as possible.

Preparation of Seed

At least one month prior to application the seed should be removed from 0° F. storage and placed in a cold room held at approximately 35° F. This acts as a tempering process and permits the seed to thaw gradually.

If fall sowing is to be employed no further treatment of the seed is necessary. The seed will be dormant until warm spring weather, at which time germination will take place. Fall seeding seems to be more successful than spring application with stratified seed. If seeding takes place in November just prior to the heavy leaf fall from broadleaf vegetation, the seed has a much better opportunity to find its way to mineral soil. Rain and snow aid materially in forcing the seed downward to mineral soil giving it the best chance of germination and establishment.

Should spring application be desired, seed can be stratified and disseminated just prior to germination. Probably the only advantage of spring sowing of stratified seed in western Oregon is the sharp reduction in time that the seed is exposed to rodent depredations. Several disadvantages are encoun-

tered. Application should take place when the stratified seed reaches the point of germination. Weather conditions may be adverse at this time and the seed will have to be held at a lower temperature to keep it from germinating. Such irregular conditions may prove detrimental to the stratified seed. Disseminating devices may injure the stratified seed when application takes place. On land supporting a moderate cover of lower types of vegetation the seed may fall on a leaf mat or other debris. When germination occurs there will be little opportunity for the seedling to establish a root system through the leaves or other ground cover before drying out.

RODENT BAIT

Two types of bait have proven satisfactory for rodent control operations. These are wheat treated with sodium fluoroacetate (compound 1080) and wheat treated with thallous sulphate (Tl_2SO_4). Both baits are dyed green to reduce the possibilities of birds finding and eating them. An overcoating of cooking oil is applied to the bait to eliminate sluffing off of minute poison crystals that might be on the surface of the wheat kernels and to prevent leaching of the poison.

The combination of the two baits at the rate of 1/4 pound each per acre is used in preference to a single rodenticide, since each has different qualities that makes it valuable in rodent control. The 1080 bait is highly toxic; one kernel of fresh bait will kill a mouse. The poison is infinitely soluble in water; however, and is subject to leaching during rainy periods. Thallous sulphate bait, on the other hand, is not quite as toxic but does not leach from the wheat kernel as readily. Thus, the combination of the two baits (5) affords quick and fairly lasting control. In the event that a mouse should receive a sub-lethal dose of one rodenticide and develop an aversion to it, the second bait would be present for the mouse to take. Neither of the two

continues to be effective after the wheat kernels become water soaked and begin to disintegrate, since they are no longer palatable to the mice.

Procurement of Bait

Certain specifications for rodenticides have been drawn up by the State Board of Forestry so that a uniform product results. Figures 4 and 5 set forth the specifications for 1080 and thallous sulphate bait.

BAITING AND SEEDING

Both baiting and seeding are accomplished with the helicopter. General operational requirements and special equipment needed are the same for both activities. They can best be described by the information set forth in the sample bid form, Figure 6.

The general requirements cover various factors relating to an aerial seeding operation that should be considered for the protection of both the aircraft operator and the person requesting the services.

Helicopter Specifications

Detailed specifications for aircraft and disseminating mechanism are set forth under Section III, page 4 of the sample bid form, Figure 6.

All helicopter operators in the Pacific Northwest are using a centrifugal type seed disseminator. Some are operated electrically, others hydraulically, both are satisfactory. Certain modifications and special requirements may be necessary under varying conditions. Plates VII and VIII show the type of disseminating mechanism in current use.

Baiting

One of the most important phases of aerial seeding is rodent control. On its success or failure may depend the results of the entire project.

Satisfactory rodent control is being obtained at the present time by

Figure 4

Oregon State Board of Forestry
Poison Bait Specifications
1080

Bait: To be large kernel Rink or White Holland soft wheat free of chaff and other foreign matter.

Poison: To be sodium fluoroacetate (compound 1080).

Formulation: Wheat to be impregnated by soaking in a 5.8% aqueous solution by weight of 1080 for 24 hours at a temperature of 65° to 70° Fahrenheit. Treatment to be made in containers not subject to corrosion by 1080.

Wheat to be colored with green food dye during impregnation with poison. In addition to the green food dye, wheat is to receive an over-treatment with a coating of cooking oil, such as soya or cottonseed, in which has been dispersed a monastral green light-fast pigment, such as Dupont GT-486-D, or approved equal. The over-treatment to be applied at the rate of one pound green pigment and 40 ounces of cooking oil to each 400 pounds of wheat.

Finished product to be dried to original dry weight so as to insure no molding or deterioration of wheat.

Container: Poison bait container to be composed of two sewn sacks of fifty pound capacity. The inner sack to be of cloth or canvas; the outer sack to be of burlap or canvas. Sacks to be new, free of holes, closed, sealed and marked in accordance with government regulations concerning packaging of poisons. No tags or papers shall be placed inside of the container.

Sacks are to be further marked with stencil on both sides in the following manner: (1) Supplier's name or trademark (2) Type of poison and bait (3) Quantity (4) Date of preparation.

Figure 5

Oregon State Board of Forestry
Poison Bait Specifications
Thallous Sulphate

Bait: To be large kernel Rink or White Holland soft wheat free of chaff and other foreign matter.

Poison: To be thallous sulphate (Tl_2SO_4) .

Formulation: Wheat to be impregnated by soaking in a 4.1% aqueous solution by weight of thallous sulphate for 24 hours at a temperature of 65° to 70° Fahrenheit. Treatment to be made in containers not subject to corrosion by thallous sulphate.

Wheat to be colored with green food dye during impregnation with poison. In addition to the green food dye, wheat is to receive an over-treatment with a coating of cooking oil, such as soya or cottonseed, in which has been dispersed a monastral green light-fast pigment, such as Dupont GT-486-D, or approved equal. The over-treatment to be applied at the rate of one pound green pigment and 40 ounces of cooking oil to each 400 pounds of wheat.

Finished product to be dried to original dry weight so as to insure no molding or deterioration of wheat.

Container: Poison bait container to be composed of two sewn sacks of fifty pound capacity. The inner sack to be of cloth or canvas; the outer sack to be of burlap or canvas. Sacks to be new, free of holes, closed, sealed and marked in accordance with government regulations concerning packaging of poisons. No tags or papers shall be placed inside the container.

Sacks are to further marked with stencil on both sides in the following manner: (1) Supplier's name or trademark (2) Type of poison and bait (3) Quantity (4) Date of preparation.

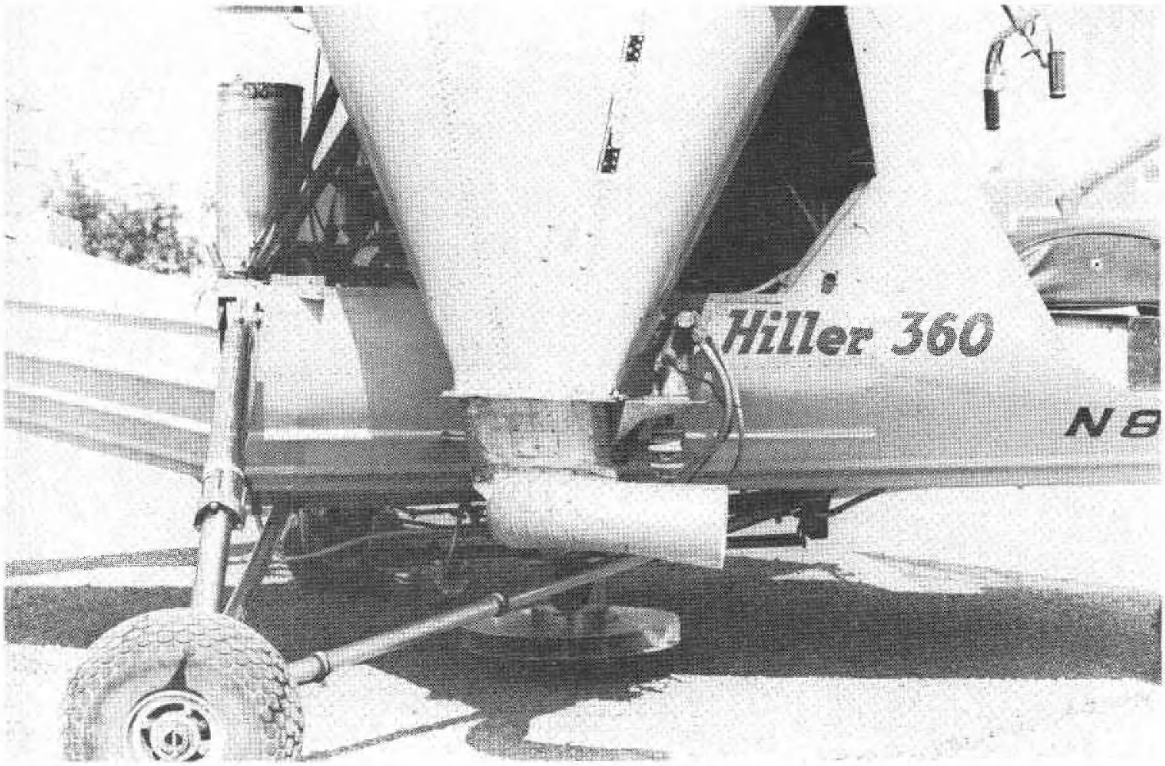


Plate VII. Bait and Seed Disseminating Mechanism, Side View

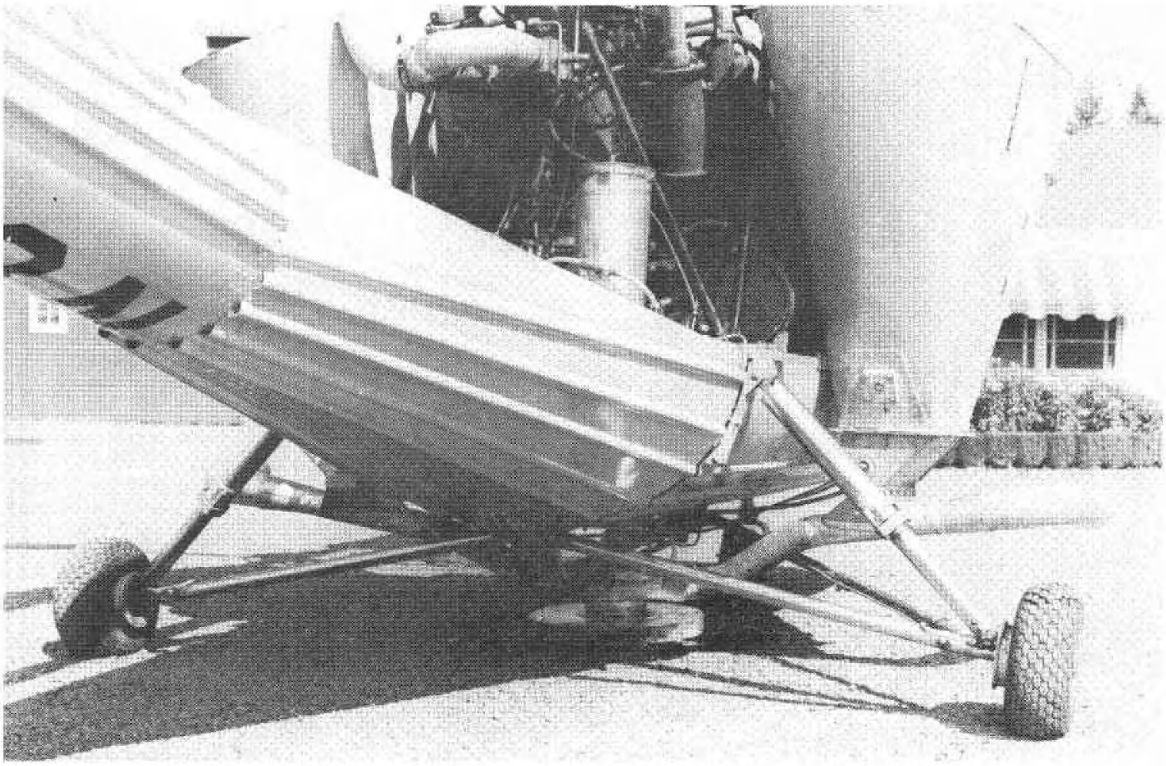


Plate VIII. Bait and Seed Disseminating Mechanism, Rear View

using 1/4 pound 1080 treated wheat and 1/4 pound thallous sulphate treated wheat for 1/2 pound bait per acre. The entire seeding area plus a 1/4 mile buffer strip around it should be baited. As stated earlier, the buffer strip is required to obtain an acceptable level of control and to prevent rodent drift into the seeding area. The bait can be flown out in single flights over the area. Sufficiently accurate distribution can be obtained in this manner.

Pre-control Census

A rodent census should be made before baiting, if results of control are to be measured. Sampling may be accomplished by a system of traps baited and placed in the area to be treated.

There are no reliable estimates of the actual number of mice per acre present on cutover or burned over forest land nor of the minimum number permissible for successful seeding. For this reason all estimates of population levels must be relative.

The potential effect of the mice and other small mammals on the seed to be distributed may be very roughly determined by the placing of seeds in spots and later counting those disturbed. This influence may be measured much more efficiently by a system of snap traps baited and placed in the area to be sampled.

A trapping system found to be quite satisfactory consists of setting in a line, 120 baited traps which are examined daily for three days (3). A common snap mouse trap such as the "Four Way Victor" is recommended. The most practical bait for this purpose is the meat of the filbert nut. This is quite attractive to mice and shrews under most conditions and is not washed away by rain. Another bait which has proven satisfactory is a mixture of raisins, peanut butter and Douglas-fir seeds. It is effective in dry weather only, since rains wash it away.

The traps should be placed at 22 foot intervals or three per chain. This will provide a line one-half mile in length. Where trapping is continued for more than three days a new location should be sought at least five chains distant from any previously trapped sites, since snap traps may cause a considerable drain upon the population.

Each trap should be examined daily for three days and the rodents or other mammals tallied by species. Traps which have been sprung should be rebaited and reset. Exposure for at least three nights is necessary because of inactivity which may persist for as many as two consecutive nights. One man can easily set or tend 120 traps in one-half day. The expenditure in manpower necessary for each trap line is reasonably low.

The amount of work can be greatly reduced by placing traps one day and not revisiting until they have been exposed for three consecutive nights. Data from traps set in this manner are not accurate where populations are high, since the seed eaters tend to live in colonies and to be limited in range. In numerous cases they spring so many traps the first or second night that some may not find an unsprung trap. However, population differences in the higher brackets are not significant in project work, since the combination of thallous sulphate bait and 1080 bait is equally effective against dense and sparse populations.

The results obtained by trapping cannot be validly converted to numbers of rodents or other mammals per acre. Results may be conveniently expressed in terms of the small mammals caught per 100 trap nights. This may be reduced to the formula $\left(\frac{M}{(T)(N)}\right) 100$ where M = the number of mammals caught in the trap line for the period, T = the number of traps in the line and N = the number of nights exposed. For example, 120 traps exposed for three days catch 60 mammals $\left(\frac{60}{(120)(3)}\right)$ 100 equals 16.7 or 16.7 mammals per 100 trap nights.

Normal undisturbed populations vary greatly from year to year and from season to season. There is often a considerable difference between one area and another a short distance away. Population density is also affected by the density and type of cover. Rodent counts made by the State Board of Forestry during the season when seeding is normally planned have produced from an unusual low of 10.55 rodents per trap night to a high of 22.78. A fall population check based on 1,800 trap nights in the Tillamook Burn indicated a mean of 16.28 mammals per 100 trap nights. This figure is reasonably accurate for cutover and burned areas in northwest Oregon.

Time of Baiting

Rodent control operations should take place as late in the fall as weather conditions will permit. Since it is necessary that baiting be conducted during dry weather and that at least a 24 hour period following baiting be rain free for optimum control, it is not advisable to delay too long. Excellent control has been obtained by baiting as early as the latter part of September and as late as the middle of October. Weather during and following these operations was dry.

Winds during baiting should not exceed 10 miles per hour. Higher winds make it difficult to maneuver the helicopter over rough terrain. This, plus the direct effect of the wind on the falling bait, makes for poor distribution.

Distribution of Bait

Prior to actual application of bait the aircraft and equipment to be used should be inspected and tests made to determine the swath width produced by the disseminating mechanism.

Reliable helicopter operators already have this information. However if a check is to be made, it is only necessary that both hoppers on the helicopter be loaded with a small quantity of clean, untreated wheat and be flown out over

a roadway, landing strip or level field where the wheat kernels can be readily spotted. The helicopter should fly at the altitude and speed that will be employed in the actual operation and should pass over a predetermined center point so the swath on either side can be measured.

The average centrifugal disseminating mechanism will produce a swath width of 210 feet with wheat. Since a certain amount of overlap is required, it is advisable that the effective swath width be reduced to 198 feet or 3 chains. Knowing the effective swath width, it is now relatively simple to calibrate the individual metering devises for each hopper.

For example, given a constant speed of 60 miles per hour at an altitude of 150 to 200 feet above tree top level and an effective swath width of 3 chains, using 1/2 pound of bait per acre, the helicopter will bait 24 acres a minute. Each metering device for each of the two hoppers should be calibrated to release 6 pounds of bait per minute or 12 pounds per minute for the two hoppers. An accurate balance scale graduated in pounds and ounces should be on hand during calibration.

After calibration is complete, distribution of wheat can be checked. The large kernel wheat used for bait averages 12,000 kernels per pound. Using 1/2 pound per acre supplies 6,000 kernels per acre or approximately 5 kernels per 36 square feet. A second test flight can be made over another location on a roadway, airstrip or field and the distribution examined.

In actual baiting operations it is advisable that the helicopter pilot note accurately his ferrying time to and from the landing strip and time consumed in distributing bait over the area. A record should be kept, at the strip, of time out and time in along with the block number being baited and the amount of bait being carried. This information will permit a close check on distribution and insure proper coverage. If an obvious time discrepancy

occurs, metering devices should be checked and reclibrated.

In an earlier section, delineation of the seeding unit was discussed. If the method recommended for lay out of area is followed, no difficulty should be experienced in acquainting the helicopter pilot with each of the blocks within the seeding unit. After the pilot, accompanied by a guide, has flown around a baiting block and become familiar with the boundaries, he is ready to begin baiting. Since the exterior seeding boundary and not the baiting boundary is marked, it will be necessary for the pilot to fly 7 complete swaths outside of the seeding boundary to complete the 1/4 mile buffer strip.

As each block is completed, the pilot flys over the next block in the company of a guide and then proceeds with the bait distribution. Where more than one helicopter is employed on a baiting and seeding operation an accurate record should be kept of the blocks baited by each pilot. It should be required that the same pilot seed the areas which he has previously baited, since he has had an excellent opportunity to become acquainted with the terrain and land marks during the baiting.

Post-control Census

After baiting, a thorough check of rodent population should be made to test the effectiveness of the treatment. At least two weeks should be permitted to elapse before post-control tests are made. This period is necessary to permit the bait to be fully effective. Actual sampling techniques should be the same as those used in the pre-control census.

Where relatively small areas are involved and the risk of invasion high, an additional sampling of the population in the spring may be advisable to determine whether the additional protection of spring rebaiting is necessary.

As previously stated there are no positive figures on the maximum number of mice or other seed eating mammals which will permit successful seeding. However, it is a valid assumption that the seed losses to rodents will be in

proportion to the number present during the period when the seeds are exposed. Thus, the fewer mice and other seed eaters remaining, the better the results that may be expected. From such reasoning it should be required that the results of any baiting done with combination thallous sulphate and 1080 bait fall within the range of normal for such material when properly applied. Listed below are the censuses taken after baiting for 9 projects on which this bait was used.

Project	No. Acres Baited	Date Trapped	Location	No. Trap Nights	No. Mammals Caught	No. Caught Per Trap Night
Rehab. Unit III, Blk. S1	15,844	10-49	Till. Burn	348	1	.28
Owl Experimental	500	11-50	Till. Burn	720	4	.55
Tom Rock Experimental	1,600	12-50	Linn Co.	450	0	.00
Boulder Creek	2,104	12-50	Polk Co.	720	3	.42
Mill Creek	1,561	12-50	Polk Co.	360	0	.00
Rehab. Unit III, Blk. S2	9,946	11-50	Till. Burn	720	0	.00
Rehab. Unit VI, Blk. S1	6,924	10-51	Till. Burn	900	4	.44
Rehab. Unit VII, Blk. S1	11,676	10-51	Till. Burn	1,500	2	.13
Rehab. Unit VII, Blk. S2	8,921	10-52	Till. Burn	525	3	.57
			Totals	6,234	17	Mean .27

If the post-control census taken on a given aerial baiting and seeding project falls within this range of normal, it can be expected that rodents will be an extremely minor factor in preventing the establishment of a stand of seedlings.

Seeding

The mechanics of seeding are quite similar to those of baiting; however, certain refinements are employed in the seeding operations. Instead of disseminating the seed in single flights across the area it is cross-flown so as to obtain better distribution. The seeding unit boundary and block boundaries are well defined by natural breaks or aluminum markers.

Time of Seeding

It is advisable to withhold seeding until the fall rains have commenced. Successful seeding operations have been carried out as early as the last week

of October and as late as the middle of February.

Winds during seeding should not exceed 5 miles per hour. Even though seed is cross-flown, excessive wind velocities will affect distribution. If light seeded species such as western hemlock or western redcedar are being used, no winds should be blowing at time of application. In general, a fairly clear period should be chosen for the seeding operation. Rain does not affect the seeding; however, it may make it difficult for flying. Weather conditions should be considered not only from the standpoint of obtaining good distribution, but also from the standpoint of safety of the helicopters and pilots.

Distribution of Seed

Swath width of various forest tree seed species can be checked in the same manner that bait swath width is determined. Calibration is carried out in the same way except that quantities per acre are based on two flights at right angles to each other instead of a single flight.

Using Douglas-fir seed at the rate of 1/2 pound per acre, calibration would be based on 132 foot or 2 chain effective swath. The flying speed and altitude would be the same as for bait, 60 miles per hour and 150 to 200 feet above tree top level, respectively. Since the area is to be cross-flown, it will be necessary that 1/4 pound of seed per acre be distributed in each flight. Each metering device should be calibrated to release 2 pounds of Douglas-fir seed per minute or 4 pounds per minute for the two hoppers. Metering devices are thus set to distribute 1/4 pound of seed per acre in a single flight. The second or cross flight is made at as near right angles as topography will permit. Here again 1/4 pound of seed is distributed, making the total of 1/2 pound of seed per acre. Knowing the effective swath width of any seed and the rate of application per acre will permit accurate calibration for any seed species. Seed distribution checks can be made in the same manner as bait distribution.

As mentioned earlier, if more than one helicopter is employed, care should be taken to see that the same pilot seeds the areas that he has previously baited. It is advisable to have the pilot fly each block in the company of a guide prior to seeding, even though the pilot may recall landmarks and marker locations.

Seed poundages for each block within the seeding unit should be weighed out and labeled in advance of the operation so as to eliminate confusion and delay.

It is rather difficult to make field checks on seed distribution during application because of brush cover, topographic conditions and slight ground winds. Seed traps one mil-acre in size have been employed but have not proven satisfactory. The number that would have to be placed in the field to obtain significant results would be so great as to make it economically unfeasible. Seeds landing in the traps may bounce out or be blown out, further reducing the accuracy of the check.

GERMINATION AND ESTABLISHMENT OF SEEDLINGS

In the spring of the year following aerial seeding it will be to the best interests to observe the progress of seedling germination. Spring and summer weather conditions should be noted, since both will have a great deal of influence on germination and establishment.

Spring Germination Analyses

Several methods of checking spring germination are in current use; the screen seed cap method, the germination and survival plot method and the screened seed plot method. The first two methods will furnish general field information on germination and survival while the third will supply specific information on time of germination and germinative capacity of the seed.

The Screen Seed Cap Method

In order to have a more or less positive method of observing germination at the earliest possible time, it is necessary that seed samples be protected from rodents. Screen caps made of 1/4 inch hardware cloth such as those used in field experiments concerning the leaching of rodent baits are quite suitable (5).

A seed sample should be put out for each block within the aerial seeding unit. Each sample should be composed of 10 screen caps. Beneath each screen cap should be placed 10 seeds from a representative sample taken from the seed used on the block. As an added precaution one screen cap can be buried in an inverted position, the seeds deposited on the buried cap and the second screen cap placed over the buried one so the edges interlock.

Screen caps should be placed in a line at 1/2 chain intervals. It is advisable that the sample be laid out near a road through the block so as to make inspection convenient. The site chosen should be typical for the block.

First observations can be made in early May or later, depending on spring weather conditions and elevation of seeding unit. As germination is observed in the sample one can expect approximately the same progress throughout the block. All samples should be checked at periodic intervals. The time between visits will depend on the amount of information desired. Usually a one or two week interval is satisfactory.

A record should be kept of the seedlings as they germinate. Any mortality should be noted along with the probable cause.

The Germination and Survival Plot Method

The screen seed cap method of sampling early germination usually is carried on in conjunction with germination and survival plots. As soon as germination is noted under the screen caps, plots can be laid out across each block within the seeding unit. No time is wasted in looking over the entire

area for newly germinated seedlings preparatory to setting up the plots, since all initial observations are made on the screen seed cap samples.

Germination and survival plots are circular and 20 feet in diameter. Large plots are used so that whenever a plot site is chosen it will be possible to find some seedlings. The number of plots established depends entirely on the intensity of the record to be maintained of seedling progress. In projects of 5,000 acres or more one plot per 400 acres seems to be about the maximum that can be handled economically. On a smaller acreage more plots can be laid out in order to obtain better coverage and representative conditions.

In selecting plot sites care should be taken to see that they afford a good cross section of the area. As each plot is established a center stake should be set. The perimeter of the plot can then be determined by using a string 10 feet long fixed to the center stake and stretched out to its full length. This operation can be repeated at each visit or stakes can be driven into the ground at intervals around the circle to serve as a guide.

A progressive record of all seedlings found should be kept. The date and number of seedlings found should be recorded on the first visit. Following checks should include the recording of date, number of new seedlings germinated, number of seedlings dead and probable cause, and total number of live seedlings to date.

As seedlings are found and recorded they should be staked so that they will not be recorded more than once. Wire stakes 18 inches long with a loop at the top end which has been dipped in yellow paint serve very well. If a seedling dies, the stake can be bent in the middle to indicate the loss.

Since deer or other animals may disturb the stakes, it is advisable that seedlings be plotted on cross section paper as to their exact location in the plot. A circle 4 inches in diameter described on 10x10 cross section paper is satisfactory. Sheets are small enough to be placed in the average field

note book. By standing at the center of the plot and orienting the plot sheet all seedlings can be recorded in their exact location. An "X" can be used to designate each seedling. If a seedling dies, the "X" can be circled to indicate death.

Provided an accurate record is kept on all plots from first germination through the fall into the rainy season, one can expect to obtain a fair indication of seedling survival throughout the seeding unit. No accurate indication of stocking can be obtained from the germination and survival plots.

The Screened Seed Plot Method

When more detailed information is desired on time of germination and the germinative capacity of the seed used, the screened seed plot method may be employed. At time of seeding a few representative samples from the seed lot can be placed under large screen caps.

Three or four screen covered samples of from two to three thousand seeds each for each of the major exposures is adequate. One sample for each exposure might be sufficient but frequent loss due to animal disturbance and the effect of heavy winter snows and rains necessitate the extras.

To test germinative capacity of the seed, samples for laboratory tests should be removed just before natural germination is anticipated. These should be submitted for analysis immediately after removal. At least ten seeds should be left in each screened plot to serve as an index to the time natural germination can be expected.

Stocking Surveys

Three types of surveys are employed to obtain, first, some indication of initial stocking, second, an indication of over-all stocking, and third, final over-all stocking. These are the transect, the preliminary stocking survey and the final stocking survey.

The Transect

After seedlings have weathered their first summer season it will be particularly interesting to obtain some indication of initial stocking. This can be accomplished by establishing a transect within the seeding unit, the transect being a line of four mil-acre plots located at 2 chain intervals. It should be so located as to furnish a good cross-section of conditions prevailing within the unit. Permanent plots should be established, center stakes set and seedlings staked and plotted on cross-section paper. Such a practice will permit resurvey of the transect with the least amount of difficulty in the following year.

At least one mile of transect should be established for each 5,000 acres in the unit. On smaller acreages the transect can reach completely across the area seeded.

Information taken from the plots is the same as collected in a regular stocking survey. The data can be compiled in the manner used in presenting stocking percentages and trees per acre under Results of Aerial Seeding Projects, Aerial Seeding, 1950.

The Preliminary Stocking Survey

When seedlings are two years old a preliminary stocking survey can be conducted to obtain an indication of over-all stocking. Necessarily, such a survey must cover the entire seeded area. Here the regular system of conducting a stocking survey can be used. It is quite possible that all seedlings will not be found. However, it must be borne in mind that the purpose of this survey is to get an indication of over-all stocking. Should local fail spots or skips appear in the stocking pattern they can be resurveyed by running lines at right angles to the original survey. If no stocking is found by this process it may be necessary to plant those areas that can support tree growth. On the other hand, sufficient stocking may be picked up to eliminate further need

for reforestation.

Through use of the preliminary stocking survey it is possible to locate and correct failures three years in advance to the final stocking survey.

The Final Stocking Survey

By the time seedlings are 5 years old they have become readily discernible in the lower types of vegetative cover. The seedlings have weathered the early critical periods and should be able to withstand extended dry periods during the summer and severe cold during the winter. It is at this stage in the establishment of a new forest that a final stocking survey can be made.

The same method employed in the preliminary stocking survey can be used. Fail spots and skips can be treated in the same manner. If any nonstocked areas appear some arrangement should be made to plant them so as to complete the stocking on the seeding unit.

Figure 6

Oregon State Board of Forestry

REQUEST FOR QUOTATIONS
ON
AERIAL BAITING AND SEEDING

THIS IS NOT
A CONTRACT

Salem, Oregon-July 25, 1952

Quotation No. Rehab.-128

Please state hereon, in the space provided, the lowest price at which you can furnish the necessary equipment and services to accomplish the aerial baiting and seeding specified below. The right is reserved to accept or reject any or all quotations. Bidders will use this form only in submitting quotations. Retain duplicate copy for your files.

The aerial baiting and seeding is to be completed and approved in accordance with specifications and time limitations specified below.

Quotations will be received until 2 P.M., August 8, 1952 at the office of the State Forester, 2600 State Street, Salem, Oregon. Project to be under the supervision of R. M. Kallander, Rehabilitation Director.

I

WORK TO BE ACCOMPLISHED

To furnish to the State Forester, acting on behalf of the State Board of Forestry, equipment, personnel and services for aerial baiting and seeding by helicopter of certain forest areas hereinafter specified in conformity with the following requirements and specifications.

Quotation No. Rehab.-128

II

GENERAL REQUIREMENTS

1. Performance Bond - The successful bidder will be required to furnish a service or performance bond of the type required by the State of Oregon in the amount of his bid. Bond forms will be furnished the successful bidder. Bond to be returned upon the successful performance of the contract.

2. Aircraft and Personnel - Two helicopters properly equipped for aerial dissemination of bait and forest tree seed as specified below. An experienced supervisor, two pilots and adequate ground personnel for proper maintenance and servicing as specified below.

3. Examination of Specifications - The bidder is expected to examine the specifications and to visit the designated aerial seeding tracts so that he may thoroughly familiarize himself with conditions at the site. No consideration will be given any claim that a bid was made without full comprehension of conditions to be encountered.

4. Baiting and Seeding Area - Tillamook Burn Unit - Approximately 8,850 acres to be baited and approximately 6,100 acres to be seeded in Townships 1 and 2 South, Ranges 7 and 8 West, W.M. of Tillamook County. Elevations range from 500 to 2,000 feet above sea level.

The Tillamook Burn Unit is shown on the attached map labeled "Exhibit No. 1".

Acreages listed above are approximate. The State Forester reserves the right to request the baiting and seeding of 10 per cent more or less than the acreage designated.

5. Commencement and Prosecution of Work -

(a) The successful bidder shall begin baiting operations on the Tillamook Burn Unit on September 22, 1952 or as soon thereafter as weather permits. Unless otherwise authorized in writing by the State Forester, the successful bidder shall keep all required equipment and personnel continuously on the project and shall take full advantage of suitable flying weather until the baiting is completed.

(b) The successful bidder shall begin seeding operations on November 1, 1952 or as soon thereafter as weather permits. Unless otherwise authorized in writing by the State Forester, the successful bidder shall keep all required equipment and personnel continuously on the project and shall take full advantage of suitable flying weather until the seeding is completed.

6. Permits and Licenses - The successful bidder shall, without additional expense to the State Board of Forestry, obtain all required licenses and permits. All aircraft and pilots provided by the successful bidder must comply with all current CAA and Oregon State Board of Aeronautics rules and regulations.

7. Liability - The successful bidder shall be solely responsible for any injuries or damages arising from the operation of any aircraft and other equipment in carrying out the aerial baiting and seeding operations. This provision shall not apply to any injury from or as a result of the poison bait when applied in the manner prescribed by the State Board of Forestry within the unit boundaries. The successful bidder shall comply with the provisions of Chapters 1 and 2 of Title 98, Oregon Compiled Laws Annotated.

8. Workmen's Compensation - The successful bidder shall provide for all pilots and ground personnel workmen's compensation insurance coverage which provides at least the average benefits scheduled by the Oregon Workmen's Compensation Act.

9. Additional Baiting and Seeding Area - Any additional baiting and seeding requested by the State Forester before the completion of the project shall be chargeable at the unit price quoted by the successful bidder and shall be subject to the conditions of these specifications.

10. Subcontracts - The successful bidder shall not, without written approval from the State Forester, enter into any subcontract covering any part of the work contemplated by the above specifications and requirements.

11. Contract - The successful bidder shall enter into a written contract with the State Forester, acting on behalf of the State Board of Forestry; such contract shall be in duplicate and contain the terms, conditions and quotations stated herein.

III

DETAILED SPECIFICATIONS

1. Aircraft and Disseminating Mechanism Specifications -

(a) All helicopters shall be capable of carrying a pay load of at least 200 pounds of bait or seed at elevations up to 4,500 feet above sea level.

(b) All helicopters shall be equipped with 2 hoppers, one on each side of the aircraft, and each capable of containing at least 100 pounds of Douglas-fir seed.

(c) All helicopters shall be equipped with power driven, centrifugal type adjustable seed disseminating mechanism capable of maintaining a constant measured rate of dissemination. The disseminating mechanism shall be so constructed as to be readily adjustable in the field for the quantity or rate of dissemination of bait or forest tree seed specified below.

2. Personnel Requirements -

(a) The successful bidder shall provide a representative experienced in aerial dissemination of bait and seed, who shall supervise the operation as directed by the authorized representative of the State Forester.

(b) All helicopter pilots provided by the successful bidder shall be experienced in the aerial dissemination of bait and seed.

(c) The successful bidder shall not change pilots after baiting or seeding work has begun without the written approval of the State Forester.

(d) An experienced helicopter mechanic, who is thoroughly acquainted with the seed disseminating mechanism, shall be on duty at the site of baiting and seeding operations for the duration of the baiting period and seeding period.

3. Facilitating Equipment - The successful bidder will bear all costs of operation and maintenance of aircraft including fuel and lubricants, transportation, storage, and loading facilities.

4. Certified Statements - To receive consideration, each bid shall be accompanied by a certified statement giving:

(a) Descriptions, license numbers and evidence of availability of all helicopters specified above for the project.

(b) Evidence of availability of properly qualified helicopter pilots and a record of the general helicopter flying, baiting and seeding experience

of each as specified above.

(c) The name of the representative experienced in aerial dissemination of bait and seed who will supervise the operation and record of his experience.

(d) Evidence of availability of ground personnel as specified above.

(e) Evidence of the ability of the bidder to provide performance bond specified above.

(f) Evidence of bidder's past performance.

5. Inspection -

(a) The State Board of Forestry will inspect the bidder's aircraft, disseminating mechanism, facilitating equipment and personnel before the contract is awarded.

(b) The equipment will also be subject to inspection in the project area prior to start of baiting or seeding.

6. Bait and Seed -

(a) Bait will be poisoned wheat.

(b) Seed will be Douglas-fir.

7. Rates and Methods of Application -

(a) Bait on the Tillamook Burn Unit shall be applied at the uniform measured rate of 1/2 pound per acre, no cross-flying.

(b) 6,100 acres will be seeded at the rate of 1/2 pound Douglas-fir seed per acre. The area shall be cross-flown at the rate of 1/4 pound seed per acre per application. Cross-flights shall be as near right angles to each other as is compatible with terrain.

(c) Both bait and seed shall be applied from a constant elevation of 150 feet to 200 feet above tree top level and at a constant speed of not

less than 45 miles per hour and not more than 60 miles per hour to insure proper distribution.

8. Time of Baiting and Seeding

(a) Baiting operations on the Tillamook Burn Unit will begin on September 22, 1952 or as soon thereafter as weather conditions permit.

(b) Seeding operations on the Tillamook Burn Unit will begin on November 1, 1952 or as soon thereafter as weather conditions permit.

(c) Baiting operations will be confined to periods of dry weather when wind velocities are less than 10 miles per hour.

(d) Seeding operations will be confined to periods when wind velocities are less than 5 miles per hour.

9. Acceptance - As bait and seed are applied field checks of distribution will be made. Any inadequacies detected shall be corrected by the successful bidder without additional charge to the State Board of Forestry prior to acceptance of the work.

10. Facilities to be Furnished by the State Board of Forestry -

(a) Guide for prospective bidders at time baiting and seeding areas are visited.

(b) A representative to acquaint the successful bidder's pilots with the baiting and seeding blocks within the project unit.

(c) Suitable bases from which to operate aircraft.

(d) Bait and seed prepared and measured for dissemination, delivered to bases of operation, and loaded in aircraft.

(e) Adequate maps, aerial photos and other data necessary for orientation of pilots.

11. Payment -

(a) Upon satisfactory completion of baiting operations and acceptance of the work by the authorized representative of the State Forester, payment will be made for baiting operations based on the unit price quoted by the successful bidder.

(b) Upon satisfactory completion of seeding operations and acceptance of the work by the authorized representative of the State Forester, payment will be made for seeding operations based on the unit price quoted by the successful bidder.

IV

QUOTATION

This bid form when filled out and signed by the bidder shall be deemed an offer; such offer can only be withdrawn prior to the opening of bids at 2 P.M. on August 8, 1952.

1. Tillamook Burn Unit.

(a) Per acre rate baiting 1/2 pound poison wheat $_____ x 8,850 acres $_____

(b) Per acre rate seeding 1/2 pound Douglas-fir seed $_____ x 6,100 acres $_____

Total $_____

2. Terms _____% Time_____days

Date_____ Firm_____

Address_____

Signed by_____

RESULTS OF AERIAL SEEDING PROJECTS

Since the inauguration of Oregon's rehabilitation program, aerial seeding has become a major medium of reforestation.

The first large scale project was carried out in the fall of 1949. Methods and equipment employed at that time have been greatly improved. A general account of major seeding projects follows.

Aerial Seeding, 1949

In the fall of 1949 9,701 acres in the Tillamook Burn were aerial seeded with Douglas-fir seed. A total of 15,844 acres was baited which included a 1/4 mile buffer strip around the seeding unit.

Bait was applied at the rate of 1/2 pound per acre. It consisted of 1/4 pound 1080 treated wheat and 1/4 pound of thallous sulphate treated wheat, both dyed green.

Rodent control operations took place between September 22 and October 1, 1949. Several days were lost when operations were shut down because of high east winds. Only one helicopter was used to apply the 7,922 pounds of bait.

No pre-control rodent population check was made on the area, since research projects carried on in the vicinity indicated a fairly high rodent population. Following baiting a post-control check was made. One mouse was caught in 348 trap nights and the mouse was caught in a known skip area.

Seeding began on November 1 and was completed on the 5th. Douglas-fir seed was applied at the rate of 1/3 pound per acre on 8,602 acres. A combination of 1/4 pound high elevation Douglas-fir seed and 1/4 pound noble fir seed was applied to 1,099 acres ranging from 2,500 to 3,000 feet above sea level.

The electrically operated metering device and seed disseminator used was similar to that employed in dusting and clover seeding operations. Calibration was fairly accurate, although continual checks were necessary to maintain proper

calibration. The bait and seed disseminating mechanism consisted of two long Venturi tubes with flaired openings at the ends. The tubes were connected to the hoppers just beneath the metering devices. Bait or seed was released from the hoppers through the metering devices by means of modified fluted feed rolls similar to those used in seed drills. The bait or seed passed from the metering devices into the tubes which were fed by an air blast from the cooling fan on the helicopter. Upon hitting the air blast the bait or seed was forced out the flaired ends of the tubes into the air.

The maximum swath width of both bait and seed was 80 feet. The effective swath width was set at 66 feet or 1 chain so as to allow sufficient overlap. Both bait and seed were distributed in single flights. No cross-flying was employed in seeding. Baiting and seeding was completed at the rate of 8 acres per minute.

Costs of the 1949 operation were very reasonable. A brief cost summary is set forth in Figure 7.

Lands lying within the 9,701 acre unit were quite well adapted to aerial seeding. Most of the area had reburned in the 1945 Tillamook fire and brush cover had not yet reached a critical point in density. Some land is always unsuitable or non-productive within a large seeding unit. Talus slopes, marshy bottoms, and dense stands of alder along watercourses are some that occurred. Since it could not be expected that naturally seeded or planted trees would grow on such sites, it was necessary that they be written off as non-productive even though they were seeded in the process of the operation.

A preliminary stocking survey conducted during the summer of 1952 indicates an over-all stocking by 4 mil-acre plots of 47.76% or 415 trees per acre (1) and 22.25% or 320 trees per acre by mil-acre plots (2). These figures include an insignificant number of natural seedlings established prior to aerial seeding.

Figure 7

Cost of Helicopter Aerial Seeding, Tillamook Burn
Rehabilitation Project, 1949

Township 1 North, Ranges 5 & 6 West

Unit III, Block S1

Item	Acreage	Total Cost	Average Cost per Acre
D.-fir Seed 1/3 pound per acre	8,602	$21,853.95)	
D.-fir Seed[1] 1/4 pound per acre		)	$2.6063
N. fir Seed[2] 1/4 pound per acre	1,099	3,430.26)	
Bait[3] 1/2 pound per acre	15,844 *	5,892.00	.6073 **
Bait flying at .2975 per acre	15,844 *	4,715.19	.4860 **
Seed flying at .2975 per acre	9,701	2,886.05	.2975
Miscellaneous controls	9,701	654.32	.0674
Total		$39,431.77	$4.0645

* Area baited includes 1/4 mile buffer strip around seeded acreage.

** Cost per acre of bait and bait flying based on seeded acreage.

1 Douglas-fir seed average cost per pound $7.67

2 Noble fir seed cost per pound 4.41

3 1080 bait cost per pound .82

Thallous sulphate bait cost per pound .65

Stocking throughout the 9,701 acre area varies from zero in nonproductive areas and obvious skips to a high of 60% by 4 mil-acre plots on the most favorable sites. The major portion of the unit supports stocking of 40%. It is significant that within the 1,099 acres seeded with 1/4 pound high elevation Douglas-fir seed and 1/4 pound noble fir seed no noble fir seedlings were found.

Had a seed disseminating device of the type currently in use been available and had the seed been cross-flown there is no doubt that the stocking would have been considerably better. Obvious skip areas appear in the stocking pattern on lands that are well adapted to seedling growth and establishment. Some of the skips are of sufficient size that it may be necessary to plant to obtain acceptable stocking. At the present time no positive method of seeding such small areas is available.

Aerial Seeding, 1950

An area in the Tillamook Burn consisting of 7,504 acres was seeded by helicopter in the fall of 1950. The baiting totaled 9,946 acres including the 1/4 mile buffer strip.

The bait mixture used was composed of 1/4 pound thallous sulphate treated wheat, 1/8 pound coated 1080 wheat and 1/8 pound soaked 1080 wheat for a total of 1/2 pound per acre. All baits were dyed green.

Dissemination of bait was carried out from November 3rd through 8th. Two helicopters were employed in the operation.

No check was made on the rodent population prior to baiting. Trapping after baiting resulted in no rodents caught during 720 trap nights.

Seed was applied during the period December 3rd through 6th. One-half pound of Douglas-fir seed per acre was disseminated.

The type of disseminating device employed in the 1950 operations was similar to that described in Figure 6, sample bid form. The effective swath

Figure 8

Cost of Helicopter Aerial Seeding, Tillamook Burn
Rehabilitation Project, 1950

Township 1 North, Range 7 West

Unit III, Block S2

Item	Acreage	Total Cost	Average Cost per Acre
D.-fir Seed[1] 1/2 pound per acre	7,504	$28,777.84	$3.835
Bait[2] 1/2 pound per acre	9,946 *	2,740.22	.365 **
Bait flying at $.1862 per acre	9,946 *	1,851.95	.247 **
Cross-flying seed at $.3136 per acre	7,504	2,353.25	.314
Miscellaneous controls	7,504	428.46	.057
Total		$36,151.72	$4.818

* Area baited includes 1/4 mile buffer strip around seeded acreage.

** Cost per acre of bait and bait flying based on seeded acreage.

1 Douglas-fir seed average cost per pound $7.67

2 1080 bait soaked cost per pound .82

1080 bait coated cost per pound .2045

Thallous sulphate bait cost per pound .65

width using wheat was 3 chains. Douglas-fir seed described a swath width of 1½ chains. Cross-flying was employed so as to obtain the best distribution possible. Baiting was accomplished at the rate of 24 acres per minute. Seeding was completed at the rate of 6 acres per minute.

Costs during 1950 were slightly higher than 1949 because of the increase in amount of seed used and increase in helicopter costs for cross-flying. Figure 8 presents cost summary.

Fires covered the entire seeding area in 1933 and 1939. The 1945 fire burned over the eastern half. Vegetative cover was considerably heavier than on lands seeded in 1949. Because of this, seed quantity was increased from 1/3 to 1/2 pound per acre.

Natural stocking and seed source was practically nonexistent. Soil was generally favorable except on steep slopes. Approximately 70% of the area presented favorable exposures while about 30% was slightly less favorable to unfavorable.

A 1½ mile transect through the area was established in November, 1952 to obtain an indication of initial stocking. In 1953 the seedlings will be two years of age. A preliminary stocking survey such as was conducted in the 1949 seeding will be carried out on the 7,504 acres seeded in 1950.

Following are the results of the initial stocking survey:

No. of 4 Mil-acre Plots	Number Stocked	No. of Mil-acre Plots	Number Stocked	Per cent Stocking 4 mil-acre Plots	Per cent Stocking Mil-acre Plots	No. of Trees per Acre 4 mil-acre Plots	No. of Trees per Acre Mil-acre Plots
63	26	252	39	41.1	15.5	360	210

The spring and summer of 1951 was extremely dry. Weather went from a cold-wet condition to a hot-dry condition in a very short period of time. No doubt, germination was retarded and survival sharply reduced by these extreme conditions.

Aerial Seeding, 1951

Two tracts of state forest land in the Tillamook Burn were seeded in the fall of 1951. One unit is located in the southeast portion of the burn and the second in the south central part.

The first area is 4,047 acres in size; 6,924 acres were baited for rodent control using 1/4 pound of thallous sulphate treated wheat and 1/4 pound 1080 treated wheat for a total of 1/2 pound per acre. Considerable time was lost during the baiting period, September 20th to October 6th, due to high east winds and smoke from forest fires. Two helicopters were used to complete the baiting.

Rodent checks prior to baiting netted 96 mice in 600 trap nights. Post-control checks netted 4 mice in 900 trap nights.

Seeding was accomplished on October 25th and 26th. One block of 460 acres was seeded with a mixture of 1/3 pound western redcedar and 1/3 pound Douglas-fir seed. The balance of the area, 3,587 acres, was seeded at the rate of 1/2 pound Douglas-fir seed per acre. Cross-flying was employed. In the case of the seed mixture, the western redcedar was flown out in an east-west direction and the Douglas-fir seed in a north-south direction. The two species had to be distributed in separate flights because the western redcedar described a swath 1 chain in width and the Douglas-fir seed 2 chains in width. Douglas-fir seed on the balance of the area was cross-flown, 1/4 pound per acre in each direction.

The disseminating device used was of the type described in Figure 6, sample bid form. A few improvements were made in the spinner (see plate VII and VIII) which increased the swath width of Douglas-fir seed from 100 feet to 132 feet.

Costs of the combination seeding were slightly higher than for straight Douglas-fir seed. Figures 9 and 10 show differences in costs.

Figure 9

Cost of Helicopter Aerial Seeding, Tillamook Burn
Rehabilitation Project, 1951

Township 1 South, Range 6 West

Unit VI, Block S1

Item	Acreage	Total Cost	Average Cost per Acre
Douglas-fir seed[1] 1/3 pound per acre	460	$1,014.28	$2.2049
Western redcedar seed[2] 1/3 pound per acre	460	742.58	1.6143
Bait[3] 1/2 pound per acre	810 *	252.77	.5495 **
Bait flying at $.39 per acre	810 *	268.46	.5831 **
Cross-flying seed at $.69 per acre	460	317.40	.69
Miscellaneous controls	460	78.75	.1712
Total		$2,674.24	$5.8130

* Area baited includes 1/4 mile buffer strip around seeded acreage.

** Cost per acre of bait and bait flying based on seeded acreage.

1 Douglas-fir seed average cost per pound $6.615

2 Western redcedar seed cost per pound 4.843

3 1080 bait cost per pound .82

Thallous sulphate bait cost per pound .65

Figure 10

Cost of Helicopter Aerial Seeding, Tillamook Burn
Rehabilitation Project, 1951

Township 1 South, Range 6 West

Unit VI, Block S1

Item	Acreage	Total Cost	Average Cost per Acre
D.-fir Seed[1] 1/2 pound per acre	3,587	$11,769.30	$3.2811
Bait[2] 1/2 pound per acre	6,114 *	1,971.06	.5495 **
Bait flying at $.39 per acre	6,114 *	2,091.58	.5831 **
Cross-flying seed at $.69 per acre	3,587	2,475.03	.69
Miscellaneous controls	3,587	614.09	.1712
Total		$18,921.06	$5.2749

* Area baited includes 1/4 mile buffer strip around seeded acreage.

** Cost per acre of bait and bait flying based on seeded acreage.

1 Douglas-fir seed average cost per pound $6.565

2 1080 bait cost per pound .82

Thallous sulphate bait cost per pound .65

Even though the brush cover was fairly well advanced throughout the area it was very well adapted to aerial seeding. Both the 1933 and 1939 fires had burned over the land, but it remained untouched during the 1945 blaze. Very little reproduction was present and this only in isolated spots on north slopes. Soil and exposure were generally favorable.

In November of 1952 a transect 1½ miles long was established in the seeded area to obtain some indication of the stocking after the summer season. No attempt was made to check stocking on western redcedar at this time. The results of the survey which follow are quite encouraging:

No. of 4 mil-acre Plots	Number Stocked	No. of Mil-acre Plots	Number Stocked	Per cent Stocking 4 mil-acre Plots	Per cent Stocking Mil-acre Plots	No. of Trees per Acre 4 mil-acre Plots	No. of Trees per Acre Mil-acre Plots
55	33	220	64	71.1	30.2	800	450

The second area seeded had burned over in April 1951. A total of 11,676 acres were baited to prepare 8,393 acres for seeding. Bait was applied at the same rate used on the first area seeded in 1951. Control measures were completed during the period October 6th through 9th.

Trapping in advance of rodent control accounted for 86 mice in 600 trap nights. After baiting two mice were caught in 1,500 trap nights.

Aerial seeding operations began on October 26th and were completed on the 29th. The area was cross-flown at the rate of 1/2 pound Douglas-fir seed per acre.

Cost per acre as shown in Figure 11 was the same as for the seeding in the first Douglas-fir block completed in 1951.

Figure 11

Cost of Helicopter Aerial Seeding, Tillamook Burn
Rehabilitation Project, 1951

Township 2 South, Range 7 West

Unit VII, Block S1

Item	Acreage	Total Cost	Average Cost per Acre
D.-fir Seed[1] 1/2 pound per acre	8,393	$27,538.27	$3.2811
Bait[2] 1/2 pound per acre	11,676 *	4,611.95	.5495 **
Bait flying at $.39 per acre	11,676 *	4,893.96	.5831 **
Cross-flying seed at $.69 per acre	8,393	5,791.17	.69
Miscellaneous controls	8,393	1,436.89	.1712
Total		$44,272.24	$5.2749

* Area baited includes 1/4 mile buffer strip around seeded acreage.

** Cost per acre of bait and bait flying based on seeded acreage.

1 Douglas-fir seed average cost per pound $6.565

2 1080 bait cost per pound .82

Thallous sulphate bait cost per pound .65

Previous to the April 1951 fire the area had burned over in 1933 and 1939. Brush cover which had grown up following the two major fires was destroyed in 1951. However, the fire occurred so early in the year damage to the soil was generally light. Hard burns did occur where there were heavy concentrations of fuel. Since the fire occurred prior to the emergence of bracken fern, fireweed and other lower types of vegetation, this vegetation furnished sufficient cover for direct seeding by the fall of 1951.

Results of a 2½ mile transect surveyed in November 1952 indicated that the stocking will not measure up to that found in Unit VI, Block S1; nevertheless it showed promise. Tabulation of stocking follows:

No. of 4 mil-acre Plots	Number Stocked	No. of Mil-acre Plots	Number Stocked	Per cent Stocking 4 mil-acre Plots	Per cent Stocking Mil-acre Plots	No. of Trees per Acre 4 mil-acre Plots	No. of Trees per Acre Mil-acre Plots
103	49	412	113	53.8	31.0	495	465

SUMMARY

Aerial seeding in Oregon has made considerable strides since the first successful experiment took place in 1945. Rodent control techniques have been greatly improved; methods of seed application have been refined, and the helicopter has taken the place of fixed wing aircraft as the medium of distribution.

In setting up a project a number of important factors must be taken into consideration before adaptability to aerial seeding can be determined. These factors are size of area, seed source, natural stocking, cover, soil condition, degree of burn, exposure and slope.

If aerial seeding is to be undertaken, proper delineation of seeding area, choice of seed species, types of rodent bait and method of application of bait and seed should be worked out in detail. Current methods and techniques and recommended specifications are outlined briefly.

An account of several major aerial seeding projects completed under the rehabilitation program indicates what may be expected in terms of stocking, if these methods and techniques are followed. Adverse weather conditions may occur at irregular intervals and cause some losses. Local failures can be expected and skips may appear in the stocking pattern. But under generally favorable conditions aerial seeding will produce satisfactory results.

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