# NATURAL VERSUS ARTIFICIAL REGENERATION IN BENTON COUNTY, OREGON

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## INTRODUCTION

No single form of reproduction is adapted to all conditions. The choice in the method of regeneration is very largely an economic one. The criteria that should determine between natural and artificial regeneration and between seeding and planting are economy, simplicity and success in reproduction of a crop without deterioration of the soil. In one locality, a species can be regenerated most advantageously by direct seeding; in another by planting, and in another by natural reproduction. The factors which determine economy, simplicity and success in reproduction are numerous and vary for each locality. Because certain operations have resulted in successful regeneration at one time under a particular set of conditions, it does not follow that similarly conducted operations will be as successful when carried out at other times under other conditions.

Regeneration that is attained at a low cost but results in an incomplete stand must be counted as a failure and is more to be avoided than regeneration that is attained at a higher cost but is successful. The tendency in the United States has been toward employment of inexpensive methods which has resulted in a high percentage of failures. The result has been a high cost for regeneration based upon the total area. In 1913 Greely (1) stated that the experience of the preceding 10 years in the national forests clearly showed that it would have been preferable to develope successful methods and learn their limitations on the most favorable sites before attacking lands where forests were never produced by nature.

## OBJECT AND SCOPE

The object of this paper is to present data from which the advisability may be determined by immediate planting to supplement natural regeneration of Douglas fir in Benton County, Oregon. Considerable differences occur between areas of relatively close geographical location; it is therefore thought best to limit any conclusions that may be drawn from this experiment to the immediate vicinity of Benton County, Oregon.

A survival count of transplants was made on the experiment area and the cause of death; percent survival; effect of grass competition; deer browsing; slope, and aspect on survival was made. The quantity of natural reproduction was determined.

Some of the more important points in choosing between natural and artificial reproduction are discussed.

## REVIEW OF RELATED STUDIES

In 1937 Isaac (2) stated, "Enough natural reproduction to produce a fully stocked stand immediately after logging occurs on only a small percentage of the clear-cut and broadcast-burned areas in the Douglas fir region."

In 1938, referring to studies at Wind River Valley, Washington, Isaac (3) stated, "Data indicates that under conditions such as now exist on the cut-over areas studied, and on most of the areas in the Douglas fir region after logging and slash burning, Douglas fir seedling losses are so high as to almost preclude natural restocking unless special measures are taken to bring it about."

Munger (4) pointed out if brush has two or three years start over the tree reproduction, it is almost impossible for Douglas fir seedlings to become established in competition with it. Hoffman (5) stated that in some places Douglas fir is unable to compete successfully with other species and regains the area only by a slow process of invasion.

In 1938 Godwin (6) studied logged off lands on the East coast of Vancouver Island. His studies show that of 19,981 acres logged in the past 17 years, 5.4 percent are satisfactorily restocking.

These studies quickly lead one to the conclusion that satisfactorily restocking of cut-over lands in the Douglas fir region is a problem of great importance.

Natural regeneration of Douglas fir is uncertain. In 1937 Isaac (7) in his studies of Wind River Valley, Washington stated, "Of the seedlings on the cut-over area that survived their first season, which has been shown averaged only 20 percent of each year's crop, many died in their second, third and fourth years. The total loss of 1928-1930 seedlings during the 4 year period 1928 - 1931 was 89.1 percent."

The preceding statement indicates that under conditions such as now exists on the cut-over areas studied, and on most other areas in the Douglas fir region after logging and broadcast slash burning, Douglas fir seedling losses are so high as almost to preclude rapid natural restocking unless special measures are taken to bring it about. Most of the losses result from a combination of ground and weather conditions. Since nothing can be done about the weather, the chief means of bringing better restocking is to provide more favorable ground conditions for seedling establishment through modification of logging practices. (7)

In deciding between natural and artificial regeneration all circumstances surrounding each case should be carefully considered. Kummel, Rindt, and Munger (8) stated that the place of artificial reforestation in the practice of forestry in the Douglas fir region arises more from the necessity to correct the devastation wrought by fire and improper cutting than as an essential first step in the process of timber growing. In this same publication (8) it states that in places it may be better to plant promptly after logging than to depend on natural reproduction, in order to prevent erosion, to forestall capture of the area by brush, or to avoid the loss of years of potential timber production.

The Oregon State Board of Forestry apparently prefers to wait for possible natural regeneration before resorting to planting. The Oregon law concerning restocking of cut-over land, passed in 1947, states that five years after date of completion of the cutting operation, the state forester will examine the land and plant such portions as are not adequately stocked.

Aufderheide, Assistant Supervisor of the Siuslaw National Forest, was interviewed in January 1947 and he gave the policy of the Siuslaw National Forest regarding reforestation of cut-over lands as follows:

1. Clear cut areas small enough to facilitate natural reseeding.
2. Plant soon after slash burning to get ahead of brush competition.
3. Plant soon after slash burning to insure early stocking.

The decision to plant immediately was made for the following reasons as stated by Aufderheide:

1. Natural restocking is not a certainty.
2. The time required for good stocking to become established may be cut down from ten years to three years.
3. An area near the one under consideration was logged 20 years earlier and it is not yet satisfactorily restocked.

# THE EXPERIMENT AREA

The experiment area is located on the east slope of Mary's Peak in the western part of Benton County, Oregon. The land is owned by the United States Forest Service ? which sold the timber on the west half of Section 36, Township 12 South, Range 7 West, Willamette Meridian to Rex Clemens.

An area of 140 acres was logged by the high-lead system in the spring of 1946. There were enough decadent and unmerchantable trees in the area which were left to cause the area to appear to have been cut by the seed tree method. However, it was supposed to have been clear cut with seed blocks left on all sides, particularly on the ridges. Where the plots are located there are numberous good Douglas fir seed trees on all sides in addition to old growth timber on the ridge to the north of the plots. (See map for location of cutting line).

Slash was broadcast burned in September 1946. Aufderheide stated that he believed the slash fire was a little too hot, causing probable loss of seed source within the clear cut area. However, it is believed that seed in the area was not injured. Along the road fills and cuts and other places where the soil was loose first year seedlings were noticed. Hoffman (5) states that seed in cones will live through a fire.

The Siuslaw National Forest planted the area during the winter of 1946 - 1947 with exceptions of a very steep slope with a south exposure which was not included in the experiment. This area was to be planted at a later date when some ground cover had become established. The area was planted with 2-0 root pruned stock from the Wind River Nursery, Washington, with a spacing of 7.5 feet by 7.5 feet. Ranger Hopkins who was in charge of the planting stated that it was an excellent job of planting.

The Soils Department of Oregon State College classified the surface soil from the study area as Aiken silty clay loam. The area cut was of Site III quality.

The climate is similar to that of the forest area of Benton County. The elevation is approximately 1400 feet. The rainfall on this area may be slightly higher than on other forest areas in Benton County on this side of the summit of the coast range. The clouds come through the Alsea pass and are forced upward over the experiment area by Mary's Peak, resulting in somewhat higher rainfall on this area.

Yield from the area was 7564M fbm or 56M fbm per acre. Knutsen-Vandenburg funds received from the area were $0.25 per M, giving a total of $1891.00 or $13.51 per acre (9).

Planting was done on the area by the one man grub hoe method by contracts let by the Siuslaw National Forest. The planting on the area on which the experiment plots are located was done during December 1946 and January 1947.

During this time frosts occurred frequently causing many of the trees heeled in to be frozen together. This required the tedious job of separating the frozen roots from one another before planting the seedlings. When these seedlings were separated some root injury could have occurred which might cause the death of some of the seedlings at a later date.

In the fall of 1946, the fall before the planting was done, the U.S.F.S. sowed grass seed with hopes that before summer dry spells, the grass would be high enough to provide some cover to the seedlings. Isaac (10) from his experiments at Wind River, Washington, stated that the soil surface temperature of more than 125° farenheit will kill Douglas fir seedlings. At the time of planting the grass was approximately an inch high. In addition to the grass protection, care was taken to plant the seedlings in sheltered places from the noon and afternoon sun. This was done by planting on the north side of stumps and logs.

The grass which was seeded on the area was believed to have caused more deer-browsing damage than would have occurred without grass on the area. This area is included in the Mary's Peak game reserve and even at the time of planting deer were seen nearly every day in the planting area.

The planting was contracted out by the Forest Service to Robert R. Brown and the author. The author planted most of the area which includes Transect C while Transects A and B were planted by several men. We were required to meet the following specifications in planting the trees as quoted in the contract, U. S. Forest Service Bid Form 33:

I. Spacing

Trees should be planted at an average spacing of 7.5 feet between rows and 7.5 feet apart in the rows.

It will be considered more important to plant each tree in the best location for survival and growth than to adhere to uniform spacing. Therefore, trees may be planted as close as 5 feet and as distant as 10 feet apart to take advantage of better planting spots.

Spots to avoid for planting a tree are listed below and any trees planted in such places will be considered unsatisfactory.

1. Mounds of loose soil subject to unusual drying or erosion
2. Abnormal depressions subject to filling with soil or debris
3. Loose rotten weed
4. Spots where soil is burned red by a hot fire
5. Clumps of dense vegetation
6. Rodent colonies as evidenced by holes, runways or mounds of loose soil
7. Within 5 feet of an established natural tree

II. Placement of Tree Roots

The roots of each planted tree should be so placed in the ground that they assume a near natural arrangement. They should not be twisted, tangled, compacted together or turned up at the ends.

III. Depth of Planting

The root cellar of each planted tree should be at or near the ground line. A tolerance of 1/2 inch high or low will be allowed.

IV. Position of Stem

Each planted tree should stand erect, perpendicular to the horizontal plane, not perpendicular to the slope of the ground.

V. Firmness

Each planted tree should be sent firmly in the ground so that if pulled on by the needles, they will come off at the stem without loosening the tree.

Soil around the roots should be so filled in and firmed that there are no air pockets around or adjacent to the roots.

After the soil is firmed around the tree, it should be at its natural level with no depression or mound at or adjacent to the stem.

VI. Care of Trees

Roots of trees must be kept moist at all times by keeping them covered with wet moss or shingle tew.

The supply of trees at the planting site must be kept in a cool shady place, never left exposed to the sun or wind.

If mold, dryness of roots or other evidence of injury is noticed at any time, it should be immediately called to the attention of the Forest Supervisor.

The contractor will do no root pruning, top pruning, or culling. If it should appear that any of these treatments is necessary, the conditions should be reported to the Forest Supervisor and he will arrange to have the necessary work done.

Each area was inspected on the preceding points by the Forest Service officer in charge and each area was required to pass his inspection by 95 percent. The particular area where the experiment is located passed by 95 percent while all the other areas passed 100 percent. This failure to pass 100 percent was due to spacing and not because of the other specifications.

## THE EXPERIMENT

The method of procedure was to follow through the experiment set up by Brown (9) the following spring after planting.

In February 1947, 25 circular plots of 1/100 acres each were located in the area as shown on the map. An initial point, marked by a 10d nail on top of a Douglas fir stump with a diameter of approximately 40 inches was selected on the edge of the logging truck road. The stump is blazed on the south and east sides. In each blaze is lettered in blue keel chalk the inscription "IP" standing for initial point. From this point three transects were run across the area in a manner to give a good selection of conditions on the area. On transect "A" there are eight plots located at two chain intervals from the initial point on transect "B". There are eight plots located at one chain intervals with the first plot from the initial point being 41 links distances. On transect "C" the plots are located at one chain intervals from the initial point. Transects run in the following directions from the initial point.

Transect "A" - S 80 degrees E

Transect "B" - N 62 degrees 30 minutes E

Transect "C" - N 62 degrees 30 minutes W

Control for the initial point was brought from the southwest corner of the Section 36, Township 12 south, Range 7 west, Willamette meridian by transverse with staff compass, abney and chain. The distance to plots and bearing of transects from initial point were determined with the same equipment. The center of each plot was marked with a wooden stake. On each stake was written in blue keel chalk the number of the plot and the transect.

The seedling count on the plots was made in March 1948 in the same manner that was used by Brown (9) which was as follows:

A cord, 11.78 feet in length was looped over the stake marking the center of the plot. The cord was swung in a circular motion with the outer end of the cord indicating the boundaries of the plot. A count of the planted seedlings and a stake driven by each was accomplished. The distance to seed source, either edge of timber or seed trees whichever were closer, was estimated for each plot. Altitude, aspect and ground cover for each plot was given. In addition to the data taken by Brown (9) there was condition of planted seedlings, number of natural seedlings and probable cause of death in the case of those trees found dead. (See tables 1, 2, and 3)

The condition of each seedling was judged in the following manner: Seedlings judged as thrifty showed good growth, the needles were blue-green, terminal buds present and no indication of injury except light browsing. Those seedlings judged as unthrifty had poor color, showed little growth and were generally heavily browsed.

The cause of death was difficult to determine. In cases where the seedling was gone from the stake it was assumed that it had been pulled up by deer or rodents. Few rodents are believed to be in the area and many deer have been seen which leads one to the conclusion that most of the missing seedlings were pulled up by deer. Where the seedlings were still by the stake but were dead the cause of death was said to be from mechanical injury or root competition with grass. No seedlings were considered killed by grass if any other cause deemed likely. Only those seedlings which were growing in between several clumps of grass were considered killed by competition with grass. In these cases the grass appeared to crowd out the seedlings.

## CONDITION OF THE PLANTATION

Most of the mature and the over mature trees which were left during logging are dead. All of the hemlock and old-growth Douglas fir trees which were left in the open by themselves have died. In places where the defective trees were numerous and there were only occasional trees taken, nearly all of the trees still remain and appear in good condition. Most of the individual seed trees have either died from exposure or blown down. However, this does not leave the area without adequate seed source because there is either virgin timber or groups of trees within easy seeding distance to any particular place in the area. A few natural seedlings are showing after two years.

All plots combined showed a survival of 115 out of 150 planted trees or 77 percent for the first year and a half. The trees have survived one summer and two winters. Unless there is a very dry summer this year nearly all of the present planted trees should live to become merchantable.

## SURVIVAL OF THE PLANTATION

Transect "A" had a survival of 83 percent, Transect "B" 76 percent, Transect "C" 71 percent for average survival on the experiment of 77 percent. Deer caused 37 percent of the losses, seeded grass 37 percent, mechanical injury 14 percent and unknown caused 12 percent.

Table 4. Causes of Dead Trees

| Cause | Transect "A" | Transect "B" | Transect "C" | Total | Per-Cent |
|---|---|---|---|---|---|
| Dear | 5 | 2 | 5 | 12 | 34 |
| Grass | 2 | 4 | 6 | 12 | 34 |
| Mechanical | 1 | 2 | 4 | 7 | 20 |
| Unknown | 1 | 1 | 2 | 4 | 12 |
| Total | 9 | 9 | 17 | 35 | 100 |

## GRASS COMPETITION LOSSES

Losses due to grass competition were a major factor on this plantation. The U. S. Forest Service seeded the area to grass immediately after the slash burn in September 1946 for the following reasons:

(1) To help prevent erosion on the denuded ground; (2) Experiment with various grasses and their effect on planted trees; (3) Esthetic values; and (4) To help prevent brush from coming into the area.

Specific data on the effect of grass sowing upon Douglas fir regeneration is scant. Observation studies by Isaac (12) indicates that the practice is discouraging to tree reproduction, but does not necessarily preclude seedlings. Much depends upon density of the sod cover and intensity of use. On Transect "A" plots numbered above two were out of the grass area and of the total losses on those plots not appeared to be from competition with other plants.

The data show that survival on the transects with grass was 71 and 76 percent on an average survival of 73.5 percent for the area seeded with grass. The area on Transect "A" which was outside of the grass seeded area showed a survival of approximately 88 percent. This indicates a survival of almost 15 percent more on the unseeded area; however, some of this difference might be attributed to frost heaving. Transect "C" was planted in December and Transects "B" and "A" were planted in March and April.

Considering that Transect "A" had a 5 percent loss from frost heaving, the loss from planted grass is 10 percent.

These points quickly lead one to the conclusion that sowing of grasses on an area with natural reproduction is not a good practice from the standpoint of tree survival. However, the grass does prevent erosion, should prevent brush from coming in and make for better esthetic values.

DEER BROWSING LOSSES

Deer caused 34 percent of the losses to planted seedlings by killing them. Nearly all seedlings showed heavy browsing and probably some will die next summer. In addition much damage was done by deer in pruning the tops back so much that the tree does not have enough leaf surface to fully utilize the nutrients which are furnished by the roots. The tree, also, must send out a new leader each spring and thereby consuming considerable plant food which might have been used by the tree in growth had it not been browsed. Manley (11) in an experiment on the same area found that deer had killed as high as 33 percent of the planted seedlings the first year after planting. The U. S. Forest Service made seedlings count in December 1947 on the same area. Their tree count showed that 10 percent were in a thrifty condition, 89 percent of the trees were in an unthrifty condition and 1 percent were dead. Those trees which were classed in the unthrifty condition had all been browsed heavily.

It is difficult to exclude deer from a forest area and no way, as yet, has been found to prevent their browsing of Douglas fir seedlings. However, the planting of grasses on an area tends to attract the deer to the area and cause heavier browsing losses. Manley (11) points this out as he found an estimated survival of 27 percent on areas of heavy grass sod while on areas without grass the survival was 84 percent.

## MECHANICAL LOSSES

Mechanical losses accounted for 20 percent of the total losses. These losses included those caused by injury to tissues of the stem or roots by animals, by man, by fallen snags, or rolling rocks, etc. Partial exposure of the roots from frost heaving, by settling of the soil, by swaying of plants by the wind or by too shallow planting. Partial or complete burial occasioned by sliding down of the soil, by earth thrown by burrowing animals, by fallen snags or by too deep planting.

These losses may have been considerably higher if grass had not been seeded in the area, because a heavy grass sod will prevent soil erosion.

## UNKNOWN LOSSES

Unknown losses were called such because the stake by the seedling and the seedling could not be found. Unknown losses accounted for 12 percent of the total losses. Some of these losses might belong to mechanical losses due to slides or fallen snags covering the tree. The cause of death could not be determined and therefore they were said to be unknown.

## EFFECT OF SLOPE ON SURVIVAL

Table 5. Steepness of slope compared to percent of loss.

| Slope Percent | Total Trees 1947 | Number of Dead Trees | Percent of Dead Trees |
|---|---|---|---|
| 0 - 10 | 20 | 4 | 20.0 |
| 11 - 20 | 34 | 7 | 20.6 |
| 21 - 30 | 36 | 6 | 16.7 |
| 31 - 40 | 23 | 6 | 26.0 |
| 41 - 50 | 20 | 6 | 30.0 |
| 51 - 60 | 17 | 6 | 35.3 |

Slope exerts an influence on reproduction in various ways. Some of the more important effects are run off, temperature, light, wind, soil moisture, and depth of soil. It can be seen from Table 5 that as the slope increases the percent of survival decreases. On slopes which have a gradient of over 100 percent any type of reproduction is difficult to obtain. It has been proven that a survival of less than 70 percent for a plantation is considered a failure (8). This would indicate that planting on slopes which are steeper than 50 - 60 percent is not practical. On the other hand, these slopes are the ones which need planting to help prevent serious soil erosion. The U. S. Forest Service at the present time is making some experiments with seeding an area to grass on slopes which are around 100 percent with grass to hold the soil and then after the grass has the soil stabilized they intend to plant trees on the area.

## EFFECT OF ASPECT ON SURVIVAL

Table 6. Percent of loss compared with aspect.

| Aspect | Total Trees 1947 | Number of Dead Trees | Percent of Dead Trees |
|---|---|---|---|
| NW | 13 | 3 | 23.0 |
| N | 45 | 12 | 26.7 |
| NE | 35 | 7 | 20.0 |
| E | 28 | 5 | 17.8 |
| SE | 29 | 8 | 27.5 |
| | 150 | 35 | |

Aspect effects survival in several ways. It determines the amount of direct sunlight and heat reaching the tree, the exposure to winds of certain directions, and as a resultant, the heat and water content of the soil. Aspect may also have some effect on survival because of the relative susceptability of trees on different slopes to frost. On south slopes the trees start growth earlier and are thus exposed to late spring frosts.

It can be noted from Table #6 that the NE and E slopes suffered smaller losses than the other slopes. While this data is limited the trend of the survival indicates better survival from north to east exposures. The north has a relatively high loss but this was thought due more to time of planting. Most of the plots making up the north exposure were planted during the frost season.

EFFECT OF SHADE ON SURVIVAL

Table 7. Percent of loss compared with amount of shade.

| Amount of Shade | Total Number of Trees 1947 | Number of Dead Trees | Percent of Dead Trees |
|---|---|---|---|
| Bare | 51 | 13 | 25.5 |
| 3/4 Bare | 31 | 8 | 25.8 |
| 1/2 Bare | 46 | 11 | 24.0 |
| Dead shade | 22 | 3 | 13.6 |
| | 150 | 35 | |

The data on Table 7 indicates only a slight tendency for seedling establishment to be effected by amount of shade. All shade on the area was dead shade, that is there was no brush or other competing vegetation furnishing shade except the planted grass. A large percentage of the grass on the area of the experiment was tall oat grass which might be considered to furnish shade, however the root competition from the grass would tend to effect the shade benefit derived from it. On Transect "A" plots 3 to 8 were not in the grass seeded area.

Table 8. Percent of loss compared with amount of shade from those plots which were outside of grass seeded area.

| Amount of Shade | Total Trees 1947 | Number of Dead Trees | Percent of Dead Trees |
|---|---|---|---|
| Bare | 7 | 1 | 14.3 |
| 1/2 Bare | 28 | 4 | 14.3 |
| Dead Shade | 7 | 0 | 0 |
| | 42 | 5 | |

Table 8 shows a comparison loss with amount of shade. All shade was dead shade from logs, snags, stumps, etc. Although the data is limited, Table 8 shows the same tendency as was noted in Table 7, that the more shade that a seedling can be planted in, the better the chance for survival. It is possible to have too much shade as was shown by Nettleton (16) in his experiment on the Carlton area of the Tillamook burn. His experiment showed 100 percent failure where the trees were in dead shade, where no sunlight reach trees and the best survival where the trees had a light moving shade such as bracken fern. The trees in the light moving shade had a survival of 98 percent.

## NATURAL REPRODUCTION

The experiment area was broadcast slash-burned in September 1946 and any reproduction which was on the area after the fire came from seed of the 1946 and 1947 seed crop. As a result what seedlings are to be found are very small at the time of this experiment and makes finding them difficult so some may have been overlooked. On some plots the ground was literally covered by them. In such an instance only four were tallied because this would be enough to fully stock the area of the plot. In counting the seedlings the plot was divided into four equal parts and if there were more than one seedling in each quarter - only one was counted. No plots over eight chains from uncut timber and most plots were closer. See Tables 1, 2, and 3. There were also a few scattered seed trees which were not taken in logging and were not originally considered a seed supply. In general there was an excellent seed supply to all the area.

It was considered too soon to draw any definite conclusions on natural restocking. However, Table 9 clearly indicates that natural restocking in an area seeded to grass is difficult to obtain and that natural reproduction on the non-seeded area was good.

Table 9. Number of natural seedlings on grass seeded area compared with non-seeded area.

| Type of Area | Number of Seedlings | Number of Plots Taken | Number of Seedlings per acre | Stocking[2] Percent |
|---|---|---|---|---|
| Grass | 14 | 19 | 74 | 18.5 |
| Bare[1] | 13 | 6 | 217 | 54. |

1 - Contained scattered weeds
2 - Stocking percent based on 400 trees per acre

## NATURAL VERSUS ARTIFICIAL REGENERATION

In theory the removal of the old timber should be followed immediately by establishment of the new crop. In practice often a number of years is lost before reproduction is complete. In the managed forest, time is an important factor. The long delays often experienced in obtaining natural reproduction must be avoided. An important advantage claimed for artificial reproduction is that loss of time is avoided because sturdy trees for the new crop can be planted immediately after harvesting of the timber. Time will be gained both because the trees may be several years old when set out and because the ground does not lie idle for one or more years as may happen if reliance is placed upon natural regeneration. In difficult cases it may take from 10 - 30 years or more after the cutting for an area to restock completely by natural means, owing either to lack of seed years or to other unfavorable conditions. On clear-cut areas natural reproduction usually cannot be secured after cutting without some delay. On short rotations and where intensive application of silviculture is justified saving two or more years of time may be of distinct financial benefit.

An adequate seed crop for natural regeneration is not certain. Some seed is produced by Douglas fir annually except for about 1 year in a 4 or 5 year period. General observations made over the Douglas fir region as a whole from 1909 to 1941, a 32 year period, indicate an abundant crop in 7 years, a medium crop in 6, a light crop in 13, and a failure in 7 of the years. (12) This is not based on observations at one point, but is the summation of reports from the region at large made by different people.

In years of heavy cone crops not all the trees produce. Even open-grown trees fail to flower some years, and individual forest grown trees may even rest during so called good seed years. These are years where Douglas fir fails over extensive areas to produce cones, other years it fails to produce viable seed. (12)

In the review of related studies of this paper the inadequate stocking of the Douglas fir area was brought out. It can be noted from the foregoing paragraphs that natural regeneration is not assured although adequate seed source is provided for.

Near Blodgett, Oregon the U. S. Forest Service planted an area in 1942 after brush alder had had a start on the area and it resulted in a near failure. In one section of the area the alder was cut before planting, this area showed the poorest survival in all the areas. Munger (4) stated that, "If brush has two or three years start over tree reproduction, it is almost impossible for Douglas fir seedlings to become established in competition with it." It appears then if reproduction is not accomplished the first year or two that brush will take over and reproduction of the desired species will not be attained.

The Oregon State Board of Forestry apparently chooses to wait for possible natural regeneration before resorting to planting. The law, in regard to violation of restocking provisions, states, "Five years following the date of the completion of the operation on the violation area, the state forester shall examine the area and plant such portions as are not adequately stocked." (17)

It is sometimes argued that the safety and vigor of the stand may be affected unfavorably by the use of artificial reproduction. Proponents of this argument make much of the fact that reproduction as its name implies is nature's method, free of man's interference, and consequently, they claim, should renew the forest with healthy trees adapted best to the site. This may be countered by showing that artificial reproduction, correctly applied, makes use of only species on healthy plants of local strain and adapted to the site. It may even be that by using seed from better trees than those now in the stand, the race in a given locality may be improved.

## COSTS OF NATURAL AND ARTIFICIAL REGENERATION

The generally accepted idea that natural regeneration is far less expensive than planting is not borne out in practice. Natural regeneration requires that the cuttings should be so arranged that at least a portion of the trees remain in the area until a new crop has been established. When a new crop is attained by planting, the old stand can be removed in a single cutting. In natural regeneration it may be necessary to remove the crop in two or more cuttings at intervals of 5 to 10 years. Where more than one cutting is used, considerable additional expense is involved in removal and inspection. The cost of logging may be increased somewhat when a stand is removed in two or more cuttings separated by intervals of several years.

In cases where an area is clear-cut with the exception of isolated trees, the stumpage value of the trees left in some cases may exceed in value the cost of planting. This is true in areas of virgin timber where seed trees cannot be made up of cull trees. Because of the large machinery necessary to log this type of area, the seed trees which were left cannot be harvested economically after regeneration has been attained and are not likely to remain sound until the new crop is ready for harvest.

The cost of leaving seed trees is difficult to determine. It is dependent on the amount of defect in an area and the number of seed trees left. The defect in an area may range from 5 or 10 percent to as high as 50 percent. The number of seed trees left per acre must be two or more as stated in the Oregon Forest laws. The stumpage of old-growth Douglas fir has been selling between 10 and

30 dollars per thousand board feet. As an example say that two trees were left per acre and that one of the two were merchantable but was of low quality for old growth, the stumpage of such a tree was 10 dollars per thousand board feet and that the average size of the tree was 40 inches dbh which has a volume of approximately 2500 board feet. Such a case would mean that the cost of natural regeneration was $25 per acre. But even then the regeneration is not certain because the seed crop may be poor and brush and weeds could take over the area as has happened in much of the cut-over areas of the Douglas fir region.

The cost of planting the experiment area was $19.96 per acre with a spacing of 7.5 by 7.5 feet. The cost for labor was $15.00 per acre. The cost of supervision at 10 percent and depreciation of tools and equipment 10 percent or $3.00. Planting stock was provided from the Wind River Nursery at a cost of $2.40 per thousand seedlings. Collins (14) gives average total planting cost of $20.00 per acre.

The Weyerhauser Timber Company on their Longview,Washington operation, where Douglas fir is the chief species, practice clear cutting in mature stands on relatively small areas. Natural reproduction is obtained from nearby seed sources, on most of the area. Conklin (15) states that on lands cut in this manner 5 years or more ago, 50 percent of the area is adequately stocked, 30 percent needs some planting to make the new stand fully stocked, and 20 percent of the area is barren of reproduction.

The following quotation, taken from the report on the Cedar River, Watershed of Seattle, Washington, sums up a regeneration practice that has proven to be practical and economical. Their forestry practices have paid good cash dividends.

"On land recently acquired by the city of Seattle upon the completion of logging even though natural regeneration seems assured, all edges of the areas should be partially planted so that dominant trees will be obtained. Good seed years, when seed is produced in abundance by Douglas fir, occur only at intervals varying from 3 - 8 years and therefore the pre-planting of areas, while awaiting natural regeneration, will be worth the cost. This will avoid the tendency for too-fully-stocked even-age stands of Douglas fir to develop and stagnate. Attention should also be given to the introduction of hemlock and cedar into the young stand of Douglas fir and the consequent improvement in the quality of young fir timber...

"Immediately after logging, all areas adjacent to streams, where deciduous trees and brush will otherwise quickly occupy the ground, should be planted with appropriate species. In most instances these would be Douglas fir, hemlock or cedar...

"Seed for planting should of course be obtained from trees growing under the same climatic conditions as those to which the young seedlings will be subjected. Experience in European forests, notably in Sweden, where it has been found that seed obtained from dominant trees in the same area that is to be planted is superior to seed produced only 15 to 20 miles distant, suggests the desirability of gathering cones after trees are filled in the logging operations on the area. At the higher elevations near and above the 3000 foot contour, climatic conditions are such that seedlings or transplants grown from seed gathered at low elevations in the Puget Sound area will not be hardy." (18)

## CONCLUSION

It is time we begin to use some definite means of of conservation and long range planning in the management of our forests. In the past, competition, greed and ignorance have led to the misuse of our forests.

In many forests natural reproduction can be established more cheaply than artificial reproduction, but with increasing stumpage prices of today the cost of natural regeneration, particularly in old growth stands, may exceed the cost of planting. Cost alone, without consideration of the completeness and potential quality of the new crops is not the best criterion. A new crop which will be composed of the best species and will fully stock the whole area in contrast to one partially stocked or composed of inferior species, may be worth paying more to obtain.

Planting is the quickest, safest, and easiest known method of restocking. The planted seedlings have from 2 - 10 years head start on natural reproduction. Natural reproduction is not certain, approximately half of the cut-over lands in the Douglas fir region are adequately stocked. The reproduction may be Hemlock or some other less desirable species. A person does not need to be an expert silvaculturist to plant an area, but to provide for natural regeneration with any degree of certainty, he must be an expert. The U. S. Forest Service, with some of the best Silviculture men in the northwest, are turning more to planting every year.

TRANSECT A

| Plot Number | Aspect | Slope Percent | Cover | Dist. to seed source (chains) | Number of Seedlings 1947 | Number of Seedlings 1948 | Nat. Reprod. | Number of Seedlings Thrifty | Number of Seedlings Unthrifty | Number of Seedlings Dead | Cause of Death* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | E | 60 | Bare | 12 | 4 | 2 | 1 | 1 | 1 | 2 | M,G |
| 2 | N | 20 | Dead | 10 | 8 | 6 | 0 | 3 | 3 | 2 | G,D |
| 3 | N | 5 | Dead | 4 | 7 | 7 | 1 | 5 | 3 | 0 | – |
| 4 | NE | 15 | Bare | 1 | 7 | 6 | 3 | 4 | 2 | 1 | D |
| 5 | NE | 50 | ½ Bare | 1 | 7 | 5 | 0 | 3 | 2 | 2 | D,U |
| 6 | NE | 30 | ½ Bare | 4 | 5 | 5 | 1 | 2 | 3 | 0 | – |
| 7 | E | 40 | ½ Bare | 6 | 8 | 7 | 4 | 4 | 2 | 1 | D |
| 8 | SE | 40 | ½ Bare | 5 | 8 | 7 | 4 | 5 | 1 | 1 | D |
| Total | | | | | 54 | 45 | 14 | 27 | 17 | 9 | D – 5<br>G – 2<br>M – 1<br>U – 1 |

*Cause of death

D – Deer

G – gross

M – Mechanical

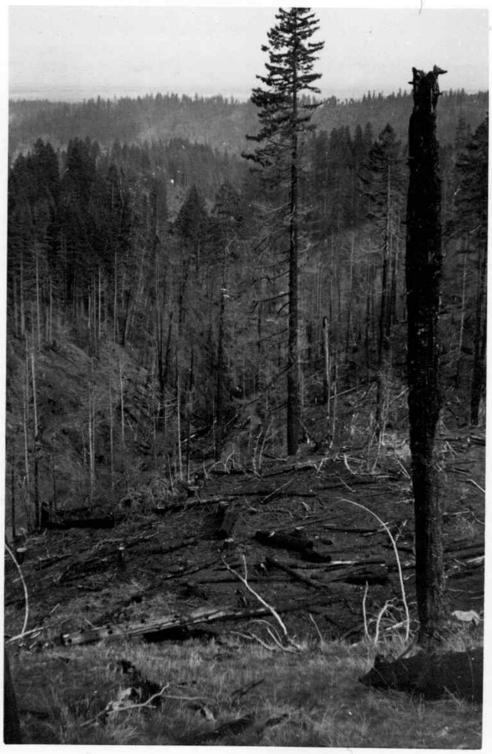
U – Unknown

TRANSECT B

| Plot Number | Aspect | Slope Percent | Cover | Dist. to seed source (Chains) | Number of Seedlings 1947 | 1948 | Nat. Reprod. | Number of Seedlings Thrifty | Unthrifty | Dead | Cause of Death |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | E | 10 | Bare | 5 | 4 | 3 | 1 | 2 | 1 | 1 | G |
| 2 | E | 25 | Bare | 3 | 6 | 6 | 2 | 4 | 2 | 0 | - |
| 3 | SE | 35 | Bare | 3 | 3 | 1 | 0 | 1 | 0 | 2 | D,G |
| 4 | SE | 60 | Bare | 4 | 4 | 3 | 1 | 2 | 1 | 1 | M |
| 5 | SE | 50 | Bare | 6 | 5 | 3 | 0 | 1 | 2 | 2 | D,M |
| 6 | SE | 60 | Bare | 7 | 3 | 3 | 1 | 2 | 1 | 0 | - |
| 7 | SE | 30 | Bare | 7 | 6 | 4 | 0 | 3 | 1 | 2 | G,U |
| 8 | E | 20 | 3/4 Bare | 7 | 6 | 5 | 0 | 3 | 2 | 1 | G |
| TOTAL | | | | | 37 | 28 | 5 | 18 | 10 | 9 | G-4 |
| | | | | | | | | | | | D-2 |
| | | | | | | | | | | | M-2 |
| | | | | | | | | | | | U-1 |

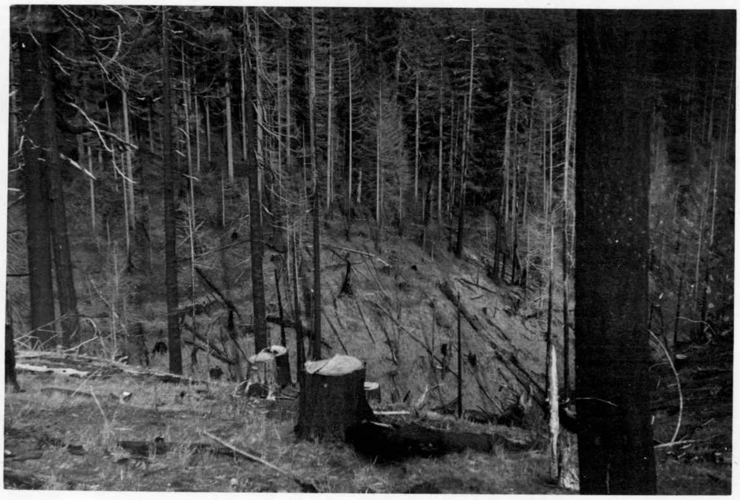
TRANSECT C

| Plot Number | Aspect | Slope Percent | Cover | Dist. to seed source (chains) | Number of Seedlings 1947 | Number of Seedlings 1948 | Nat. Reprod. | Number of Seedlings Thrifty | Number of Seedlings Unthrifty | Number of Seedlings Dead | Cause of Death |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | N | 5 | Bare | 6 | 1 | 1 | 3 | 0 | 1 | 0 | - |
| 2 | N | 10 | 1/2 Bare | 8 | 8 | 5 | 0 | 1 | 4 | 3 | D,G,U |
| 3 | NW | 20 | 1/2 Bare | 7 | 6 | 4 | 0 | 2 | 2 | 2 | D,M |
| 4 | NW | 15 | Dead | 8 | 7 | 6 | 0 | 3 | 3 | 1 | G |
| 5 | NE | 30 | 3/4 Bare | 5 | 10 | 9 | 1 | 5 | 4 | 1 | M |
| 6 | N | 40 | 1/2 Bare | 6 | 4 | 2 | 0 | 1 | 1 | 2 | G,D |
| 7 | NE | 60 | 3/4 Bare | 7 | 6 | 3 | 0 | 2 | 1 | 3 | G,M,U |
| 8 | N | 50 | Bare | 6 | 8 | 6 | 2 | 2 | 4 | 2 | D,G |
| 9 | N | 30 | 3/4 Bare | 6 | 9 | 6 | 2 | 4 | 2 | 3 | D,M,G |
| TOTAL | | | | | 59 | 42 | 8 | 20 | 22 | 17 | D-5<br>G-6<br>M-4<br>U-2 |



General View of Study Area
Along Transect "A"

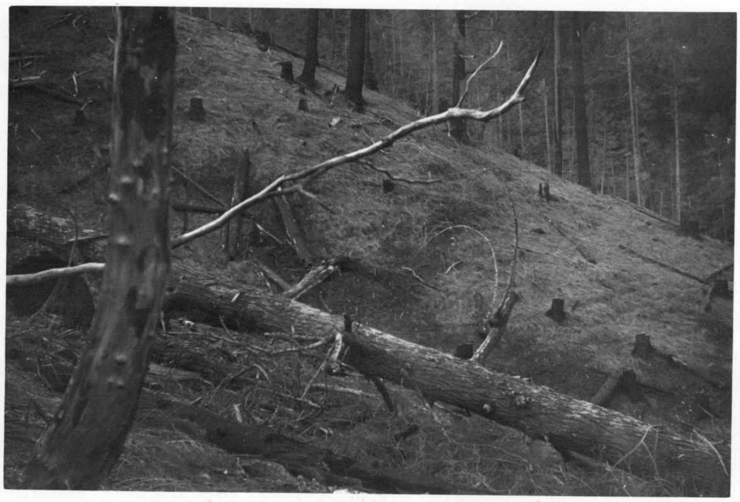
Transect "B", Plot B-7



View Along Transect "B"

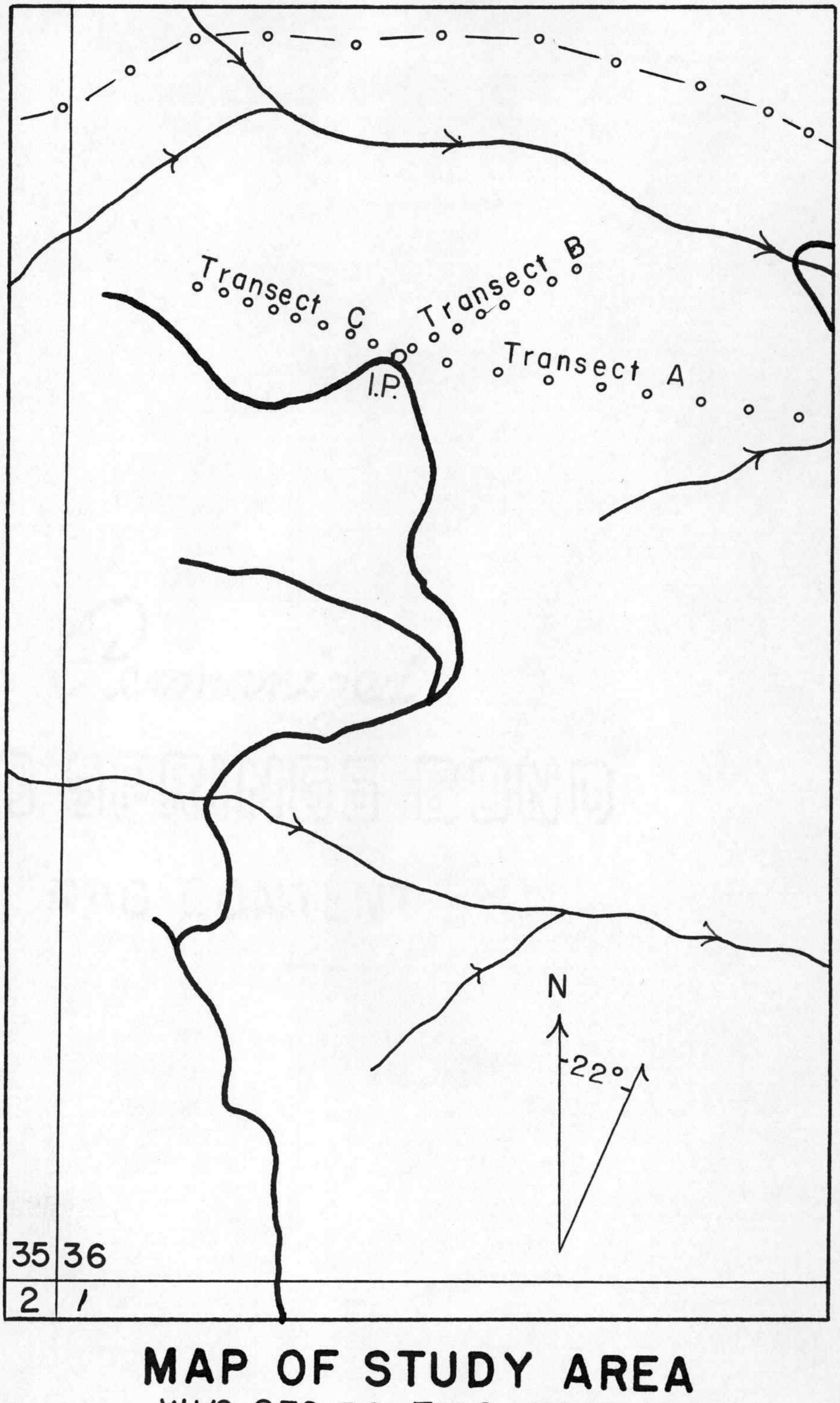
View Along Transect "C"

Initial Point



Looking from Transect "A"
to Transect "B"

Grass Sod Along
Transect "B"




**MAP OF STUDY AREA**

W1/2 SEC. 36, T12S, R7W WM.

SCALE: 1 INCH = 8 CHAINS

LEGEND

STREAM → SECTION LINE —

ROAD — EDGE OF TIMBER -o-o

STUDY PLOT o

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