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Seeds in the Forest Floor of the Ponderosa Pine Type

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SEEDS IN THE FOREST FLOOR OF THE PONDEROSA PINE TYPE

by

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INTRODUCTION

Regeneration of forest stands is often complicated by the establishment and competition of brush on logged and burned-over areas. The encroachment of brush in the ponderosa pine type of Idaho, particularly Ceanothus velutinus, Dougl. presents a difficult problem to the forest manager. The brush competition severely reduces the growth rate of associated trees, thus extending the period necessary to grow a crop of trees. This situation may seriously limit the economic production of a wood crop of ponderosa pine.

Any approach to the solution of brush problems should include a thorough understanding of brush ecology. Those phases of ecology dealing with reproduction and distribution of brush need special emphasis. It has been assumed that most of the brush on logged or burned-over areas originated from seed stored in the forest floor; yet little is known of the quantity or distribution of these seeds.

This study was carried out to learn what kind, number and viability of seed is present in the forest floor, and to investigate the number of seed located in different forest conditions, aspects and soil layers.

To achieve the above objectives, 48 square-foot, duff-soil samples were taken in the ponderosa pine type of the Boise Basin

Experimental Forest in Idaho.[1] Seeds were separated from the samples and major species identified, pretreated and germinated. Appropriate statistical techniques were employed to determine significant results among the different forest conditions, aspects and soil layers sampled.

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1 Maintained by the Intermountain Forest and Range Experiment Station, U. S. Forest Service, Ogden, Utah

REVIEW OF LITERATURE

Studies concerned with the natural storage of seeds in the forest floor have been restricted in number. Early investigations by Hofman, Isaac, Haig (6, 7, 1) and others were concerned with the longevity of naturally stored tree seeds. The importance of tree seed stored in the duff as a source of forest regeneration stimulated these studies.

The influence of lesser vegetation on tree establishment and growth has led to investigations of other seed in the forest floor. The blister rust disease of white pine is dependent on the *Ribes* spp. as alternate hosts. The importance of *Ribes* seed stored in the forest floor as a source of regeneration led Fivaz (5) to conduct a study under laboratory and natural conditions. He observed large numbers of *Ribes* seedlings occurring after logging, fire, windfall, road building and controllable experimental disturbances. Seedlings were found to originate deep in the duff and in the mineral soil. He estimated that *Ribes* seed would remain viable 25 to 75 years. In a later study Davis and Moss (4) found that 81 to 90 percent of the viable *Ribes* seed is stored in the lower humus next to the mineral soil. They gave an estimate of seed longevity of 120 to 130 years.

Three important systematic studies of the seed content of the forest floor have been made in this country. Oosting and Humphreys (11) investigated the number of viable seeds in the soil of a successional series of old field and forest soils in the Southeast. They took duplicate samples in each of ten age classes of succession.

These age classes ranged from newly abandoned old fields to the climax oak-hickory type forest. The viable seeds were identified from germinated seedlings. There were 5,989 seedlings (547 per square foot of surface sampling area), and 127 species of which 16 were woody plants. Some of the species were not present in the vegetation on the site sampled and indications are that many species retained viability through several stages of succession.

Olmsted and Custis (10) took four square-foot samples in each of three hardwood and four softwood forest stands in the Northeast. They were able to identify 27 species and secure germinations from eight species. They found a total of 265 seeds per square foot, but only 15 per square foot were viable. Most significant was the occurrence of Rubus seeds in more stands than other species of seed and the high germination percent (71-100) of Carex spp. Rubus spp. establishes itself rapidly on disturbed or burned areas similar in many respects to Ceanothus and Ribes plants previously mentioned.

Quick (12, 13) took 66 two-square-link duff samples in ecologic niches of a forest stand in California. The area of his sampling was about 57 square feet and from this he was able to identify Ceanothus, Ribes, Manzanita, Prunus, Carex, Luzula, Polygonum, mistletoe and grass. There were approximately 47 germinable seeds per square foot of area sampled and over 70 percent were Ceanothus seeds. Approximately five percent were Ribes and seven percent were grass seeds.

METHOD OF PROCEDURE

The Boise Basin Experimental Forest was chosen as the study area. Virgin stands typical of the ponderosa pine type of Central Idaho were found within its boundaries. The area had been divided into compartments and some mapped for forest types, age classes and topography. The mapped areas were used as the sampling units and ranged in elevation from 4900 to 5600 feet.

Description of forest conditions and aspects

Three forest conditions which could be easily identified in the field were chosen as sampling areas: open-brush areas, sapling-pole stands, and mature-overmature timber.

The open-brush areas had no timber or reproduction of the tree species growing within their boundaries. The vegetation growing in these areas varied from dense brush to poor or no ground cover. Some areas had pure stands of *Ceanothus* or *Physocarpus* spp. and some had mixtures of many species.

The sapling-pole stands ranged from 3-11 inches in diameter, were relatively even-aged and had no overstory. The average age varied from 40-60 years. The density of these stands was variable. The canopy was generally open on south aspects and closed on north aspects. Brush was occasionally present but not as a general understory.

The mature and overmature timber was over 11 inches in diameter (average approximately 30 inches) and had no understory of the tree species. The canopy was open. The average age varied between 250-350 years. Brush occasionally occurred in small patches where the canopy was more open or broken. Samples were not taken in the latter areas because of the similarity to open-brush areas.

The three forest conditions were sampled on north and on south aspects. The above situation was duplicated in sampling, that is one set was taken on the east side of a drainage and one set on the west side. The latter situation is shown diagrammatically in Figure 1. Sampling in this manner did not result in true north and south aspects. Those north and south aspects on the west facing side of the drainage generally had west facing components; those on the east facing side of the drainage generally had east facing components. Four samples were taken in the smallest category of forest condition and aspect. This is shown below in Table 1.

Table 1. Number of samples taken within each aspect and forest condition of the study. 1952.

Stand Condition	Aspect				Total
	East		West		
	North	South	North	South	
Open-Brush	4	4	4	4	16
Sapling-Pole	4	4	4	4	16
Mature Timber	4	4	4	4	16
Total	12	12	12	12	48

Sampling technique

The methods by which the sampling was planned and the samples taken were designed to give an unbiased estimate of the number and kind of seeds in the forest floor of the forest conditions and aspects described in the preceding section. Forest conditions were mapped on tracing paper and superimposed on a topographic map. From this it was possible to determine the aspect of each of the mapped forest conditions. Each of the forest conditions and their corresponding

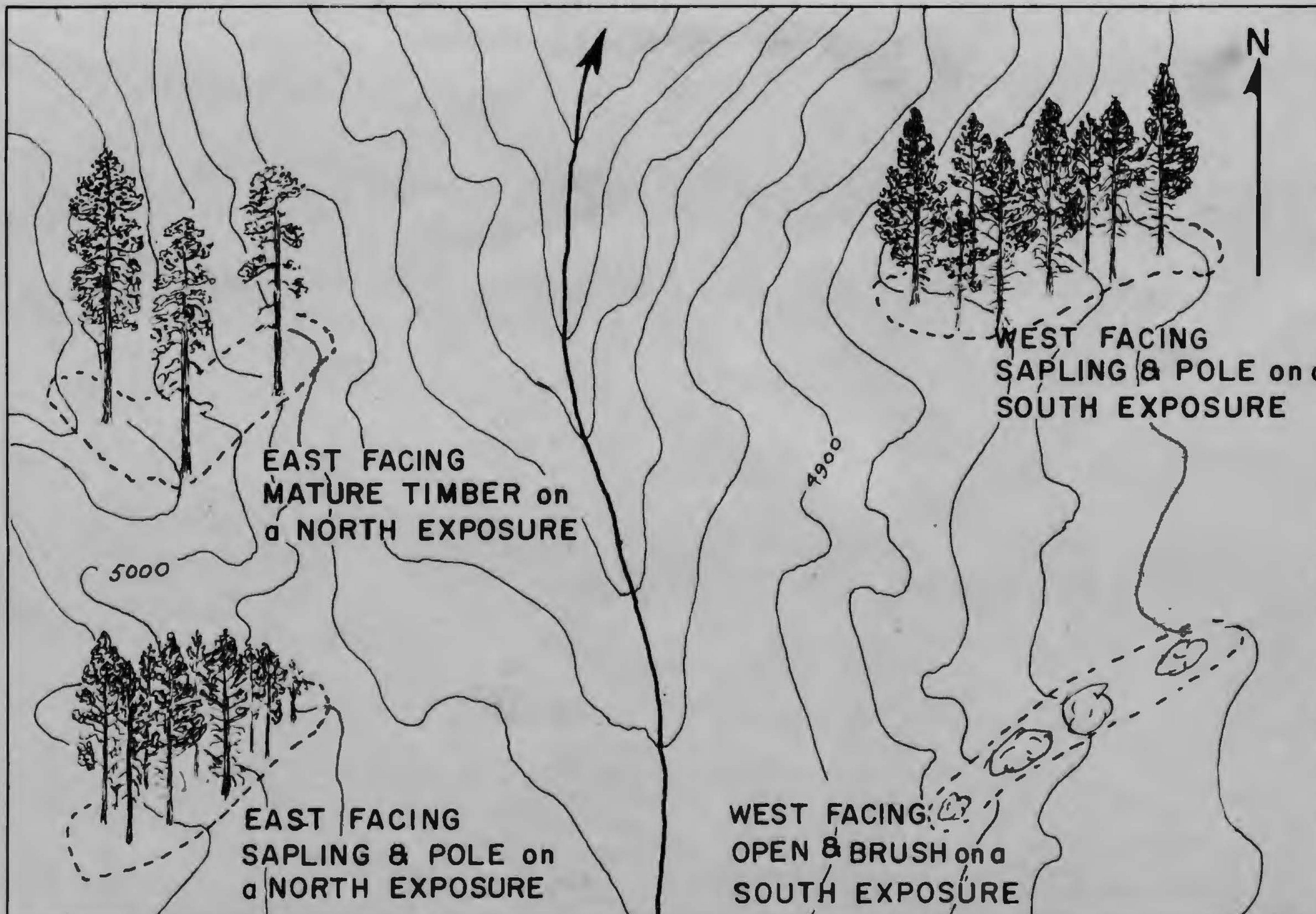

FIGURE 1 Diagrammatic relationship of some of the vegetative conditions and the exposures on which the duff-soil samples were taken.

aspects were then numbered. With the aid of a list of random numbers, areas were then chosen as the conditions and aspects to be sampled until all predetermined categories of forest condition and aspect (Table 1) were filled. A numbered dot grid was placed over the areas chosen and four sampling points were randomly selected in each.

The points were located in the field by pacing and with the aid of a compass. Samples were taken only if predetermined descriptions (p.5) were met.

The equipment used to take the duff-soil samples consisted of the following: a rigid frame 3" deep and exactly one-foot square (inside dimensions), a tin shovel cut to fit the square, a machete, a spatula and paper bags. Figure 2 shows the equipment used.

Figure 2. Equipment used to take square-foot, duff-soil samples.

The samples were taken as follows: The square-foot frame was securely fastened to the ground on the sample point and the duff and soil cut along the inside of the square. The end-gate on the square was opened and the soil layers removed with the shovel. Where they existed, three layers were taken: the litter or Aoo horizon, the felt or Ao horizon and approximately 3/4 inch of mineral soil or A_1 horizon. Figure 3 shows the litter layer being removed at a sample point.

Figure 3. Removing the litter layer at a sample point.

Separation of seed from samples

The material from the sample soil layer was sieved into four fractions—coarse, medium, fine and extra fine as shown in Figure 4. The extra fine fraction was material passing through a 28 mesh sieve. No seeds were separated from the extra fine fraction.

Figure 4. A litter layer separated into four fractions to facilitate seed separation.

Seeds were recovered from the fractions by spreading out the soil particles on light-colored cardboard and picking over small areas at a time. Figure 5 shows seed being separated from the fraction. The separated seeds were put in paper envelopes and stored at temperatures of 35° - 55° F.

Figure 5. Seed being separated from one fraction of a felt layer.

Identification of recovered seeds

Seeds were collected from known species during sampling. The collected seeds were compared to the seeds recovered from the samples to establish some identities. Identification was further facilitated by using known seeds from botanical herbarium specimens, and from a seed collection of the Wildlife Research Unit in Logan, Utah. Some identifications were made and corroborated by the Grain Branch of the United States Department of Agriculture.

As the seeds were identified, they were separated into three categories: Parts of seeds which were recognizable but not viable (referred to as fractional in this study), whole seeds which were judgedto be empty, and whole seeds which were potentially viable. The numbers of empty and fractional seeds were recorded and the seeds discarded. The potentially viable seeds were placed in nylon sacks preparatory to pretreatment and germination. Identification cards printed with India ink and coated with plastic were enclosed.

Pretreatment and germination

Each species of seed was treated prior to germination in order to obtain the highest possible number of germinations. Treatments which were thought to give optimum results were applied. Recommendations for kind and length of pretreatment were taken primarily from three references (2, 9, 18).

Stratification was the principal form of pretreatment. Prior to stratification, *Ceanothus* seeds were boiled for five minutes and *Symphoricarpos* seeds were abraded lightly with a file. All other species were given stratification without other treatments.

Stratification was accomplished by placing seeds on trays between moist layers of sphagnum moss and refrigerating at 36° - 41° F. Table 2 shows the periods of stratification and germination given the major species of seed. All seeds except Symphoricarpos were dusted with "Arasan" before stratification to reduce mold infection.

Table 2. Stratification and germination periods for the major species of seed recovered and identified.

SPECIES	Duration in Days	
	Stratification	Germination
Amelanchier spp.	180 + 50[1]	90 + 30[2]
Carex spp.	180 + 50	90 + 30
Ceanothus velutinus	90	110
Physocarpus malvaceus	30 + 30 + 50	37 + 40 + 30
Pinus ponderosa	45	120
Polygonum spp.	180 + 50	90 + 30
Prunus spp.	90	100
Pseudotsuga menziesii	45	120
Purshia tridentata	60	90
Symphoricarpos spp.	100 + 90	90 + 30

[1] Break in stratification indicates a period under germinative conditions.

[2] Break in germination indicates a period in stratification.

When the stratification period for a given species was complete the seeds were exposed to germinative conditions. Glass-covered flats were used for this purpose. Sphagnum moss covered with sand served as a substrate. Boxwood squares (2 x 2 inches) with plastic-coated identifying tags separated the many categories of seed. All germination units were sterilized in live steam for two hours prior to use. Sterile water was applied to maintain condensation on the glass. As a result of these precautions almost no mold developed after as long as ten months in a flat.

The flats were covered with paper or burlap to limit evaporation and then put in a greenhouse. Pine, fir, *Ceanothus*, and bitterbrush flats were kept in a greenhouse at 75° - 95° F. All other flats were kept at 65° - 85° F. Germinations were recorded daily as they occurred. At the conclusion of the germination period, the seeds were cut to determine the number of hard, rotten and empty seeds.

Statistical technique

The numbers of seed found in the forest conditions, aspects, and soil layers sampled, varied considerably for some species. In order to arrive at more reliable conclusions for the important species, a chi-square statistical analysis was applied to the data. A test of the independence of factors at the 10 percent level of significance was completed according to the method outlined by Snedecor (14). The variables were north and south aspects; the forest conditions of open-brush, sapling-pole, and mature timber; and the soil layers of duff and mineral soil. Detailed outline of the statistical method and statistical analysis are given in the appendix.

RESULTS

The 48 square feet of duff-soil samples produced 16 identified species. The total would be approximately 40 species if the miscellaneous unidentified seeds are included. A total of 164 seeds per square foot, including viable and non-viable seeds was recovered from the samples. Of the species on which germination and cutting tests were made, 10 seeds per square foot were viable. Approximately 22 seeds per square foot were viable if the ungerminated fresh grass seed is included. Table 3 shows species, number and the total viability of the seed recovered. Table 5 in the Appendix includes the species, number and viability of the seeds recovered from the different forest aspects, conditions and soil layers. There were no viable seeds recovered of ponderosa pine (Pinus ponderosa), Douglas fir (Pseudotsuga menziesii), bitterbrush (Purshia tridentata) or snowberry (Symphoricarpos spp.). The two brush species, snowbrush (Ceanothus velutinus) and ninebark (Physocarpus malvaceus) each have slightly less than 75,000 viable seeds per acre.

The frequency of occurrence of seeds in the samples was largest for ponderosa pine (46 out of 48 samples). For viable seeds, however, Carex and Ceanothus were found in more samples than the other species. This information is shown in Figure 6 for grass and all species on which germination tests were carried out.

General statements concerning the number of seeds recovered on the different aspects, forest conditions and soil layers are difficult

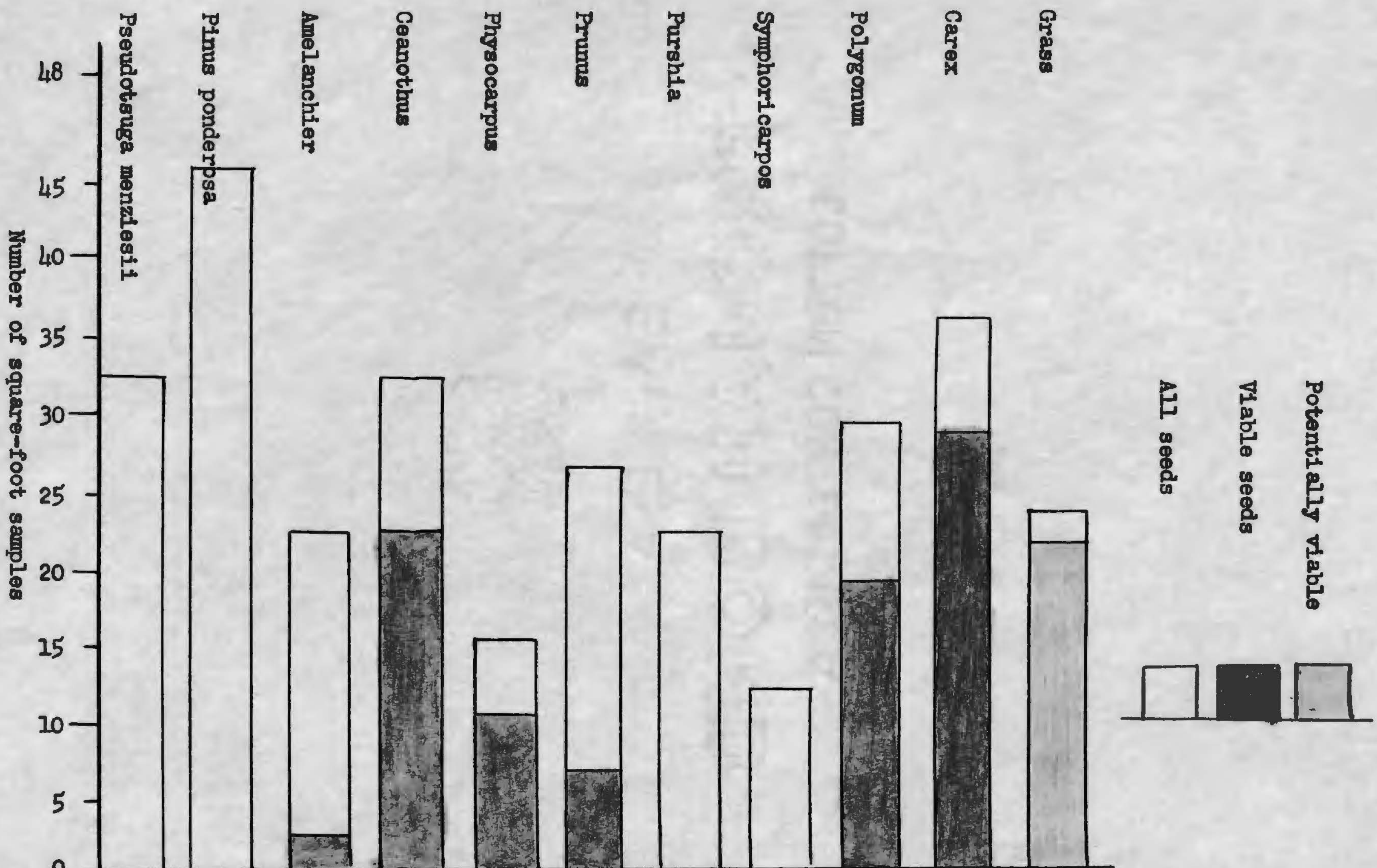

Figure 6. Occurrence of viable and non-viable seeds of principal species in 48 square-foot, duff-soil samples taken in different forest conditions and aspects in the ponderosa pine type.

to make. Interrelationships among the variables are many, and it is therefore best if the major species are considered individually.

Table 3. Species, number and viability of seed recovered from 48 square-foot, duff-soil samples in the ponderosa pine type of Central Idaho.

Species	Number of Seeds Recovered					
	All Seeds			Viable Seeds		
	Total	Per Sq.Ft.	Per Acre	Total	Per Sq.Ft.	Per Acre
Allium spp.[1]	15	.31	13,503	---	---	---
Amelanchier spp.	614	12.79	557,132	2	.04	1,742
Balsamorhiza spp.[1]	27	.56	24,394	---	---	---
Carex spp.	714	14.88	648,173	186	3.88	169,013
Ceanothus velutinus	329	6.85	298,386	80	1.67	72,745
Galium spp.[1]	138	2.88	125,453	---	---	---
Grass spp.[2]	1,114	23.21	1,011,028	585	12.19	530,996
Lomatium spp.[1]	7	.15	6,534	---	---	---
Physocarpus malvaceus	1,380	28.75	1,252,350	82	1.71	74,488
Pinus ponderosa	1,118	23.29	1,014,512	---	---	---
Polygonum spp.	651	13.56	590,674	101	2.10	91,476
Prunus spp.	200	4.17	181,645	9	.19	8,276
Pseudotsuga menziesii	516	10.75	468,270	---	---	---
Purshia tridentata	103	2.15	93,654	---	---	---
Symphoricarpos spp.	228	4.75	206,910	---	---	---
Trillium spp.[1]	44	.92	40,075	---	---	---
Umbelliferae[1]	46	.96	41,818	---	---	---
Unidentified	619	12.89	561,488	---	---	---
Total	7,863	163.82	7,135,999	1,045	21.78	948,736

[1]Identification not verified until recently, therefore, no germination tests carried out.

[2]The number of seeds in viable column was not checked by viability tests. The number represents fresh seed that had been separated from old and deteriorated seed on the assumption that a larger proportion of the fresh seed would be viable.

Ponderosa pine (Pinus ponderosa)

No viable seeds were recovered from the samples. Fourteen seeds were rotten and these originated in the duff. Approximately 65 percent of the seeds were fractional.

Seven percent of the seeds were in open-brush areas, 37 percent in sapling-pole stands and 58 percent in mature timber. North-west[1] aspects of sapling-pole stands had over 70 percent of the seeds in that forest condition. Mature timber showed the least difference between aspects.

Without regard to forest conditions and aspects, there were seven times as many seeds in the duff as in mineral soil. Mature timber had the largest number in the duff. North aspects had a larger proportion of seed in the duff than south aspects.

Douglas fir (*Pseudotsuga menziesii*)

No viable seeds were recovered from the samples. Five seeds were rotten and these originated in the duff. Eighteen percent of the seeds were fractional.

The distribution of the seeds among the forest conditions is 4 percent in open-brush, 21 percent in sapling-pole and 75 percent in mature timber. In open-brush and sapling-pole areas most of the seeds were on north-east aspects. In mature timber the largest number of seeds was found on the east-facing side of the drainage.

The proportion of seeds between the duff and mineral soil varies with east and west aspects; east having a ratio of 18:1 and west 5:1. The forest conditions do not show an affect on these ratios.

Snowbrush (*Ceanothus velutinus*)

The samples yielded 329 viable and non-viable seeds. Of this number, 60 percent were empty, 12 percent were fractional, and the

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[1]Refers to north aspect sampled on the west facing side of the drainage.

remainder proved to be viable. Results of germination tests on sample seed and on freshly collected seed exposed to the same conditions are shown in Table 4. Only 26 percent of the sample seed germinated as compared to 40 percent for the fresh seed. A larger proportion of the sample seed was hard when cut.

Table 4. Number and percent of sample and freshly collected Ceanothus seeds germinating after being exposed to the same germinative conditions.

Seed	Sample		Fresh[1]	
	Number	Percent	Number	Percent
Germinated	24	26	122	40
Hard	56	60	30	10
Rotten	13	14	153	50
Total	93	100	305	100

[1]Seed was collected in the sampling area.

No significant difference existed in the number of viable seed between open-brush areas and sapling-pole stands. Mature timber had considerably less with 15 percent of the 80 viable seeds. Within the individual forest conditions, significantly larger numbers of seed were recovered from one aspect: open-brush, north-east; sapling-pole, north-east; mature timber, north-west.

The duff and mineral soil on north aspects generally had equal numbers of viable seed. South aspects had a greater proportion in the mineral soil. Sapling-pole stands had more viable seeds in the mineral soil than in the duff. Seeds originating in the mineral soil appeared to result in greater numbers of germinations than those occurring in the duff; however, this could not be proved.[1]

[1]Low expected numbers which were present result in a biased chi-square analysis.

Ninebark (*Physocarpus malvaceus*)

The seed from the samples produced 82 germinations from 1,380 seeds. Actually this is close to 100 percent germination because cutting tests indicated that no rotten or hard seeds were present. Most of the empty seeds were probably empty before the germination test. The germination percent of 400 fresh seeds exposed to the same germinative conditions was 84.

The germinated sample seeds were distributed among the forest conditions with 76 percent in open-brush areas, 17 percent in sapling-pole stands and 7 percent in mature timber. Within the forest conditions north-east aspects had many more germinable seeds than the other aspects except in mature timber which showed variation between aspects.

No viable seeds were found in the mineral soil of mature timber. The other forest conditions had the viable seed equally distributed between the duff and mineral soil.

Serviceberry (*Amelanchier* spp.)

Two seeds of 614 sample seeds exposed to germinative conditions were viable. Low viability may be attributed to eel worms which were observed working in the seeds. For a comparison of germinative results, 107 fresh seeds were given a germination test under the same conditions. Forty-four percent germinated and 53 percent were found to be empty.

The distribution of the sample seeds among the forest conditions was 63 percent open-brush, 36 percent sapling-pole and 1 percent mature timber. The greatest concentration of seeds was on south-east exposures. Sixty-nine percent of the seeds were in the duff.

Chokecherry (Prunus spp.)

Ten seeds of 200 recovered from the samples were viable. All of the viable seeds originated in open-brush areas on the east facing side of the drainage. All of the seeds (viable and non-viable) were distributed with 90 percent in open-brush areas, 7 percent in sapling-pole stands and 3 percent in mature timber. Approximately 68 percent of these were in the duff.

Bitterbrush (Purshia tridentata) and Snowberry (Symphoricarpos spp.)

No viable seeds of these species were recovered. The viability of the snowberry seeds may have been impaired in pretreatment by filing the seeds too deeply. Almost all (97 percent) of the bitterbrush seeds assumed sound before pretreatment were rotten when cut. A germination test of 200 fresh bitterbrush seed resulted in 40 percent germination, 34 percent hard and 26 percent rotten seeds. The lack of viable sample seeds may have been natural or some inestimable factor may have influenced the results.

The distribution of the bitterbrush seeds from the samples was 64 percent open-brush, 33 percent sapling-pole and 3 percent mature timber. The number of seeds within each of these conditions varied by aspect; the largest concentration being on south-east, open-brush areas. Fifty-five percent of the seeds were in the duff.

Approximately 92 percent of the snowberry seeds were in open-brush areas, 6 percent in sapling-pole stands and 2 percent in mature timber. Of those seeds in open-brush areas, 99 percent were on north-west aspects. Those seeds in sapling-pole stands were only on south aspects and those in timber were on several aspects. Sixty-six percent of the seed was in the duff.

Sedge (*Carex spp.*)

Twenty-six percent of the 714 seeds recovered were viable. Of the viable seeds, 17 percent germinated and 83 percent were hard.

The distribution of the viable seeds was 12 percent open-brush, 47 percent sapling-pole and 41 percent mature timber. All of the viable seeds in open-brush areas were from a north-east aspect. In sapling-pole stands, north aspects had approximately five times as many seeds as south aspects. The number of viable seeds in mature timber varied only slightly with aspect.

Open-brush areas had about equal numbers of seed between the duff and mineral soil. Sapling-pole stands had about twice as many and mature timber four times as many seeds in the duff as in the mineral soil.

Grass species

No germination tests were conducted on the grass species. However, fresh seeds were separated from the old and badly deteriorated seeds under the assumption that a greater proportion of the fresh seed would be viable. Approximately half of the grass seeds were fresh.

The fresh seed (including *Bromus tectorum*) was distributed among the forest conditions with 83 percent in open-brush, 13 percent in sapling-pole and 4 percent in mature timber. One sample taken in an open-brush area on a south-west aspect greatly influenced the results: Over 300 fresh seeds of cheatgrass (*Bromus tectorum*) were recovered. South-west aspects contained over 90 percent of the fresh and old seeds; less than one percent was recovered from north aspects. Ratios of fresh seed in the duff to that in the mineral soil by forest condition are: open-brush 22:1, sapling-pole 14:1 and mature timber 1:1.

Knotweed (*Polygonum* spp.)

Germination and cutting tests indicated that 16 percent of the seed recovered was viable. Twenty-four percent of the viable seed germinated. The viable seeds were distributed among the forest conditions with 55 percent in open-brush areas, 39 percent in sapling-pole stands and 6 percent in mature timber. Over 76 percent of the viable seeds originated on south aspects. There were approximately twice as many viable seeds in the duff as in the mineral soil.

Other herbaceous species

Only 15 onion (*Allium* spp.) seeds were recovered from the samples. These originated in the duff of mature timber. Most of the balsam-root (*Balsamorhiza* spp.) seeds originated in the duff of open-brush areas.

Most (73 percent) of the bedstraw (*Galium* spp.) occurred in the duff of open-brush areas and the remainder in sapling-pole stands. Seven *Lomatium* spp. seeds were found on a south-east, open-brush area. The *Trillium* seeds were located on several aspects and forest conditions with more in the duff than mineral soil.

CONCLUSIONS AND DISCUSSION

The forest conditions and aspects sampled in this study greatly influenced the number of seeds found in the forest floor. Generally, simple relationships did not exist in the number of seeds recovered among the forest conditions, aspects and soil layers. The numerous interactions between these variables can be explained by the different environments of the sites samples and the influence of the environments on species composition, seed production and seed longevity. In most cases these interactions indicate that forest conditions, aspects and soil layers must be considered concurrently and not individually.

The number of seed recovered for each species was most abundant where the species was observed growing most often. For example, ninebark was observed most often on north-east aspects. The latter location produced the largest number of ninebark seeds. Viable seeds in the mineral soil were most abundant on the same sites. Where a sample produced an unusually large number of seeds, the large number could usually be credited to vegetation growing nearby.

The number of seeds occurring in the forest floor was probably influenced by the work of rodents. This is especially true of pine. Squillace and Adams (15) indicate that 92 percent of pine seed from a heavy crop may be destroyed by rodents. This high loss may be further substantiated by this study. Sixty-five percent of the pine seed recovered were fractional. All other species had about 10 to 20 percent fractional seed. The excessive number of fractional pine seed may have been the result of destruction by rodents.

The probable longevity of some species of seed in natural duff or soil storage can be estimated from the results. No viable seeds of ponderosa pine or Douglas fir were recovered from the samples. Because the samples were taken in the fall, it can be assumed that the seed crop of the previous year had lost its viability by that time. However, it is possible that the seed year, or work of rodents, insects or fungi may have influenced the results.

Most of the seed recovered from the duff (Ao + Aoo soil horizon) probably reached that soil horizon much later than those occurring in the mineral soil. Those seeds occurring in or below the unbroken felt had been there much longer than those seeds occurring in the litter (Aoo soil horizon) layer. If no duff was present, which was true on some south aspects, then mixing of fresh and old seed could have taken place by erosion.

Several species of viable seed occurring on south aspects in mineral soil (where a felt layer had not formed) also occurred below a felt layer on other sites. Viable seeds occurring in relative abundance under the latter condition were snowbrush, sedge, and knotweed. On this basis the longevity of these seeds can be estimated. Trimble and Tripp (16) have a few conclusions concerning the time necessary to accumulate duff in lodgepole pine:

> "...30-40 years must elapse after establishment of the stand before any litter or humus layer begins to form. At 50 years the organic layer is still patchy. Litter depth averages about 1/2 inch. The partially decomposed F horizon layer averages about the same. Stands 100 years old have a good humus layer with 1/2 inch litter and 1-2 inch absorbent layer of F and H combined."

In stands over 200 years, they found 3-6 inches of duff. Kittredge (8, p. 166) indicates that there is not much difference in the rate of accumulation of litter in different types of forest stands. Many of the felt layers in the samples taken on the Experimental Forest were an inch thick. It is therefore probable that many of the viable seeds occurring in the mineral soil of mature timber had been there over 100 years.

Snowbrush usually becomes established in dense stands following a fire or logging disturbance. Most of the snowbrush results from seed stored in the duff. This is supported by a fire damage study (17) which showed that 65 percent of the quadrats had seedlings of snowbrush on them; by Curtis' study (3) which indicates an increase in germinative capacity of snowbrush seed following a fire; and by the recovery of a large number of viable snowbrush seed from the samples of this study. This situation, where seed stored in the duff is an important part of the reproduction and establishment of snowbrush, may also be true for other species. A large number of viable sedge (Carex geyerii) and knotweed (Polygonum spp.) was recovered from the duff and mineral soil.

The presence of viable seeds in the soil of forest stands, especially of snowbrush, can be of considerable importance to the forester. Areas of brush often remain unstocked or established seedlings may maintain imperceptible growth. These conditions can cause undesirable changes in management plans: Rotations may need to be extended or productive acreage reduced.

Large areas burned by wildfire and now covered with brush emphasize the need for putting these areas into productivity. Smaller brush covered areas in old-growth stands and recently logged-over areas also whittle away at productivity. The author has observed stagnated pine seedlings in patches of snowbrush of less than 1/10 acre.

Specific recommendations concerning practical use of the information in this paper are difficult to make. The knowledge of where, what kind and the number and viability of seeds in the forest floor could affect the management of ponderosa pine, but present knowledge of brush ecology limits the number of conclusions that can be elicited from the data.

Control of brush will probably become more practical with the development of selective herbicides. It may be practical and economical to treat newly germinated seedlings rather than mature brush. Knowledge of where most of these seedlings may be found and the timing of spray application may be aided by the information in this report.

Slash burning is capable of producing the same brush conditions that exist after most wildfires. Further investigation of the extent of brush occurrence after slash fires may indicate greater discretion in the use of broadcast burning of slash. This is especially true for snowbrush and sedge and may also be true of other species.

SUMMARY

Regeneration of ponderosa pine in Central Idaho is often complicated by the establishment of brush on logged and burned-over areas. Much of the brush results from seed stored in the forest floor, but little is known of the species or distribution of the seed present. This study was carried out to learn the kind, number and viability of seed present in different forest conditions, aspects and soil layers.

Forty-eight square-foot samples were taken in the forest floor of several compartments of the Boise Basin Experimental Forest. Each sample was taken in layers of litter, felt and mineral soil, where they existed. Three forest conditions (open-brush, sapling-pole and mature timber) were sampled on north and south aspects.

Seed was separated from the samples and the principal species identified: *Amelanchier* spp., *Carex* spp., *Ceanothus velutinus*, *Physocarpus malvaceus*, *Pinus ponderosa*, *Polygonum* spp., *Prunus* spp., *Pseudotsuga menziesii*, *Purshia tridentata*, *Symphoricarpos* spp. These species were given stratification and other required pretreatments and exposed to germinative conditions in glass-covered flats. A chi-square analysis was completed on the totals of seeds occurring within the categories using tests of homogeneity as recommended by Snedecor (14).

The 48 square feet of duff-soil samples produced 16 identified species or a total (including unidentified seeds) of 164 seeds per square foot. Ten seeds per square foot were determined to be

viable by germination tests. No seeds of ponderosa pine, Douglas fir, bitterbrush or snowberry were determined to be viable. Snowbrush, ninebark, sedge and knotweed had 75,000 or more viable seeds per acre.

Many interactions between forest condition, aspect and soil layers were indicated in the statistical analysis. Generally each species of seed was more abundant on one aspect, one forest condition and one soil layer rather than having the seeds equally distributed among all aspects, forest conditions and soil layers.

Viable snowbrush seeds were most abundant on north aspects of open-brush and sapling-pole stands with about half of the seeds in mineral soil. Most of the viable seeds of ninebark were on north aspects of open-brush areas with about half in the mineral soil. The viable seeds of sedge originated primarily on north aspects with most being in sapling-pole stands and mature timber. More seeds were in the duff than mineral soil. Most of the viable seeds of knotweed originated on south aspects in open-brush areas and were twice as plentiful in the duff as mineral soil.

The variation in the distribution of different species of seeds among the sites sampled may be attributed to the different environments and the influence of the environment on species composition, seed production and seed longevity.

From the rate of duff accumulation and duff formation, indications are that seeds of snowbrush, sedge and knotweed may have remained viable 20-100 years.

The presence of viable seeds in the soil of forest stands can be of considerable importance to the forester. Brush competition causes mortality and reduction in growth of ponderosa pine. Much of the brush competition results from fire and logging disturbances. A knowledge of the presence of viable seeds in the forest floor may be of importance in future brush control projects.

APPENDIX

Table 5. Kind, number and viability of seeds recovered from 48 square-foot samples[1] taken in different conditions and aspects in the ponderosa pine type of Central Idaho, 1952.

Seed		East						West						
		North			South			North			South			
		Open Brush.	Sapling Pole	Mature Timber	Open Brush.	Sapling Pole	Mature Timber	Open Brush.	Sapling Pole	Mature Timber	Open Brush.	Sapling Pole	Mature Timber	Total
<u>Allium</u> spp. Onion ALL[2]	Duff	—	—	14	—	—	—	—	—	1	—	—	—	15
	Mineral	—	—	—	—	—	—	—	—	—	—	—	—	—
	Total	—	—	14	—	—	—	—	—	1	—	—	—	15
<u>Amelanchier</u> spp. Serviceberry ALL	Duff	12	19	1	136[3]	112	3	134	4	2	—	3[4]	—	426
	Mineral	5	3	—	48	76	1	54	—	—	—	1	—	188
	Total	17	22	1	184	188	4	188	4	2	—	4	—	614
<u>Balsamorhiza</u> spp. Balsam-root ALL	Duff	—	—	—	14	1	1	—	—	—	8	—	—	24
	Mineral	—	—	—	1	—	—	—	—	—	2	—	—	3
	Total	—	—	—	15	1	1	—	—	—	10	—	—	27

[1]Four samples in each subclass, i.e., open-brush.
[2]Refers to total of all seeds in the category including fractional and viable seeds if they are present.
[3]Includes one hard seed.
[4]Includes one germinated seed

Continued

Table 5. Continued

Seed		East North Open Brush	East North Sapling Pole	East North Mature Timber	East South Open Brush	East South Sapling Pole	East South Mature Timber	West North Open Brush	West North Sapling Pole	West North Mature Timber	West South Open Brush	West South Sapling Pole	West South Mature Timber	Total
<u>Carex</u> spp. <u>Sedge</u>														
GERMINATED	Duff	1	3	1	—	1	4	—	4	10	—	—	—	24
	Mineral	1	—	—	—	1	—	—	3	1	—	—	1	7
	Total	2	3	1	—	2	4	—	7	11	—	—	1	31
VIABLE	Duff	12	14	12	—	4	20	—	36	22	—	6	9	135
	Mineral	11	13	3	—	1	2	—	10	5	—	3	3	51
	Total	23	27	15	—	5	22	—	46	27	—	9	12	186
ALL	Duff	47	49	85	—	18	69	9	81	67	—	19	45	489
	Mineral	31	73	7	—	21	22	17	12	14	—	12	16	225
	Total	78	122	92	—	39	91	26	93	81	—	31	61	714
<u>Ceanothus velutinus</u> Snowbrush														
GERMINATED	Duff	—	4	—	1	—	—	—	1	—	1	—	—	7
	Mineral	4	5	—	2	2	1	—	—	1	1	1	—	17
	Total	4	9	—	3	2	1	—	1	1	2	1	—	24

Continued

Table 5. Continued

Seed		East						West						Total
		North			South			North			South			
		Open Brush.	Sapling Pole	Mature Timber	Open Brush.	Sapling Pole	Mature Timber	Open Brush.	Sapling Pole	Mature Timber	Open Brush.	Sapling Pole	Mature Timber	
Ceanothus velutinus														
VIABLE	Duff	15	9	—	1	—	1	—	3	3	1	—	—	33
	Mineral	8	22	—	2	2	2	1	—	5	1	3	1	47
	Total	23	31	—	3	2	3	1	3	8	2	3	1	80
ALL	Duff	148	19	1	19	2	3	—	6	3	2	1	1	205
	Mineral	49	34	—	10	6	2	11	—	6	1	3	2	124
	Total	197	53	1	29	8	5	11	6	9	3	4	3	329
Galium spp.														
Bedstraw														
ALL	Duff	—	—	—	1	19	—	83	2	—	3	5	—	113
	Mineral	—	—	—	—	11	—	14	—	—	—	—	—	25
	Total	—	—	—	1	30	—	97	2	—	3	5	—	138
Grass spp.														
FRESH[1]	Duff	—	—	—	41	1	—	3	—	2	420	68	13	548
	Mineral	—	—	—	12	—	10	—	—	1	9	5	—	37
	Total	—	—	—	53	1	10	3	—	3	429	73	13	585

[1]Seed separated into "fresh" and "old" (deteriorated) on the basis of appearance under the assumption that the fresh seeds would have a larger proportion viable.

Continued

Table 5. Continued

Seed			East: North: Open Brush	East: North: Sapling Pole	East: North: Mature Timber	East: South: Open Brush	East: South: Sapling Pole	East: South: Mature Timber	West: North: Open Brush	West: North: Sapling Pole	West: North: Mature Timber	West: South: Open Brush	West: South: Sapling Pole	West: South: Mature Timber	Total
Grass spp.															
	OLD	Duff	—	—	—	58	—	—	2	—	1	370	—	73	504
		Mineral	1	—	—	4	1	1	—	—	—	6	—	12	25
		Total	1	—	—	62	1	1	2	—	1	376	—	85	529
	ALL	Duff	—	—	—	99	1	—	5	—	3	790	68	86	1052
		Mineral	1	—	—	16	1	11	—	—	1	15	5	12	62
		Total	1	—	—	115	2	11	5	—	4	805	73	98	1114
<u>Lomatium</u> spp. Desert Parsley															
	ALL	Duff	—	—	—	6	—	—	—	—	—	—	—	—	6
		Mineral	—	—	—	1	—	—	—	—	—	—	—	—	1
		Total	—	—	—	7	—	—	—	—	—	—	—	—	7
<u>Physocarpus</u> <u>malvaceus</u> Ninebark															
	GERMINATED and VIABLE	Duff	35	4	—	—	3	2	—	—	4	—	—	—	48
		Mineral	27	7	—	—	—	—	—	—	—	—	—	—	34
		Total	62	11	—	—	3	2	—	—	4	—	—	—	82

Continued

Table 5. Continued

Seed		East North Open Brush	East North Sapling Pole	East North Mature Timber	East South Open Brush	East South Sapling Pole	East South Mature Timber	West North Open Brush	West North Sapling Pole	West North Mature Timber	West South Open Brush	West South Sapling Pole	West South Mature Timber	Total
Physocarpus malvaceus														
ALL	Duff	809	143	--	2	11	16	4	1	16	--	--	--	1002
	Mineral	288	83	--	--	--	7	--	--	--	--	--	--	378
	Total	1097	226	--	2	11	23	4	1	16	--	--	--	1380
Pinus ponderosa														
Ponderosa Pine														
ALL	Duff	34	38	143	13	8	133	5	269	136	10	42	146	977
	Mineral	4	7	23	4	10	10	--	28	9	8	17	21	141
	Total	38	45	166	17	18	143	5	297	145	18	59	167	1118
Polygonum spp.														
Knotweed														
GERMINATED	Duff	--	--	--	--	3	--	2	3	--	6	1	--	15
	Mineral	1	--	--	--	--	--	1	--	--	6	--	1	9
	Total	1	--	--	--	3	--	3	3	--	12	1	1	24
VIABLE	Duff	1	--	--	3	27	--	7	6	--	20	3	4	71
	Mineral	2	1	--	1	--	--	8	--	--	14	2	2	30
	Total	3	1	--	4	27	--	15	6	--	34	5	6	101

Continued

Table 5. Continued

Seed		East						West						Total
		North			South			North			South			
		Open Brush	Sapling Pole	Mature Timber	Open Brush	Sapling Pole	Mature Timber	Open Brush	Sapling Pole	Mature Timber	Open Brush	Sapling Pole	Mature Timber	
Polygonum spp.														
ALL	Duff	2	2	—	7	62	—	36	15	—	185	22	14	345
	Mineral	14	5	—	6	12	—	47	1	—	178	35	8	306
	Total	16	7	—	13	74	—	83	16	—	363	57	22	651
Prunus spp.														
Chokecherry														
VIABLE	Duff	4	1	—	1	—	—	—	—	—	—	—	—	6
	Mineral	1	—	—	2	—	—	—	—	—	—	—	—	3
	Total	5	1	—	3	—	—	—	—	—	—	—	—	9
ALL	Duff	59[1]	1	—	27	1	1	35	4	2	4	2	—	136
	Mineral	29	1	1	21	2	1	6	—	—	—	3	—	64
	Total	88	2	1	48	3	2	41	4	2	4	5	—	200
Pseudotsuga menziesii														
Douglas fir														
ALL	Duff	18	76	133	2	—	137	—	3	68	—	17	21	475
	Mineral	1	6	1	1	—	11	—	—	12	—	7	2	41
	Total	19	82	134	3	—	148	—	3	80	—	24	23	516

[1]Includes one germinated seed.

Continued

Table 5. Continued

Seed		East						West						
		North			South			North			South			
		Open Brush	Sapling Pole	Mature Timber	Open Brush	Sapling Pole	Mature Timber	Open Brush	Sapling Pole	Mature Timber	Open Brush	Sapling Pole	Mature Timber	Total
<u>Purshia tridentata</u> Bitterbrush														
ALL	Duff	1	—	—	27	—	—	12	3	—	7	7	—	57
	Mineral	4	4	2	12	1	—	1	3	1	2	16	—	46
	Total	5	4	2	39	1	—	13	6	1	9	23	—	103
<u>Symphoricarpos</u> spp. Snowberry														
ALL	Duff	1	—	—	—	6	1	135	—	2	—	5	—	150
	Mineral	1	—	1	—	2	—	73	—	—	1	—	—	78
	Total	2	—	1	—	8	1	208	—	2	1	5	—	228
<u>Trillium</u> spp.														
ALL	Duff	9	—	—	—	—	16	4	—	—	—	—	2	31
	Mineral	4	1	—	—	—	2	3	—	2	—	—	1	13
	Total	13	1	—	—	—	18	7	—	2	—	—	3	44
<u>Umbelliferae</u> Carrot														
ALL	DUFf	—	—	—	—	36	—	—	—	—	—	—	4	40
	Mineral	—	—	—	—	6	—	—	—	—	—	—	—	6
	Total	—	—	—	—	42	—	—	—	—	—	—	4	46

Continued

Table 5. Continued

Seed		East						West						Total
		North			South			North			South			
		Open Brush	Sapling Pole	Mature Timber	Open Brush	Sapling Pole	Mature Timber	Open Brush	Sapling Pole	Mature Timber	Open Brush	Sapling Pole	Mature Timber	
Miscellaneous Unidentified ALL	Duff	41	5	28	5	63	24	69	34	148	7	45	10	479
	Mineral	18	14	2	8	23	4	35	4	10	13	4	5	140
	Total	59	19	30	13	86	28	104	38	158	20	49	15	619
TOTAL GERMINATED	Duff	37	11	1	1	7	6	2	8	14	7	2	--	96
	Mineral	33	12	—	2	3	1	1	3	2	7	1	2	67
	Total	70	23	1	3	10	7	3	11	16	14	3	2	163
TOTAL VIABLE	Duff	67	28	12	6	34	23	7	45	29	21	10	13	295
	Mineral	49	43	3	5	3	4	9	10	10	15	8	6	165
	Total	116	71	15	11	37	27	16	55	39	36	18	19	460
TOTAL ALL	Duff	1181	352	405	358	340	404	531	422	448	1016	236	329	6022
	Mineral	449	231	37	128	171	71	261	48	55	220	103	67	1841
	Total	1630	583	442	486	511	475	792	470	503	1236	339	396	7863

STATISTICAL TECHNIQUE

Three main factors were sampled in this study: forest conditions, aspects and soil layers. The subdivision of each of these is shown below:

Forest Conditions	Aspects		Soil Layers
Open-Brush	East	West	Duff
Sapling-Pole	North-South	North-South	Mineral
Mature Timber			

The random selection of samples is described on p. 6. Four samples were taken in each combination of forest condition and aspect at each location. For instance, 24 samples were taken on the east facing side of the drainage--12 on north aspects and 12 on south. Each of the forest conditions on north and south aspects had four samples taken in each. A total of 48 samples was taken.

In the statistical analysis a chi-square test of independence as described by Snedecor (16, pp. 194-200) was applied to various combinations of factors to ascertain homogeneity or interaction of the factors. The long method was used first and the short-cut method used as a check. Determination of the chi-square value for a test of independence was achieved by using the formula:

$$X^2 = \frac{(\ ad - bc - N/2)^2\ N}{ABCD}$$

Values for the symbols are shown in Table 6. The chi-square value was found with the proper degrees of freedom in Snedecor (16, Table 9.2) and the probability of a higher chi square determined. If the probability was less than 10 in 100 (the 10 percent level of confidence) then the conclusion was that the factors were not independent. For example, a test of independence was made for the factors of aspect and soil layer as shown in Table 6.

Table 6. Number of viable sedge seed recovered from soil samples taken in different layers of soil and on different sides of a drainage, showing symbols used in formula for test of independence.

Soil Layer	Aspect		Total
	East	West	
Duff	62 (a)	73 (b)	135 (C)
Mineral	30 (c)	21 (d)	51 (D)
Total	92 (A)	94 (B)	186 (N)

From the above table the chi-square value for independence is 1.974 and the probability of a higher chi square is 16 in 100. Therefore, at the 10 percent level of confidence the factors of aspect and soil layer are independent and there is no statistically significant interaction between them.

If the factors proved to be independent, it was then possible to test the border totals for homogeneity. This was accomplished by using the formula: $X^2 = \sum \frac{(X - M)^2}{M}$ Where X is the number found in a category (A in Table 6) M is the mean value of the categories being tested ($\frac{A + B}{2}$ in Table 6) and $\sum$ indicates that the value is computed for each category and a summation made. In the tabular example above, a test for homogeneity of the border totals for east and west aspects (A and B) reveals no significant difference. However, a test of duff and soil totals (C and D) indicates a highly significant difference.

The statistical analysis for a particular species and category of viability may have some weaknesses. An insufficient number of samples in the smaller categories, i.e., an open-brush area on a north aspect with numbers of seed less than five. Bias is present in a chi-square analysis where the numbers are less than five. It was therefore necessary to use totals of combined categories as a basis for estimating chi-square, i.e., north and south aspects considered without regard to side of drainage, east or west. The use of totals omits the categories within, and in some cases the "within" categories may vary considerably. In some instances so few seeds were found, especially germinated seeds, that no test of independence or homogeneity of totals could be completed without bias. Interpretation with the above weaknesses may therefore be subject to some error.

ANALYSIS DATA

The type of analysis described in the preceding section on Statistical Technique was completed in some cases for three groups of seed for a species--all of the seeds found regardless of viability, hard seeds and germinated seeds together as a viable group, and germinated seeds. No analysis was completed for seed on which germination tests were not conducted. No analysis was completed where results were obvious. Where complete analysis was not worked and knowledge of homogeneity was desired for certain factors, spot chi-square checks were made.

The tabular presentation of the factors statistically tested for each species follows. The resulting chi-square values and probability of a higher chi square are indicated.

Ponderosa pine (*Pinus ponderosa*)

All Seeds

	Open-Brush			Sapling-Pole			Mature Timber		
	East	West	Total	East	West	Total	East	West	Total
North	38	5	43	45	297	342	166	145	311
South	17	18	35	18	59	77	143	167	310
Total	55	23	78	63	356	419	309	312	621

Indep. X^2 = 13.311 Prob. = Less than .01

Indep. X^2 = 4.367 Prob. = .03

Indep. X^2 = 2.978 Prob. = .08

Soil Horizon	East		West		Total
	North	South	North	South	
Duff	205	164	410	198	977
Mineral	21	37	37	46	141
Total	226	201	447	244	1118

Indep. X^2 = 6.773 Prob. = Less than .01

Indep. X^2 = Excessive Prob. = Less than .01

Soil Horizon	Stand Condition			Total
	Open-Brush	Sapling-Pole	Timber	
Duff	62	357	558	977
Mineral	16	62	63	141
Total	78	419	621	1118

Indep. X^2 = 9.662
Prob. = .01

Douglas fir (Pseudotsuga menziesii)

All Seeds

	Open-Brush			Sapling-Pole			Mature Timber		
	East	West	Total	East	West	Total	East	West	Total
North	19	—	19	82	3	85	134	80	214
South	3	—	3	—	24	24	148	23	171
Total	22	—	22	82	27	109	282	103	385

Low exp. nos. Indep. X^2 = Excessive Indep. X^2 = Excessive

Soil Horizon	EAst		West		Total
	North	South	North	South	
Duff	227	139	71	38	475
Mineral	8	12	12	9	41
Total	235	151	83	47	516

Indep. X^2 = 2.992 Indep. X^2 = .203
Prob. = .08 Prob. = .66

Soil Horizon	Stand Condition			Total
	Open-Brush	Sapling-Pole	Timber	
Duff	20	96	359	475
Mineral	2	13	26	41
Total	22	109	385	516

Indep. X^2 = 2.481
Prob. = .18

Serviceberry (*Amelanchier spp.*)

All Seeds

	Open-Brush			Sapling-Pole			Mature Timber		
	East	West	Total	East	West	Total	East	West	Total
North	17	188	205	22	4	26	1	2	3
South	184	—	184	188	4	192	4	—	4
Total	201	188	389	210	8	218	5	2	7
				Low exp. nos.			Low exp. nos.		

Snowbrush (*Ceanothus velutinus*)

Germinated Seeds

	Open-Brush			Sapling-Pole			Mature Timber		
	East	West	Total	East	West	Total	East	West	Total
North	4	—	4	9	1	10	—	1	1
South	3	2	5	2	1	3	1	—	1
Total	7	2	9	11	2	13	1	1	2
	Low exp. nos.			Low exp. nos.			Low exp. nos.		

Soil Horizon	East		West		Total
	North	South	North	South	
Duff	4	1	1	1	7
Mineral	9	5	1	2	17
Total	13	6	2	3	24
	Low exp. nos.		Low exp. nos.		

Soil Horizon	Stand Condition: Open-Brush	Sapling-Pole	Timber	Total
Duff	2	5	—	7
Mineral	7	8	2	17
Total	9	13	2	24

Low exp. nos.

Soil Horizon	Stand Condition: Open-Brush	Sapling-Pole	Timber	Total
East	7	11	1	19
West	2	2	1	5
Total	9	13	2	24

Low exp. nos.

Soil Horizon	Stand Condition: Open-Brush	Sapling-Pole	Timber	Total
North	4	10	1	15
South	5	3	1	9
Total	9	13	2	24

Low exp. nos.

Viable Seeds

	Open-Brush			Sapling-Pole			Mature Timber		
	East	West	Total	East	West	Total	East	West	Total
North	23	1	24	31	3	34	—	8	8
South	3	2	5	2	3	5	3	1	4
Total	26	3	29	33	6	39	3	9	12

Low exp. nos.   Low exp. nos.   Low exp. nos.

Soil Horizon	East		West		Total
	North	South	North	South	
Duff	24	2	6	1	33
Mineral	30	6	6	5	47
Total	54	8	12	6	80

Indep. X^2 = .431
Prob. = .53
Duff-Mineral X^2 = 1.3
Prob. = .25

North-South X^2 = 1.389
Prob. = .23
Duff-Mineral = .50
Prob. = .46

Soil Horizon	Stand Condition			Total
	Open-Brush	Sapling-Pole	Timber	
Duff	17	12	4	33
Mineral	12	27	8	47
Total	29	39	12	80

Indep. X^2 = 5.69
Prob. = .07

Soil Horizon	Stand Condition			Total
	Open-Brush	Sapling-Pole	Timber	
East	26	33	3	62
West	3	6	9	18
Total	29	39	12	80

Indep. X^2 = 22.558
Prob. = .01

Soil Horizon	Stand Condition			Total
	Open-Brush	Sapling-Pole	Timber	
North	24	34	8	66
South	5	5	4	14
Total	29	39	12	80

Indep. X^2 = 2.676
Prob. = .17

Ninebark (Physocarpus malvaceus)

Germinated and Viable Seeds

	Open-Brush			Sapling-Pole			Mature Timber		
	East	West	Total	East	West	Total	East	West	Total
North	62	--	62	11	--	11	--	4	4
South	--	--	--	3	--	3	2	--	2
Total	62	--	62	14	--	14	2	4	6
	Low exp. nos.			Low exp. nos.			Low exp. nos.		

Soil Horizon	East		West		Total
	North	South	North	South	
Duff	39	5	4	--	48
Mineral	34	--	--	--	34
Total	73	5	4	--	82
	Low exp. nos.		Low exp. nos.		

Soil Horizon	Stand Condition			Total
	Open-Brush	Sapling-Pole	Timber	
Duff	35	7	6	48
Mineral	27	7	--	34
Total	62	14	6	82

Stand Condition X^2 = Excessive
Prob. = Less than .01

Soil Horizon	Stand Condition: Open-Brush	Sapling-Pole	Timber	Total
East	62	14	2	78
West	—	—	4	4
Total	62	14	6	82

Low exp. nos.

Soil Horizon	Stand Condition: Open-Brush	Sapling-Pole	Timber	Total
North	62	11	4	77
South	—	3	2	5
Total	62	14	6	82

Low exp. nos.

Chokecherry (*Prunus* spp.)

All Seeds

	Open-Brush			Sapling-Pole			Mature Timber		
	East	West	Total	East	West	Total	East	West	Total
North	88	41	129	2	4	6	1	2	3
South	48	4	52	3	5	8	2	—	2
Total	136	45	181	5	9	14	3	2	5

Indep. X^2 = Excessive   Low Exp. nos.   Low exp. nos.

Bitterbrush (Purshia tridentata)

All Seeds

	Open-Brush			Sapling-Pole			Mature Timber		
	East	West	Total	East	West	Total	East	West	Total
North	5	13	18	4	6	10	2	1	3
South	39	9	48	1	23	24	—	—	--
Total	44	22	66	5	29	34	2	1	3

Indep. X^2 = Excessive   Low exp. nos.   Low exp. nos.

Snowberry (Symphoricarpos spp.)

All Seeds

	Open-Brush			Sapling-Pole			Mature Timber		
	East	West	Total	East	West	Total	East	West	Total
North	2	208	210	--	--	--	1	2	3
South	--	1	1	8	5	13	1	—	1
Total	2	209	211	8	5	13	2	2	4

Low exp. nos.   Low exp. nos.   Low exp. nos.

Sedge (Carex spp.)

Germinated Seeds

	Open-Brush			Sapling-Pole			Mature Timber		
	East	West	Total	East	West	Total	East	West	Total
North	2	—	2	3	7	10	1	11	12
South	—	—	—	2	—	2	4	1	5
Total	2	--	2	5	7	12	5	12	17

Low exp. nos.   Low exp. nos.   Low exp. nos.

Soil Horizon	East		West		Total
	North	South	North	South	
Duff	5	5	14	--	24
Mineral	1	1	4	1	7
Total	6	6	18	1	31

Low exp. nos.　　　Low exp. nos.

Soil Horizon	Stand Condition			Total
	Open-Brush	Sapling-Pole	Timber	
Duff	1	7	16	24
Mineral	1	4	2	7
Total	2	11	18	31

Low exp. nos.

Viable Seeds

	Open-Brush			Sapling-Pole			Mature Timber		
	East	West	Total	East	West	Total	East	West	Total
North	23	--	23	27	46	73	15	27	42
South	--	--	--	5	9	14	22	12	34
Total	23	--	23	32	55	87	37	39	76

Low exp. nos.　　　Indep. X^2 = .008, Prob. = .92　　　Indep. X^2 = 5.214, Prob. = .02

Soil Horizon	East		West		Total
	North	South	North	South	
Duff	38	24	58	15	135
Mineral	27	3	15	6	51
Total	65	27	73	21	186

Indep. X^2 = 6.712, Prob. = .01　　　Indep. X^2 = .231, Prob. = .63

Soil Horizon	Stand Condition: Open-Brush	Sapling-Pole	Timber	Total
Duff	12	60	63	135
Mineral	11	27	13	51
Total	23	87	76	186

Indep. $X^2 = 9.452$
Prob. = .01

Grass

Fresh Seeds

	Open-Brush			Sapling-Pole			Mature Timber		
	East	West	Total	East	West	Total	East	West	Total
North	--	3	3	--	--	--	--	3	3
South	53	429	482	1	73	74	10	13	23
Total	53	432	485	1	73	74	10	16	26

Low exp. nos. Low exp. nos. Low exp. nos.

Soil	East		West		
Horizon	North	South	North	South	Total
Duff	--	42	5	501	548
Mineral	--	22	1	14	37
Total	--	64	6	515	585

Low exp. nos. Low exp. nos.

	Open-Brush	Sapling-Pole	Timber	Total
	Stand Condition			
Duff	464	69	15	548
Mineral	21	5	11	37
Total	485	74	26	585

Low exp. nos.

Knotweed (*Polygonum spp.*)

Viable Seeds

	Open-Brush			Sapling-Pole			Mature Timber		
	East	West	Total	East	West	Total	East	West	Total
North	3	15	18	1	6	7	—	—	—
South	4	34	38	27	5	32	—	6	6
Total	7	49	56	28	11	39	—	6	6

Low exp. nos. Low exp. nos. Low exp. nos.

Germinated Seeds

	Open-Brush			Sapling-Pole			Mature Timber		
	East	West	Total	East	West	Total	East	West	Total
North	1	3	4	0	3	3	—	—	—
South	—	12	12	3	1	4	—	1	1
Total	1	15	16	3	4	7	—	1	1

Low exp. nos. Low exp. nos. Low exp. nos.

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Regeneration of forest stands in central Idaho is often complicated by the establishment of brush which often originates from seed stored in the forest floor. This study was carried out to learn the distribution, kind, number and viability of seed present in the forest floor.

Forty-eight square-foot samples were taken in the forest floor of the ponderosa pine type of the Boise Basin Experimental Forest of the U. S. Forest Service. The samples were taken in three soil layers, on north and south aspects, in the forest conditions of open-brush, sapling-pole stands and mature timber.

Seeds were separated from the samples and major species identified and exposed to germinative conditions. A chi-square analysis was worked on the results.

The samples produced sixteen major species of seed and a total of 164 seeds per square foot, of which 10 per square foot were viable. Some correlation between species of seed, forest condition, and aspect was found to occur.