

COMPARATIVE GERMINATION OF TREE SPECIES ON VARIOUS KINDS OF SURFACE-SOIL MATERIAL IN THE WESTERN WHITE PINE TYPE^{1, 2}

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In formulating methods for effecting forest regeneration, considerable information is needed as to the germination habits of the species involved. Studies of germination habits have been made for several species in the western white pine type, but heretofore no sufficiently detailed investigation has been made covering the germination habits of all the principal tree species of this type.

To add to the information available on this subject standard greenhouse tests were made with all these species, on surface-soil materials typical for western white pine areas. The physical factors principally considered in controlling the experiment were light, air and soil temperatures, moisture, and relative humidity. The results are presented only as showing the comparative germination of each species tested on the kinds of soil material used.

Use was made of eight sections of forest surface soil, lifted and installed in the greenhouse intact, each of which differed from the others in character of the material forming the upper layer. The surface materials included several kinds of duff.³ Each of the sections closely resembled the others in quantity and character of sandy loam soil present. The loam was sufficiently deep to act as a reservoir for applied water making it available to seeds at the sowing depth. As a check, a section of sand was used.

All the soil sections were obtained near Priest River, Idaho, within an area of one-half mile radius and at an elevation of approximately 2,400 feet. The sources of the eight samples represented five common forest subtypes.

¹ The present paper is an abstract of one portion of a general report (unpublished) made by the writer on the study discussed.

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³ The term "duff," as used in this study, applies to all natural forest-floor materials lying above the mineral soil. Four separate "duff" layers were distinguished: Litter, duff proper, humus, and podsol (leached layer). Of these the first three were present in most of the sections, and the fourth was present in several.

The sections are classified by surface material and character of the stand as follows:

A. Undisturbed

1. Duff: overmature, partially cut, western white pine stand.
2. Duff: overmature, virgin, western white pine stand.
3. Duff: overmature, virgin, mixed stand.
4. Duff: 80-year-old, second-growth, western white pine stand.

B. Disturbed

5. Bared mineral soil: 80-year-old, second-growth, western white pine stand.
6. Ash: 80-year-old, second-growth, western white pine stand.
7. Duff: ⁴ overmature, partially cut, mixed stand.
8. Rotten wood: 80-year-old, second-growth, western white pine stand

The soil sections were placed in cedar flats. All soil sections used were given identical treatment, throughout the experiment.

The seed used in the tests were of the nine species considered to be commercially important in the western white pine type. These are: ⁵

<i>Pinus monticola</i> D. Don	western white pine
<i>Pinus contorta</i> Loudon	lodgepole pine
<i>Pinus ponderosa</i> Lawson	ponderosa pine
<i>Pseudotsuga taxifolia</i> (LaMarck) Britton	Douglas fir
<i>Abies grandis</i> Lindley	lowland white fir
<i>Larix occidentalis</i> Nuttall	western larch
<i>Picea engelmannii</i> Engelmann	Engelmann spruce
<i>Thuja plicata</i> D. Don	western red cedar
<i>Tsuga heterophylla</i> (Rafinesque) Sargent	western hemlock

In each soil section were sown 500 clean, selected seed of the current year's crop of each of the nine species, respectively. Because of the variable characteristics of western white pine seed, and to avoid any influence of the "hold-over" tendencies of seed of this species, 500 2-year-old seed of western white pine, also, were used in each section. Thus the total number of seeds sown was 45,000.

Seed were sown at comparable depths within small compartments in each of the surface-soil sections.

The germination tests were begun January 10, 1933, and were continued for 100 days, ending April 20, 1933. Germination was recorded daily. As the scope of the study did not include survival, all seedlings were plucked when they appeared above the surface.

RESULTS

The most significant of the results are presented in the accompanying tables I, II, and III.

⁴ Disturbance involved in logging had resulted in a thorough mixing of the different duff layers.

⁵ Nomenclature is after Sudworth's Check List of the Forest Trees of the United States.

TABLE I. Germination percentages within 100 days of seed sown, by surface-soil material and species, and viability of seed cut, by species¹

Soil section No.	Surface material, and character of stand	W.H.	E.S.	L.P.P.	W.R.C.	W.L.	D.F.	L.W.F.	P.P.	W.W.P.		Average germination per cent	Total number of seeds germinated
										1-year seed	2-year seed		
1	Duff: partially cut W.W.P.	4.6	12.2	48.6	27.6	8.8	60.0	9.0	63.6	13.8	2.2	25.0	1,252
2	Duff: virgin W.W.P.	23.6	15.4	52.4	63.4	40.8	78.4	9.2	56.7	20.2	1.8	36.2	1,809
3	Duff: virgin mixed	7.0	28.8	84.0	59.6	31.2	49.8	17.2	62.2	18.2	1.6	35.9	1,796
4	Duff: 80-year W.W.P.	10.6	8.2	67.6	62.0	29.4	58.6	17.2	62.0	15.6	4.0	33.5	1,676
5	Bared mineral soil	7.8	18.2	79.8	54.8	11.2	51.8	18.8	67.2	21.6	4.4	33.6	1,678
6	Ash	11.8	9.0	75.2	36.0	30.4	74.8	27.6	71.6	35.8	10.0	38.2	1,911
7	Duff	13.8	21.2	35.2	31.0	13.2	11.8	10.4	56.8	29.0	5.4	22.8	1,139
8	Rotten wood	6.4	55.8	87.0	32.4	36.0	72.4	19.0	60.6	26.6	5.8	40.2	2,010
9	Sand	13.0	17.6	65.4	18.2	22.8	35.6	11.6	61.6	21.0	3.0	26.9	1,349
	Average germination per cent	10.9	20.7	66.1	42.8	24.8	54.8	15.5	62.4	22.4	4.2	32.5	14,620
	Viability per cent	22.0	93.0	96.0	79.0	48.0	87.0	67.0	85.0	97.0	86.0		
	Total number of seeds germinated	493	932	2,976	1,925	1,117	2,466	700	2,811	1,009	191		14,620

¹ Basis of germination tests, 500 seeds in each lot, or 4,500 seeds in all. Basis of viability tests, 200 seeds in each lot, or 2,000 seeds in all. Initials given represent common names of species as follows:

W.H.—western hemlock
 E.S.—Engelmann spruce
 L.P.P.—lodgepole pine
 W.R.C.—western red cedar
 W.L.—western larch
 D.F.—Douglas fir
 L.W.F.—lowland white fir
 P.P.—ponderosa pine
 W.W.P.—western white pine.

As table I shows, results of this study indicated that the germination percentages for the nine species as a group are markedly affected by kind of surface material and character of stand. When the nine species are considered separately, the germination percentages of nearly all of them are found to vary even more pronouncedly with these factors. It was impossible to analyze the influences affecting individual lots of seed, as no experimental replication set-up was provided for in the study.

Table II shows that the three surface materials most favorable to germination, according to results with individual species, are ash, duff under a stand

TABLE II. *Surface-soil materials most and least favorable to germination, germination percentages within 100 days for these materials, and viability percentages, by species*¹

Species	Material most favorable		Material least favorable		Percentage of seeds viable
Western hemlock	Duff: virgin W.W.P.	23.6	Duff: partially cut W.W.P.	4.6	22.0
Engelmann spruce	Rotten wood	55.8	Duff: 80-year W.W.P.	8.2	93.0
Lodgepole pine	Rotten wood	87.0	Disturbed duff	35.2	96.0
Western red cedar	Duff: virgin W.W.P.	63.4	Duff: partially cut W.W.P.	27.6	79.0
Western larch	Duff: virgin W.W.P.	40.8	Duff: partially cut W.W.P.	8.8	48.0
Douglas fir	Ash	74.8	Disturbed duff	11.8	87.0
Lowland white fir	Ash	27.6	Duff: partially cut W.W.P.	9.0	67.0
Ponderosa pine	Ash	71.6	Duff: virgin W.W.P.	56.7	85.0
Western white pine					
1-year-old seed	Ash	35.8	Duff: partially cut W.W.P.	13.8	97.0
2-year-old seed	Ash	10.0	Duff: virgin mixed	1.6	86.0

¹ Basis of germination tests, 500 seeds in each lot. Basis of viability tests, 200 seeds in each lot, as shown by cutting tests.

of virgin western white pine, and rotten wood. Ash has the highest rating in respect to germination of seed of each of the species western white pine (both 1-year- and 2-year-old), Douglas fir, lowland white fir, and ponderosa pine. For seed of western hemlock, western red cedar, western larch, western white pine (1-year-old), and lowland white fir, the least favorable germination medium appears to be duff under partially cut western white pine.

It was found that the most satisfactory method of rating the surface materials as germination media is comparison of germination percentages of individual species. These comparisons are shown in table III. An alternative method, results of which are presented in the table, is comparison of germination percentages of all species as a group; this is less desirable because the results are influenced considerably by wide differences between individual species in total germination.

The ratings based on germination percentages of individual species show a marked tendency to fall into groups according to whether the soil was disturbed or undisturbed. The three highest ratings went to three disturbed surface materials, namely, ash, rotten wood, and bared mineral soil. The next went to the undisturbed surfaces, in this order: Duff under virgin western white pine, duff under virgin mixed stand, and duff under 80-year-old western white pine. The lowest rating went to an undisturbed surface mate-

TABLE III. Ratings of surface-soil materials as germination media, on basis of 100-day germination percentages of individual lots of individual species and of all species as a group, and H-ion concentration of surface-soil materials¹

Soil section No.	Surface material, and character of stand	Ratings based on germination										Rating based on germination percentages of all species as a group	H-ion concentration, in pH units		
		W.H.	E.S.	L.P.P.	W.R.C.	W.L.	D.F.	L.W.F.	P.P.	W.W.P.				Sum of individual	Final
										1-year seed	2-year seed				
1	Duff, partially cut W.W.P.	9	7	8	8	9	4	9	3	9	7	73	6.08		
2	Duff, virgin W.W.P.	1	6	7	1	1	2	8	9	6	8	49	5.96		
3	Duff, virgin mixed	7	2	2	3	3	7	4	4	7	9	49	6.20		
4	Duff, 80-year W.W.P.	5	9	5	2	5	5	5	5	8	5	53	6.93		
5	Bared mineral soil	6	4	3	4	8	6	3	2	4	4	44	7.20		
6	Ash	4	4	4	5	4	1	1	1	1	1	30	7.50		
7	Duff	2	3	9	7	7	9	7	8	2	3	57	7.66		
8	Rotten wood	8	1	1	6	2	3	2	7	3	2	35	4.92		
9	Sand	3	5	6	9	6	8	6	6	5	6	60	7.00		

¹ Best rating is 1, poorest is 9. To compute final ratings on basis of germination percentages for individual lots, ratings for each material were totalled and totals arranged in order from least to greatest. Initials given represent common names of species as in table I.

rial, duff under partially cut western white pine. Disturbed duff is separated from the other disturbed surface materials. Sand, the check material, rated next to the lowest.

No direct correlation was found between H-ion concentration of surface material and either total germination percentage or individual species germination percentages.

The results give no indication as to what seedling survival might be expected under the conditions represented in the study. In determining the composition of timber stands, factors affecting germination are less important than factors influencing survival.