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SEEDING HABITS OF UPPER-SLOPE TREE SPECIES

I. A 12-YEAR RECORD OF CONE PRODUCTION

by

Jerry F. Franklin, *Chief Plant Ecologist*

Richard Carkin, *Forester*

and

Jack Booth, *Forestry Technician*

ABSTRACT

A 12-year study of cone production by noble, Pacific silver, grand, white, subalpine, and Shasta red firs, mountain hemlock, western white pine, and Engelmann spruce shows that upper-slope species produce medium to heavy crops at 2- to 3-year intervals at most locations. The 1968 cone crop was the heaviest observed to date.

Keywords: Cone counting, Coniferae.

Production of seed is first in the sequence of events leading to establishment of natural regeneration.[1] Coniferous species are typically highly periodic in their production of cones and seed, with varying numbers of years between the heavy or very heavy crops which are most important in natural regeneration. Knowledge of patterns of cone production in order to predict the larger cone crops is, therefore, important in managing coniferous forests for natural regeneration.

Cone production by several upper-slope species important in the true fir-hemlock forests of the Pacific Northwest is the subject of this report. This study began in 1961; results from the first 7 years are reported in Franklin.[2] This note is intended as a brief progress report on cone production over the 12 years of observations now available. The additional years of data also allow us to make some comments on whether the tentative conclusions of 5 years ago are being sustained.

Data from 52 plots scattered over the Cascade Range, Olympic Mountains, and Coast Ranges are tabulated and discussed in this report. Most plots now have been observed 11 years. Species observed included noble fir (*Abies procera*), Pacific silver fir (*Abies amabilis*), mountain hemlock (*Tsuga mertensiana*), western white pine (*Pinus monticola*), grand and white firs[3] (*Abies grandis* and *A. concolor*), Shasta red fir (*Abies magnifica* var. *shastensis*),[4] subalpine fir (*Abies lasiocarpa*), and Engelmann spruce (*Picea engelmannii*).

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[1] Arthur L. Roe, Robert R. Alexander, and Milton D. Andrews. Engelmann spruce regeneration practices in the Rocky Mountains. USDA Production Research Report 115, 32 p., illus., 1970.

[2] Jerry F. Franklin. Cone production by upper-slope conifers. USDA Forest Service Research Paper PNW-60, 21 p., illus. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon, 1968.

[3] Grand fir at high elevations in the Oregon Cascade Range is a morphologically variable complex often referred to as white fir. At both Lost Prairie and Bessie Rock where cone plots are located for this species complex elements of both taxons are evident. Due to dominant morphological features, we refer to the plants at Lost Prairie as grand fir and those at Bessie Rock as white fir.

[4] Shasta red fir in southern Oregon is a morphologically variable complex sometimes referred to as noble fir. Populations may constitute hybrid swarms resulting from mingling of noble and California red firs (*Abies magnifica*), in which case none of the present taxonomic designations is correct. However, because of ecological differences between the southern Oregon true fir and the noble fir found in Washington and northern Oregon, and until the identity of the former has been satisfactorily established by taxonomic study, the southern Oregon true fir will be referred to as Shasta red fir.

STUDY AREAS AND METHODS

The location of most of the 52 plots and characteristics of the study trees are tabulated in Franklin (see footnote 2); the general locations are shown in figure 1. With the exception of the Sand Mountain subalpine fir plot, all plots are located in mature to over-mature stands of the subject species. Plots added are as follows:

Species	Locale	Ranger District and Forest	Elevation	Number of trees
			(Feet)	
Noble fir	Blue Lake	Wind River, Gifford Pinchot	3,800	18
Engelmann spruce	Lost Prairie	Sweet Home, Willamette	3,325	13
Pacific silver fir	Wildcat Mountain	McKenzie, Willamette	5,000	13
Mountain hemlock	Wildcat Mountain	McKenzie, Willamette	5,000	12
White fir	Bessie Rock	Prospect, Rogue River	4,900	22

Data consist of annual cone counts on dominant and codominant trees of the subject species repeated from the same counting point using high-powered binoculars or a spotting scope. Most of the study plots are along clearcut boundaries or roads where good views of the crowns are available; since annual variations in cone production are the main purpose of the study, edge effects are considered unimportant. For further details on the field methods see Franklin (1968) (footnote 2).

Annual cone production is presented as the median cone count on the plot. This is the middle observation when cone counts are arranged in order of magnitude. We have used medians because they appear more representative of cone production by the "typical" study tree than the average or mean count; one or two trees with large crops in a generally poor year can produce relatively large average plot values even if most trees had few or no cones. The reader interested in means and ranges of cone counts on plots can find them tabulated through 1967 in Franklin (1968) (footnote 2). If a reader wishes to convert the actual counts to total production by a tree, we suggest he use the following admittedly arbitrary multiplication factors:

Noble and Shasta red firs and western white pine	1.5
Pacific silver, grand, and subalpine firs	1.7
Mountain hemlock and Engelmann spruce	2.0

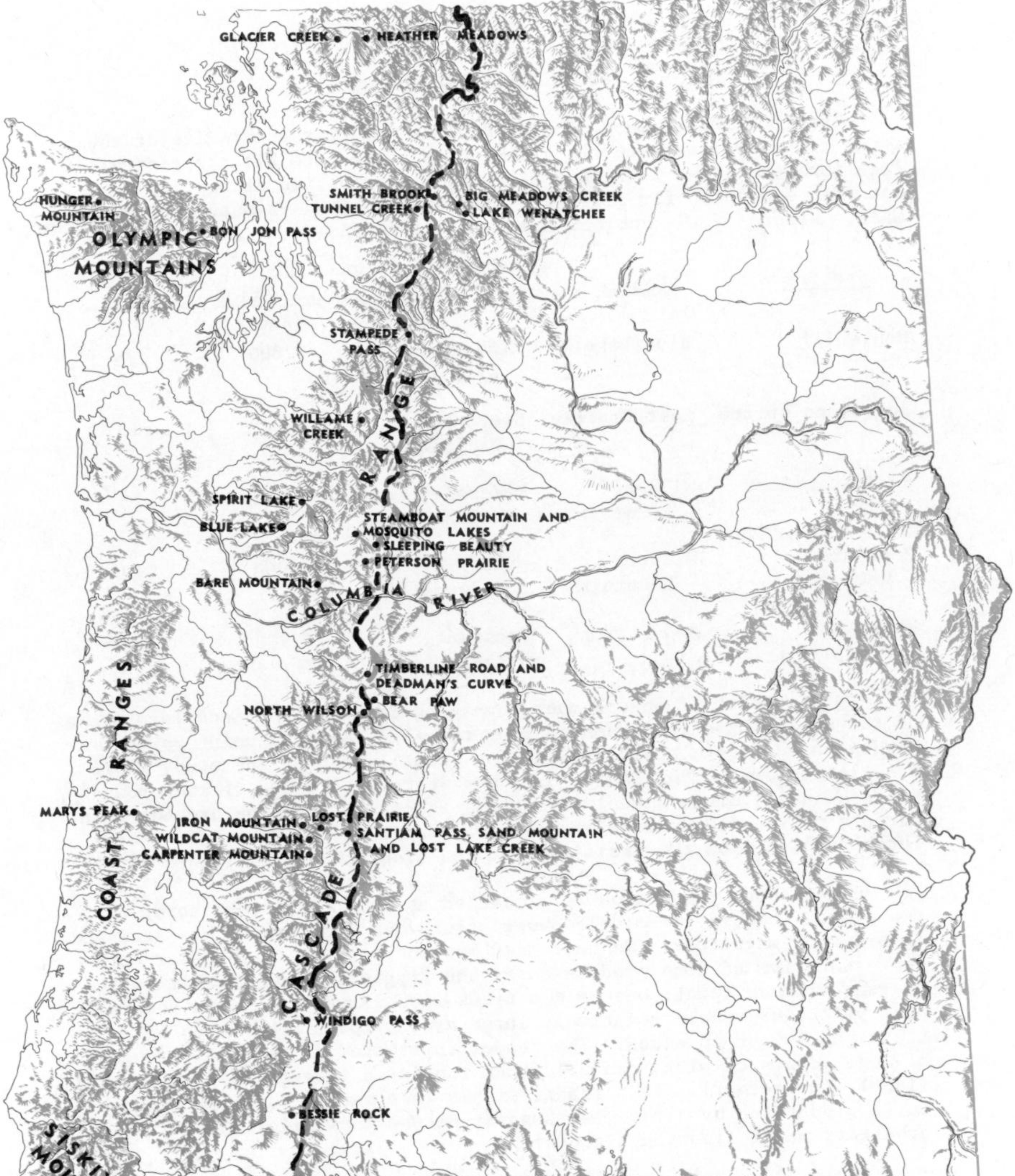

Figure 1.--*Geographic distribution of cone production study plots.*

We have used these factors only in calculating estimated maximum cone and seed yields, not in preparing tables 1 to 6.

For convenience in discussing cone data, we use general categories for cone production--failures, medium crops, very heavy crops, etc. A cone crop rating system based on the median cone count was developed to put the terms used on a quantitative basis (table 1). Considerations of number of seeds per cone and the range in cone production commonly encountered resulted in differences between species in rating definitions. The reader should note the system is based on median cone counts of a sample of dominant trees. It can be applied as well to individual trees.

Table 1.--*Cone crop rating system based on median count of a sample of dominant trees, cone counts to be made from a single observation point per tree*

Species	Crop rating	Number of cones per tree[1]
Noble, Pacific silver, and Shasta red firs and western white pine	Failure	0
	Very light	1-4
	Light	5-9
	Medium	10-19
	Heavy	20-49
	Very heavy	50+
Grand and subalpine firs	Failure	0
	Very light	1-9
	Light	10-19
	Medium	20-49
	Heavy	50-99
	Very heavy	100+
Engelmann spruce and mountain hemlock	Failure	0-10
	Very light	11-49
	Light	50-99
	Medium	100-199
	Heavy	200-299
	Very heavy	300+

[1] Median count falls within range shown.

RESULTS

Cone production data from 1961 through 1972 are presented in tables 2 through 6. In discussing these observations, we contrast the productivity over the last 5 years with the earlier data.

One outstanding feature is the consistency in cone production between almost all species and locations since 1968 (tables 2 through 6). Heavy to very heavy crops were produced in 1968 and 1971 with failures or very light crops in 1969 and 1972; at most plots, the 1968 cone crop was the heaviest recorded. Cone crops in 1970 were more variable, but very light to light crops were most common.

CONE PRODUCTION BY SPECIES

Noble fir follows the general pattern of cone production quite closely (table 2). Over an 11-year period, it has now shown itself as a fairly prolific cone producer typically yielding good crops at 3-year intervals within its main range. Trees at the eastern margin of the species' range (Stampede Pass, Sleeping Beauty, and North Wilson plots)

Table 2.--*Median*[1/] *number of cones counted on noble fir trees by location and year*

Location	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Tunnel Creek	18	280	0	8	1	24	0	441	0	4	164	0
Stampede Pass	22	12	0	2	0	0	5	55	0	9	18	0
Willame Creek	--	50	26	2	184	40	2	253	0	34	40	0
Sleeping Beauty	--	18	0	0	0	16	0	78	0	3	18	2
Spirit Lake	--	--	4	--	76	6	0	84	0	2	24	0
Blue Lake	--	--	--	--	--	--	2	149	0	1	35	3
North Wilson	--	1	0	0	0	0	12	40	0	1	35	3
Wildcat Mountain	--	82	9	3	172	0	10	151	0	0	92	0
Marys Peak	--	67	1	1	112	4	4	163	0	12	72	0
Average	20	73	5	2	68	11	4	157	0	7	55	1

NOTE: -- means no measurements were taken.

[1/] The median number is the middle observation when cone counts are arranged in order of magnitude.

show somewhat more sporadic patterns of cone production during the first half of the study but have followed the same pattern as the other plots since 1968; there is some indication of lower absolute numbers of cones being produced on these marginal plots. Noble fir at Willame Creek continues to be the most consistently productive plot; we have observed heavy to very heavy cone crops in 7 out of 11 years. Very heavy crops in 1962, 1968, and 1971 have produced the highest total cone count (940) at Tunnel Creek, however; it is interesting that this plot is at the northern limit of the noble fir range.

Pacific silver fir also followed the general pattern of good to excellent cone crops in 1968 and 1971 and few cones in intervening years with only one notable exception (Hunger Mountain, table 3). The

Table 3.--*Median*[1/] *number of cones counted on Pacific silver fir trees by location and year*

Location	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Glacier Creek #1	17	10	0	0	2	0	0	66	0	8	27	0
Glacier Creek #2	--	--	0	0	22	0	0	125	0	21	39	0
Tunnel Creek	--	--	0	0	18	0	0	61	0	0	14	0
Stampede Pass	--	3	0	0	0	0	0	9	0	0	37	0
Mosquito Lakes	--	14	0	0	0	1	0	68	0	0	28	0
Spirit Lake	--	--	0	0	92	0	0	128	0	0	67	0
Bare Mountain	--	18	0	0	2	0	0	87	0	0	23	0
Timberline Road	--	44	0	0	64	0	2	156	0	0	94	0
Santiam Pass	--	12	0	0	1	0	0	62	0	0	34	0
Iron Mountain	--	65	0	0	115	0	1	129	0	0	124	0
Wildcat Mountain	--	--	--	--	--	--	0	42	0	0	26	0
Hunger Mountain	--	8	11	0	40	0	0	207	0	81	0	11
Bon Jon Pass	--	15	0	0	0	0	0	54	0	4	18	0
Average	17	21	1	0	30	0	0	92	0	8	41	1

NOTE: -- means no measurements were taken.

1/ The median number is the middle observation when cone counts are arranged in order of magnitude.

entire 12-year record strongly suggests a general 3-year periodicity in production of cone crops at a given locale. The absolute numbers of cones produced are largest in 1968 but still well below the numbers recorded for noble fir.

Most mountain hemlock plots had very heavy cone crops in 1968 and medium to heavy crops in 1971 (table 4). In 1969, 1970, and 1972, cone crops were essentially failures on all plots except at Heather Meadows near Mount Baker; this plot had a medium crop in 1970 and followed it with a very heavy crop in 1971. In general, the 11-year record shows good crops at 3-year intervals, but some erratic behavior in the Washington plots in 1965 and 1966 suggests localized climatic effects.

Table 4.--*Median*[1/] *number of cones on mountain hemlock trees by location and year*

Location	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Heather Meadows	300	0	5	37	120	0	429	2	175	300	0
Stampede Pass	255	0	0	30	95	0	288	0	14	80	0
Steamboat Mountain	192	0	0	198	96	0	300	2	0	225	12
Deadman's Curve	265	0	0	265	6	0	1,200	0	0	150	1
Santiam Pass	600	0	0	26	8	0	750	0	0	188	0
Wildcat Mountain	--	--	--	--	--	0	410	0	0	125	0
Carpenter Mountain	380	0	3	420	1	0	620	0	0	150	0
Windigo Pass	300	0	25	130	0	0	650	0	0	125	0
Average	327	0	5	158	47	0	581	0	24	168	2

NOTE: -- means no measurements were taken.

1/ The median number is the middle observation when cone counts are arranged in order of magnitude.

Western white pine continued to be the most consistent cone producer of the species studied (table 5). However, more cone crop failures were recorded on plots in 1969 and 1972 than had been previously noted in a single year. Interestingly, the very heavy crops of 1968 and 1971 were synchronous with those of the other species; prior to 1968, good crop years for western white pine typically were not synchronized with those for other species.

Engelmann spruce and grand and white firs, which had previously shown considerable variation in peak years of cone production between plots and in relation to other species, also followed the general

Table 5.--*Median*[1] *number of cones counted on western white pine trees by location and year*

Location	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Lake Wenatchee	0	0	--	--	--	--	--	--	--	--	--
Big Meadows Creek	--	0	114	1	0	0	42	0	--	--	--
Smithbrook	--	--	16	10	10	0	22	0	39	22	26
Peterson Prairie	50	2	113	14	17	87	88	0	51	63	0
Bear Paw	34	3	77	14	2	13	40	--	--	--	--
Santiam Pass	41	12	54	11	2	70	58	0	0	58	0
Lost Prairie	--	0	8	35	0	21	189	4	8	37	0
Windigo Pass	62	1	38	39	2	4	109	0	0	57	0
Bessie Rock	--	--	--	--	59	9	144	0	27	70	4
Average	37	3	60	18	12	26	86	1	21	51	5

NOTE: -- means no measurements were taken.

[1] The median number is the middle observation when cone counts are arranged in order of magnitude.

pattern of heavy crops in 1968 and 1971 and poor crops during 1969, 1970, and 1972 (table 6). Results now suggest good crops at intervals of 2 to 3 years for these species. Subalpine fir had a very heavy crop in 1968 and, at three of four plots, medium to very heavy crops in 1971 (table 6). An average interval of 2 to 3 years is also indicated for this species by the 11-year record of cone production. Finally, the limited data for Shasta red fir show a consistency with cone production in noble fir for at least the last 5 years, i.e., good crops in 1968 and 1971.

Table 6.--*Median*[1/] *number of cones counted on subalpine fir, grand and white firs, Shasta red fir, and Engelmann spruce by location and year*

Location and species	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Subalpine fir:											
Smithbrook	--	--	45	10	0	0	182	0	0	97	0
Big Meadows Creek	--	0	126	0	63	0	118	0	22	4	0
Steamboat Mountain	53	0	3	31	3	1	84	0	0	26	0
Sand Mountain	15	0	1	44	0	0	153	0	0	78	0
Average	34	0	44	42	33	0	134	0	6	51	0
Grand and white firs:											
Big Meadows Creek	--	0	342	0	252	0	227	0	28	140	0
Peterson Prairie	--	1	148	1	302	0	184	0	8	160	0
Lost Prairie	--	0	50	36	16	11	151	0	7	136	0
Bessie Rock	--	--	--	--	--	13	326	0	0	232	0
Average	--	0	180	12	190	6	222	0	11	167	0
Shasta red fir:											
Windigo Pass	7	0	7	22	0	1	76	0	0	36	0
Bessie Rock	--	--	--	--	0	6	91	0	0	132	0
Average	7	0	7	22	0	4	84	0	0	84	0
Engelmann spruce:											
Big Meadows Creek	--	0	290	145	120	0	625	0	50	112	0
Lost Creek	--	170	0	570	12	160	1,600	0	0	600	0
Lost Prairie	--	--	--	--	--	1	750	0	10	225	0
Average	--	85	145	358	66	80	992	0	20	312	0

NOTE: -- means no measurements were taken.

[1/] The median number is the middle observation when cone counts are arranged in order of magnitude.

RECORD CROPS OF INDIVIDUAL TREES

Because of the very heavy cone crop in 1968, almost all of the earlier records of production by individual trees were shattered; only the subalpine fir record (510 cones counted) stood.

Species	Plot	Cones counted	Conversion factor	Estimated total cones	Total seeds per cone[5/]	Estimated total seeds
Noble fir	Tunnel creek	2,000	1.5	3,000	500	1,500,000
Pacific silver fir	Hunger Mountain	609	1.7	1,035	400	414,000
Mountain hemlock	Deadman's Curve	2,500	2.0	5,000	100	500,000
Western white pine	Bessie Rock	426	1.5	639	120	77,000
Grand and white fir	Bessie Rock	1,000	1.7	1,700	250	425,000
Shasta red fir	Bessie Rock	412	1.5	618	450	278,000
Engelmann spruce	Lost Lake Creek	5,000	2.0	10,000	100	1,000,000

These are, of course, only estimated values, but the quantities of seed a single tree can produce are obviously prodigious. The production of the noble fir tree approximates 100 pounds of cleaned seed and that of the Shasta red fir and Pacific silver firs 32 and 35 pounds, respectively.

CONE PRODUCTION IN MIXED SPECIES STANDS

Franklin (see footnote 2) examined cone production by different species occurring in the same locale and concluded that some seed can be expected from at least one species almost every year, i.e., all species rarely fail simultaneously. The data from 1968 to 1972 show a much greater synchrony in cone crops than from 1962 to 1967, however (table 7). In the areas shown in table 7, all species failed in 1969 and 1972, and the three Oregon locales show consistent failure of all species in 1970. This is clearly a consequence of western white pine, grand and white firs, and Engelmann spruce following the same patterns as the other species from 1968 to 1972, whereas they show considerable independence from 1962 to 1967. Our 11-year record suggests that very heavy and failure cone years for different species are as likely to be in phase as complimentary in a given locale.

[5/] Based on cone scale counts; data on file at U.S. Forest Service, Forestry Sciences Laboratory, Corvallis, Oregon.

Table 7.--*Yearly comparison of cone crop ratings*[1] *between species as observed in the same general locality*

Location and species	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Big Meadows Creek:											
Western white pine	0	0	5	0	0	0	4	0	--	--	--
Subalpine fir	--	0	5	2	0	0	5	0	3	1	0
Engelmann spruce	--	0	5	3	3	0	5	0	2	3	0
Grand fir	--	0	5	0	5	0	5	0	3	5	0
Mount Adams:											
Noble fir	3	0	0	0	3	3	5	0	1	3	1
Pacific silver fir	3	0	0	0	0	0	5	0	0	4	0
Subalpine fir	4	0	1	3	1	1	4	0	0	3	0
Grand fir	--	1	5	1	5	0	5	0	1	5	0
Mountain hemlock	3	0	0	3	2	0	5	0	0	4	1
Western white pine	5	1	5	3	3	5	5	0	5	5	0
Douglas-fir[2]	--	--	--	--	--	2	5	0	0	3	0
Western hemlock[2]	--	--	--	--	--	1	5	1	2	4	0
Santiam Pass:											
Pacific silver fir	3	0	0	1	0	0	5	0	0	4	0
Mountain hemlock	5	0	0	1	0	0	5	0	0	3	0
Western white pine	4	3	5	3	1	5	5	0	0	5	0
Subalpine fir	2	0	0	3	0	0	5	0	0	4	0
Engelmann spruce	--	4	0	5	1	3	5	0	0	5	0
Willamette Province:											
Pacific silver fir	5	0	0	5	0	1	5	0	0	5	0
Noble fir	5	3	1	5	0	3	5	0	0	5	0
Grand fir	0	0	4	3	2	2	5	0	1	5	0
Mountain hemlock	5	0	0	5	0	0	5	0	0	3	0
Western white pine	--	2	2	4	0	4	5	1	2	4	0
Engelmann spruce	--	--	--	--	--	--	5	0	0	5	0
Southern Oregon Cascades:											
Shasta red fir	2	0	2	4	0	0	5	0	0	5	0
White fir	--	--	--	--	--	2	5	0	0	5	0
Western white pine	5	0	4	4	1	2	5	0	0	5	0
Mountain hemlock	5	0	0	3	0	0	5	0	0	3	0

NOTE: -- means no measurements were taken.

[1] Crop ratings are 0 = failure, 1 = very light, 2 = light, 3 = medium, 4 = heavy, and 5 = very heavy.

[2] Estimated from collections of material in seedtraps.

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