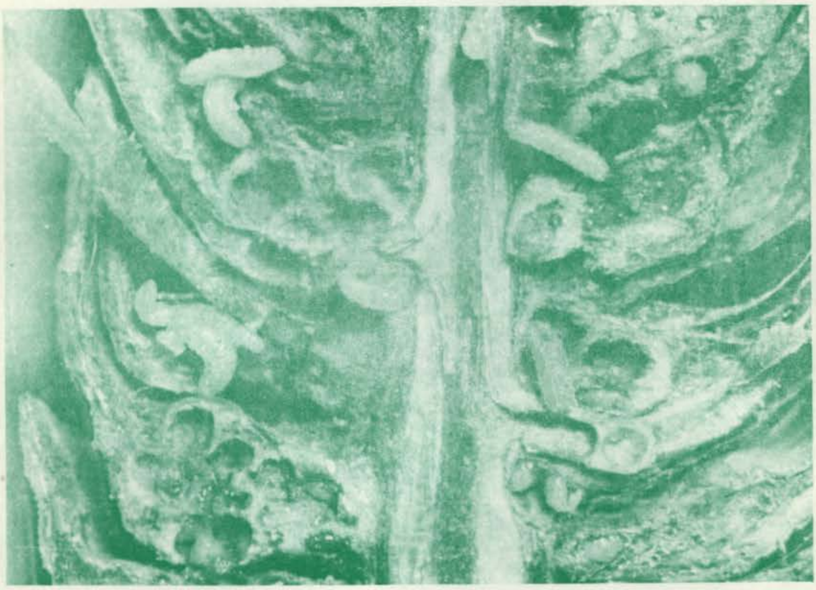
UNIVERSITY OF IDAHO

COLLEGE OF FORESTRY, WILDLIFE AND RANGE SCIENCES

SAMPLING CONE PRODUCTION IN DOUGLAS-FIR STANDS FOR INSECT POPULATION STUDIES[1]



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Sampling Cone Production in Douglas-fir Stands for Insect Population Studies[1]

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ABSTRACT

The results of a study in 1966 to ascertain the accuracy of branch-sample counts for estimating total cone (seed) production in a closed, natural stand of Rocky Mountain Douglas-fir are reported. Binocular counts of the cones were made on 2 opposite branches, each bearing a maximum number cones. Ocular counts of the number of cone-bearing branches per tree also were made. Regression analyses were run using single branch counts, 2-branch totals, and combinations of these with the product of average number of cones per branch and number of cone-bearing branches as independent variables. Actual counts were obtained by climbing each tree and recording the number of cones by branch. Polynomial regressions to degree 3 and log transformations also were tested. An acceptable estimate of total cone crop was obtained from a simple linear regression using as the independent variable the product of the observed number of cone-bearing branches and the average of a two-branch count. Average cone-bearing Douglas-fir per acre, seed per cone, seed per acre, and insect-destroyed seed acre also are reported.

Additional key words: **Pseudotsuga menziesii** var. **glauca** (Beissn.) Franco, cone and seed insects, seed losses.

Intensive management of second-growth forest stands and expanding reforestation programs require accurate data on the insect populations responsible for cone and seed losses. Past research has provided various survey techniques for gathering data on damage, but relatively little work has been done to ascertain the inter-relationships between fluctuations in cone crop and insect populations. This knowledge would permit location of seed sources and timing of collection, such that a maximum supply of undamaged seed could be obtained at minimum cost without recourse to insecticides. In stands approaching economic matur-

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ity, regeneration cuts may be timed to obtain maximum reproduction of desirable species. The prime requisite for the acquisition of this knowledge is a rapid and reasonable method of estimating cone production.

Allen (1941) showed that fall counts of female cone buds of coastal Douglas-fir (**Pseudotsuga menziesii** var. **menziesii** (Mirb.) Franco provided an estimate of the subsequent cone crop. He also suggested that the ratio of cone buds to vegetative buds would provide a basis for estimating the cone crop in broad classes. Johnson (1962) reported that fall counts of cone buds of coastal Douglas-fir provided a reliable sample of the subsequent cone crop. In British Columbia, Garman (1951) made cone counts on one side of coastal Douglas-fir crowns using tripod-mounted binoculars during several seasons, and compared those with total counts from trees felled periodically. He concluded that doubling a sample count from a young tree provided a reliable estimate of cone crop of that tree. In mature trees, however, the correction factor varied with total count. Wenger (1953) recommended that in estimating the number of cones on loblolly pine (**Pinus taeda** L.), all cones visible through binoculars should be counted with the observer facing back to sun. That count should then be doubled and multiplied by a factor obtained from comparing the total pick to the count on the first 15 to 25 trees. He reported considerable variations in counts among three observers. Hoekstra (1960) used Wenger's method in slash pine (**Pinus elliottii** var. **elliottii** Engelm.) and noted increased accuracy with tripod-mounted binoculars, and little variation between observer's counts. Fowells and Schubert (1956) counted cones in crowns of various conifers in northern California with binoculars. The count per tree was multiplied by 1.5 to obtain the total number of cones per tree. The factor was based on the assumption that two-thirds of the crown could be seen from one point. To obtain the most rapid and accurate estimate of cone crop on open-growing coastal Douglas-fir with at least 100 cones per tree, Winjum and Johnson (1962) recommended that observers stand on the south side of the tree at a point affording a clear view, and count all cones on 1 branch of each whorl. The sum of branch counts was inserted in the equation:

$$\hat{Y} = -253 + 7.76X \qquad (Sy.x = 311;\ r = .97)$$

where X = sum of branch counts. They also tested other methods, including variations in the number and position of the branches on which cones were counted, and photographic techniques. Hedlin (1964) made weekly cone counts in 4 plots of coastal Douglas-fir on Vancouver Island, British Columbia to obtain data on cone production, insect caused damage, and cone-insect populations. He made complete cone counts when cone production was light. However, only cones on 1 branch in each whorl on 2 sides of the tree were counted when the cone crop was heavy. In the latter case, the number was halved and multiplied by the average number of branches per whorl.

The results of a study conducted in late June, 1966, to ascertain the accuracy of branch sample counts in a natural closed stand of Rocky Mountain Douglas-fir (**Pseudotsuga menziesii** var. **glauca** (Beissn.) Franco) are reported here.

Methods and Materials

Description of Test Stands

A rectangular (strip) plot of 0.3 acre was established in each of 3 stands containing Douglas-fir and associated species. Two plots ("Priest River" and "Ridge Road") were located in the U.S. Forest Service Priest River Experimental Forest, Bonner County, Idaho; the third ("Horse Heaven"), in the Deception Creek Experimental Forest, Kootenai County, Idaho.

The Priest River plot ("Area 1") was established approximately 1/4 mile west of Forest Headquarters in a **Thuja plicata** Donn–**Tsuga heterophylla** (Raf.) Sarg./ **Pachistima myrsinites** (Pursh.) Raf. association at an elevation of 2300 feet with negligible slope. The Ridge Road plot ("Area 2") was located 2.7 miles east of Headquarters on South Ridge Road in a **Pseudotsuga menziessii/Physocarpus malvaceous** (Green) Kuntze association at an elevation of 3100 feet on a very steep south-facing slope. The Horse Heaven plot ("Area 3") was situated northwest of Horse Heaven landing field in the NW1/4 Section 21, R1W, T52N in an **Abies grandis** (Dougl.) Lindl./**Pachistima** association at an elevation of 2300 feet on a north-facing ridge top. Tree species composition, density and proportion of cone bearing Douglar-fir are summarized in Table 1.

Table 1. Tree Species Composition, Density, and Proportion of Cone-bearing Douglas-fir in Test Stands in Northern Idaho, 1966.

Plot	Number stems by species per plot[a]										%	Number	Number	Total	Total
	WL	WWP	GF	WRC	ES	PP	LPP	N-C-B DF	C-B DF	Total DF	C-B DF	C-B/DF per acre	DF/ acre	stems/ plot	stems/ acre
Priest River	75	14	2	16	6	–	–	39	14	53	26.4	46.7	177	166	553
Ridge Road	–	–	–	–	–	4	–	22	28	50	56.0	93.3	167	54	180
Horse-Heaven	–	4	2	–	–	–	1	41	38	79	48.1	126.7	263	86	284

a) WL (western larch)
WWP (western white pine)
GF (grand fir)
WRC (western redcedar)
ES (Englemann spruce)
PP (ponderosa pine)
LPP (lodgepole pine)
N-C-B/DF (non-cone-bearing Douglas-fir)
C-B/DF (cone-bearing Douglas-fir)

Sampling Procedure

Each cone-bearing Douglas-fir was flagged with fluorescent tape during the plot cruise to facilitate re-location for cone sampling. Each of these trees was observed through 7 x 50 binoculars from a point affording the clearest view of the crown. All cones were counted on a silhouetted (side) branch bearing the maximum number of cones in the belief that those branches could be most easily detected in a closed stand. The procedure was repeated to select a second branch on the side of crown opposite the first branch. All sample counts were made by the same person to eliminate the small error beween observers. (Occasional checks showed that differences between counts obtained by 3 different observers seldom exceeded 2-3 cones/branch). The true number of cones per tree was obtained by climbing each tree and recording, by cone-bearing branch, the actual number of cones produced. Removal of the flagging immediately after completion of the total count eliminated the possibility of sampling any tree twice. Counts in the 3 plots were completed within a period of 1 week in mid-June, 1966.

A sample of 104 cones was collected from a total of 8 trees only from the Priest River and Ridge Road plots (13 cones from each of 2 trees, and from each of 6 trees from each plot, respectively. The cone crop was very light, and cone development less advanced, in the Priest River plot). The cones were dissected scale by scale to obtain an estimate of the average number of seeds per cone, and average percent sound and insect-damaged seed.

Table 2. Means and Standard Deviations of all Variables. Northern Idaho, 1966.

Variable[a)]	Mean	Standard Deviation
X_1	8.5	5.21
X_2	6.0	3.75
X_3	14.6	8.75
X_4	29.5	16.7
X_5	166.9	173.2
Y	160.8	165.2

a) X_1 = Estimated cones from branch 1
X_2 = Estimated cones from branch 2
X_3 = Estimated cones from the sum of branches 1 and 2
X_4 = Adjusted estimated number of cone-bearing branches
X_5 = Unadjusted estimated cones per tree
Y = Total cone production

Results

Regression Analysis

There were no significant variations due to differences in either vegetation association or elevation, therefore, data from the 3 plots were grouped.

The futility of using the estimated number of cones from either branch or both branches to predict total cone production is shown in Tables 2 and 3. The standard deviation of total cone production is 165.2. The standard errors of estimate when total production is regressed on either estimated cones from branch 1, branch 2 or the sum of both branches are 108.2, 102.2, and 102.0. However, at best only 62.4% of the variation in cone production is accounted for by the sum of both branches. Expressing the independent and dependent variables in logarithms did little to improve the fit. Similarly fitting a third degree polynomial failed to increase precision.

Comparison of the observed numbers of cone-bearing branches per tree with the actual numbers showed that, on the average, 61 percent (44-100%) of the true number were visible from the single vantage point on the ground. This compares favorably with the ratio (67%) reported by Fowells and Shubert (1956). Consequently, the observed number of cone-bearing branches was multiplied by the factor 1.6 to obtain "adjusted" estimates of the number of cone-bearing branches per tree (X_4). These "adjusted" estimates were then used to comprise an independent variable which was used in combination with either the ocular counts of cones per branch 1 (X_1), branch 2 (X_2), or the sum of the 2 branches (X_3) to predict total number of cones per tree (Table 3).

Table 3. Equations for predicting total cone production (Y) of Douglas-fir trees from branch samples, branch samples plus number of branches, and the product of average branch samples times number of branches. Northern Idaho, 1966.

Independent Variables[a]	Intercept	Regression Coefficients X_i	X_4	Standard Error of Estimate	Coefficient of Determination
X_1	— 44.5	24.1	—	108.2	.577
X_2	— 49.2	34.8	—	102.2	.622
X_3	— 56.4	14.9	—	102.0	.624
X_1+X_4	—110.6	10.34	6.53	75.7	.796
X_2+X_4	—106.6	10.33	6.61	78.7	.779
X_3+X_4	—109.7	13.32	6.00	74.9	.800
X_5	15.7	.8696	—	68.4	.831

a) X_1 = Estimated cones from branch 1
X_2 = Estimated cones from branch 2
X_3 = Estimated cones from the sum of branches 1 and 2
X_4 = Adjusted estimate of number of cone-bearing branches
X_5 = Unadjusted estimated cones per tree

Multiple regression analyses utilizing number of cone-bearing branches along with either of the 3 aforementioned independent variables improved the fit considerably as shown in Table 3.

The standard error of estimate was reduced to 74.9 when the sum of both branches (X_3) and the "adjusted" number of cone-bearing branches (X_4) were used as predictors with a coefficient of determination of 80 percent. The estimating equation was:

$$Y = -109.7 + 13.32\ X_3 + 6.00\ X_4$$

Even more precision was attained by a new predictive variable which was the product of average number of cones per branch times the observed ("unadjusted") number of cone-bearing branches (X_5). The standard error of estimate was 68.4 and 83.1 percent of the variation was accounted for by:

$$\hat{Y} = 15.7 + .8696\ X_5$$

Seed Production and Loss

An F-test was conducted to determine homogeneity of variances in the 2 plots from which seed counts were made. There was no difference at the 1% level, and the null hypothesis of variance equality was accepted for both total and damaged seeds per cone.

In 1966, the cone-bearing Douglas-fir on the 2 plots in the Priest River Experimental Forest produced an average of 42.15 seeds per cone (Range 22 to 64; $s_{\bar{x}} = 0.89$; $CL_{.05} = 40.38$ to 43.92; $s^2 = 83.24$).

With an average of 70 cone-bearing Douglas-fir per acre (combined Priest River and Ridge Road plots, Table 1), and each tree bearing an average of 161 cones (actual count) 475,031 seeds per acre were produced, 15.72% of which were already destroyed by innsects early in the growing season. The proportion of damaged seeds would have been considerably greater if samples had been taken later in the summer or in the fall.

Covariance analysis showed little or no association ($r_{xy} = +0.076$) between the number of damaged seeds per cone and the total number of available seed per cone.

Literature Cited

1. Allen, G. S. 1941. A basis for forecasting seed crops of some coniferous trees. J. Forest. 39:1014-1016.

2. Fowells, H. A. and G. H. Schubert. 1965. Seed crops of forest trees in the pine region of California. U. S. Dept. Agr. Tech. Bull. 1150. 48 p.

3. Garman, E. H. 1951. Seed production by conifers in the coastal region of British Columbia related to dissemination and regeneration. Dept. Lands & Forests. B. C. Forest Serv. Tech. Pub. T35, 47 p.

4. Hedlin, A. F. 1964. A six-year plot study on Douglas-fir cone insect population fluctuations. Forest Science. 10:124-128.

5. Hoekstra, P. E. 1960. Counting cones on standing slash pine. U. S. Forest Serv. S. E. Forest Expt. Sta. Res. Note 151. 2 p.

6. Johnson, N. E. 1952. A possible sampling method for determining when to spray for control of the Douglas-fir cone midge. Weyerhaeuser Co. Forest. Res. Note 49. 10 p.

7. Wenger, K. F. 1953. How to estimate the number of cones in standing loblolly pine trees. U. S. Forest Serv. S. E. Forest Expt. Sta. Res. Note 44. 2 p.

8. Winjum, J. K. and N. E. Johnson. 1962. Estimating cone crops on young Douglas-fir. Weyerhaeuser Co. Forest. Res. Note 46. 12 p.