

*Cesium-137 in Litter and Understory Vegetation**

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ESTIMATES OF the amounts of radioactive airborne debris (fallout) deposited over broad climatic regions can be measured by sampling air, precipitation, or surface soil. Although these measurements serve useful purposes, they provide little information on the amount of fallout deposited directly upon plants and therefore available for transfer to litter-dwelling microorganisms or to herbivorous animals.

This paper reports the radiocesium concentrations in understory plants and leaf litter from three forest stands in 1964.

Stand Location, Sampling, and Analytical Methods

The understory plants and litter of three forest stands, each representative of a widespread plant association in the Cascade Mountains of Washington and each growing under a closed tree canopy, were collected on September 15 just before major leaf fall. The sampling sites were located along State Highway 14, which traverses the Cascade Mountains through White Pass. One stand was located near the pass summit, another 12 miles west of the summit, and one 12 miles east of the summit. Elevations at these sites were approximately 4000, 1500, and 2500 feet respectively. The understory vegetation was comprised of herbs and shrubs reduced in size, vigor, and density as compared with more open stands. Community structure and species composition has probably changed very little since man-made radioactive debris was first introduced into the atmosphere 20 years ago. Differences among levels of radiocesium in vegetation and litter measured in these stands therefore are not attributable to pronounced vegetation changes during this time, i.e., fire or logging.

The conifer stand east of the Cascade Mountains is representative of the *Pinus/Symphoricarpos* association as described by Daubenmire (1952). The only tree species is *Pinus ponderosa*, and the understory is comprised mostly of dwarfed shrubs of Snowberry, *Symphoricarpos albus*, with smaller amounts of *Spiraea lucida*, *Amelanchier alnifolia*, and *Rosa* sp. The sampling site west

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of the mountain summit consisted of a pure stand of Western Hemlock, *Tsuga heterophylla*, with an understory mostly of salal, *Gaultheria shallon* and *Mahonia nervosa*. The forest stand near the summit is comprised of Pacific silver fir, *Abies amabilis*, with an understory dominated by blueberry, *Vaccinium membranaceum*, and lesser amounts of *Ribes* sp. and *Rosa* sp. Some of the more common herbs are *Linnaea borealis*, *Trillium ovatum*, and *Pyrola* sp.

A 4-by-5-m plot was established in the fir and hemlock stands, and all standing understory plants in the plot were clipped near the litter surface. The loose litter was removed from two 1-by-1-m plots located at opposite corners of the larger plot. The same procedure was followed in the pine stand except the large plot was only 2.5 by 5 m in size. The collected litter consisted almost entirely of the leaves of conifers except in the hemlock stand where mosses, growing intermingled with the fallen leaves, were included in the sample.

The vegetation and litter were placed in separate plastic bags and brought to the laboratory and dried, then milled to pass a 1-mm mesh screen. A 500-ml plastic bottle was filled with milled vegetation and analyzed radiochemically for ^{137}Cs using a 9-by-11-inch sodium iodide (TI) crystal connected to a multichannel analyzer. Moisture content of the counted sample was determined by drying aliquots at 95 C, and radiochemical results are expressed as picocuries ^{137}Cs per gram dry weight.

Results and Discussion

The amount of fallout intercepted by plants is determined in part by their surface areas, the length of time that above-ground organs are exposed to the atmosphere, the amount of fallout in the atmosphere, and the precipitational regime. The retention of fallout once intercepted by plants depends upon the nature of the surface, whether smooth or pubescent, and the size of the fallout particles (Romney et al., 1963). Only long-lived radionuclides like ^{137}Cs (half-life 27 yrs) persist long enough to become a part of mineral nutrition in plants and animals.

Emergence and abscission of leaves is determined in part by environmental factors. Blueberry leaves at high elevations emerge late in the spring while snowberry leaves at lower elevations emerge early in the spring. The leaves of salal, in contrast to those of blueberry and snowberry, are evergreen and remain attached to stems for a year or more. The leaves of salal are relatively large, thick, and heavily cutinized as compared with those of blueberry. The leaves of snowberry and its associated shrubs are intermediate in size and thickness to those of blueberry and salal.

The relationships between ^{137}Cs concentration to leaf age and surface area per gram dry weight of the dominant understory shrubs are shown below:

Age of leaves: salal > snowberry > blueberry

Surface area/gram: blueberry or snowberry > salal

^{137}Cs /gram: blueberry > snowberry or salal (Table 1).

The ^{137}Cs concentrations of understory shrubs growing in the three different stands were more or less similar (Table 1). The fallout accumulated by snowberry and blueberry is largely a result of spring and summer deposition. Although the leaves of blueberry and snowberry were aurally exposed for only a relatively short time, these plants had accumulated as much ^{137}Cs as did the persistent leaved salal (Table 1). Salal did not accumulate radio-cesium in proportion to the age of its leaves. Davis, Watson, and Hanson (1963) suggested that frequent rains in a high-precipitation area might wash fallout from leaves, especially from leaves with broad, smooth surfaces like salal.

The leaves of conifers remain attached to tree branches for several years and then persist as litter for several more years after dropping to the ground. In the coniferous forests of the Pacific Northwest, leaf litter may accumulate for 50 years (Spurr, 1964). Conifer litter therefore contains more than one

TABLE 1. CESIUM-137 CONCENTRATIONS IN LITTER AND UNDERSTORY VEGETATION OF THREE FOREST HABITATS IN THE CASCADE MOUNTAINS, WASHINGTON, 1964

	<i>Picocuries per gram</i>	<i>Picocuries per square meter</i>
Pinus/Symphoricarpos h.t.		
Symphoricarpos	6.1	150
Total understory	—	150
Litter (a)	17	20,000
Litter (b)	15	12,000
Tsuga/Gaultheria h.t.		
Gaultheria	6.1	580
Berberis	6.0	86
Total understory	—	670
Litter (a)	37	40,000
Litter (b)	45	31,000
Abies/Vaccinium h.t.		
Vaccinium	9.7	120
All other species	17	170
Total understory	—	290
Litter (a)	73	54,000
Litter (b)	65	54,000

h.t. = habitat type
(a and b are duplicate samples)

year's accumulation of radionuclides. Gorham (1963) reported that pine-leaf litter accumulated fallout, although he did not identify the individual fallout radionuclides.

The relationship of ^{137}Cs concentrations in conifer litter from the three stands in relation to inferred precipitational regimes of the three regions is shown below:

Precipitation: Fir or Hemlock > Pine

^{137}Cs /gram: Fir > Hemlock > Pine (Table 1).

The annual precipitation in the pine stands averaged much less than that of the hemlock stands (Figure 1). Summer precipitation was more similar than was winter precipitation. Apparently increased annual precipitation also can contribute to the fallout concentration in conifer litter in the same way that the strontium-90 content of soil was increased (Hardy and Alexander, 1962). Whether the annual precipitation of the high-altitude fir stand

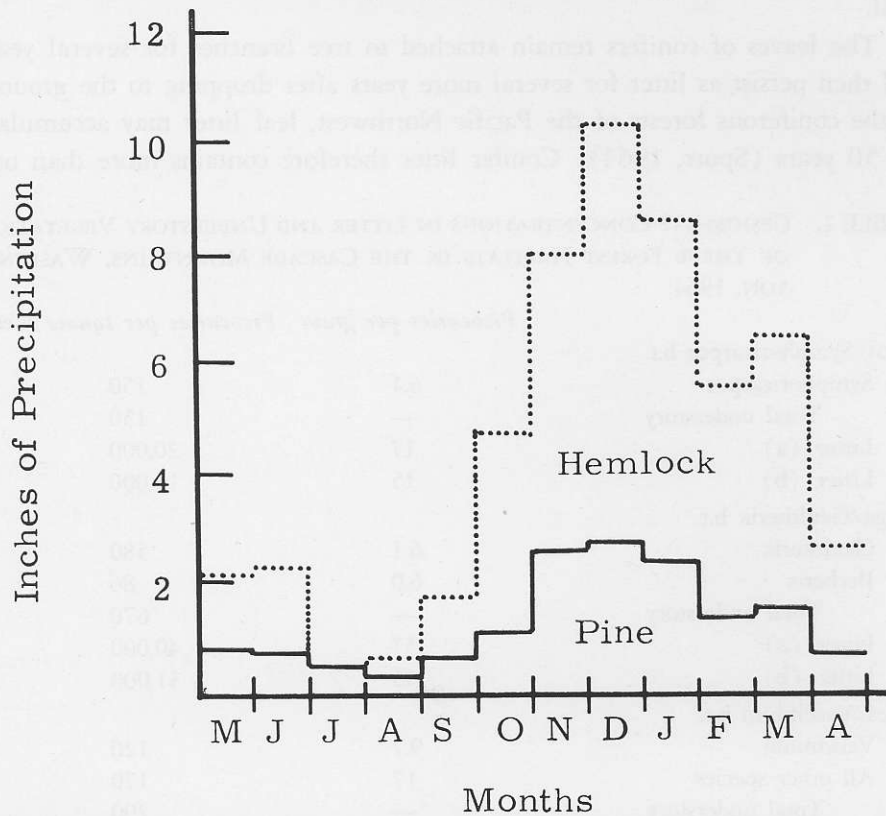


Figure 1. Long-term precipitation averages from Packwood, Washington (Hemlock), and Tieton Range Station (Pine). Data obtained from Yearbook of Agriculture 1941. Climate and Man. U.S. Govt. Printing Office, Washington, D.C. 1248 pp.

greatly exceeds that of the low-altitude hemlock site was not determined, but the cooler climate of higher altitudes permits the accumulation of a deep, long-lasting snow pack. The role of snow melt in increasing the fallout accumulation of vegetation at high elevations has been described by Osburn (1963), and similar processes may be operational here.

The understory plants of the hemlock stand were more luxuriant than those of the other sites; and contained more ^{137}Cs per m^2 of ground than other stands (Table 1). This kind of sampling is especially useful for comparing the amount of organic material available for animal food and microbial decomposition among different habitats.

By sampling leaf litter from many stands representative of widespread forest associations in Washington, it may be possible to use these stands as biologic indicators of the amounts of ^{137}Cs accumulated by forested landscapes during the past 20 years. By using climax stands as base lines for ^{137}Cs values, it seems appropriate that evaluations of the effect of fire and logging on ^{137}Cs accumulations in litter and understory could also be made.

Summary

Cesium-137 derived from worldwide fallout was measured in the understory vegetation and leaf litter of three different mature conifer stands in the Cascade Mountains of Washington in September, 1964. The ^{137}Cs concentration of understory shrubs was more or less similar among the three stands. However, more ^{137}Cs was present in the understory in the hemlock (*Tsuga heterophylla*) stand when expressed as ^{137}Cs per square meter of ground because of the more luxuriant understory growth in this habitat. Cesium-137 in leaf litter was most abundant in a fir (*Abies amabilis*) stand near the mountain summit. The leaf litter of a hemlock stand in a high-precipitation region west of the mountains had higher ^{137}Cs concentrations than did the litter from a ponderosa pine (*Pinus ponderosa*) stand from a lower-precipitation region east of the mountains.

Acknowledgements

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ASSOCIATION NEWS

Preparations are continuing for the 39th annual meeting in Missoula, Montana, on the 15th and 16th of April, 1966. Programs will be sent to all members in March. In addition, a registration card and return envelope will be included. You are urged to preregister and thus decrease the jam that has plagued us for many years at the registration table. Nonmembers may request a program from the secretary-treasurer (B. V. Ertling, College of Engineering, Washington State University, Pullman, Washington 99163).

E. E. Tylutki, Associate Editor