Field Observations On Fallout Accumulation By Plants In Natural Habitats[1].

W. H. Rickard
Senior Research Scientist,
Biology Department,
Battelle-Northwest,
Richland, Washington.

Highlight

Fallout accumulation by above-ground plant parts was related to differences in leaf and twig structure and time organs were exposed to atmosphere. Trees appeared to lessen fallout accumulation by understory shrubs.

The accumulation of worldwide fallout by plants in natural habitats has been infrequently investigated. Mosses and lichens accumulated more fallout than vascular plants (Gorham, 1959; Davis et al., 1963). The spring melt of snow increased the accumulation of fallout by alpine tundra plants (Osburn, 1963). Pubescent-leaved plants accumulated more fallout than glabrous leaved plants (Romney et al., 1963). Grasses growing on a flooded lowland habitat accumulated more fallout than grasses from a well drained upland habitat (Davis et al., 1963). Strontium-90 has been reported to accumulate in the basal portions of perennial pasture grasses (Russell, 1958).

This paper reports the levels of gamma radioactivity of some common plants collected in 1963 with reference to phenology, leaf morphology and community structure, from the natural vegetation mosaic of the lower Cummings Creek Valley, Wooten Game Range, Columbia County, Washington. The Cummings Creek Valley is one of many deep, steep-walled valleys of the Blue Mountain region of southeastern Washington (Figure 1). Soils of the slopes consist of fine-textured loess intermingled with large quantities of basaltic stones. Surface soils in the valley tend to be less stony. The vegetation mosaic is composed of grassland and forest associations. Streamside vegetation consists of a narrow band of deciduous trees, mostly alder *(Alnus tenuifolia)*, birch *(Betula* spp.), and occasional tall cottonwoods *(Populus trichocarpa)*. Grassland stands are representative of the *Agropyron/Poa* association, while most forest stands are representative of the *Pinus/Physocarpus* or *Pseudotsuga/Physocarpus* associations (Daubenmire, 1942, 1952). Grassland stands occupy the south-facing slopes and the exposed spur ridges on the north-facing slopes. Forest stands occupy portions of the valley floor, ravines and depressions on the north-facing slopes. Logging and forest fires have removed trees from some sites. The grassland vegetation is in good condition (Buechner, 1952). Dominant grasses and forbs, bluebunch wheatgrass *(Agropyron spicatum)*, lupine *(Lupinus serecius)*, and balsamroot *(Balsamorhiza sagittata)* were harvested by clipping near the ground from a stand representative of the *Agropyron/Poa* association. The leafy twigs of ninebark, *Physocarpus malvaceus* were clipped more or less at random from stands with and without an overstory or trees.

All harvested material was sealed in plastic bags for delivery to the laboratory, dried, and milled to pass a 1 mm screen. A 100 to 200 gram portion of milled sample was placed in a 500 ml capacity plastic bottle and counted in a well-type, 9 x 11

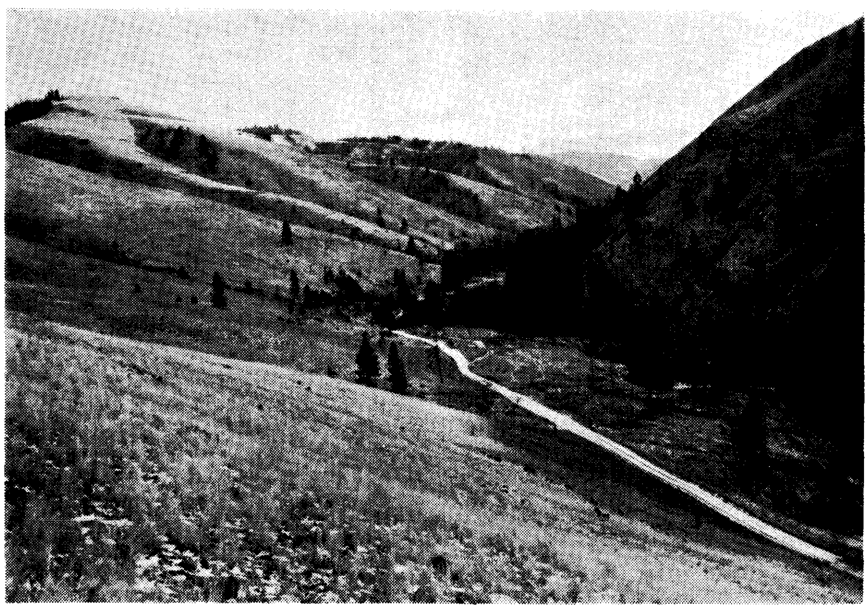

FIGURE 1. View of lower Cummings Creek Valley in winter.

[1] *Work performed under Contract No. AT(45-1)-1350 between the Atomic Energy Commission and General Electric Company. The cooperation of the Washington State Game Department in allowing the collection of samples for this study is gratefully acknowledged. This study is a part of a study designed to evaluate the effect of climate on the uptake of fallout by browsing animals.*

inch sodium-iodide (Tl) crystal connected to a 256 channel analyzer. Gamma-emitting fallout radionuclides measured were cesium-137, half-life 27 years; ruthenium, rhodium-106, half-life one year; manganese-54, half-life 300 days, cerium-praseodymium-144, half-life 285 days; zinc-65, half-life 245 days; and zirconium-niobium-95, half-life 65 days. Cerium-praseodymium-144 was always the most abundant radionuclide measured. Zirconium-niobium-95 and ruthenium-rhodium-106 were also abundantly represented. Only small amounts of manganese-54 and cesium-137 were measured. Zinc-65 was infrequently detected.

Bluebunch wheatgrass contained more radioactivity than either balsamroot or lupine (Table 1). The leaves of forbs had been aerially exposed for only about 60 days but some of green winter growth of grass had been exposed about 200 days. Some of the dead grass included in the harvest was a year or more old and also raised the average exposure time of the grass and indicates that persistence of aboveground organs is an important feature in regard to the accumulation of fallout.

To further establish the role of persistence of aboveground organs and fallout accumulation, leaves and twigs of different ages, i.e., approximately 4-month, 16-month, and 28-month-old age classes, were harvested from the branches of a ponderosa pine tree *(Pinus ponderosa)*. The new growth of pine contained less fallout than did the more aged tissues (Figure 2). This was especially evident in regard to the long-lived radiocesium.

To compare the influence of leaf and twig morphologies on the accumulation of fallout, shrubs with aboveground parts of similar age but different leaf morphology were sampled from the same location at the same time. On July 25, two kinds of shrubs of similar phenology and stature growing together were harvested of leaves and twigs. Leaves of mountain maple *(Acer glabrum)* are about twice the size and more glabrous than those of ninebark. The twigs of mountain maple are smooth-barked and the twigs of ninebark have shredded bark. Ninebark accumulated more fallout than mountain maple (Table 1), suggesting an effect of pubescent leaves and rugose stem morphology on increasing fallout accumulation. Two large perennial forbs of different leaf morphology were compared for radioactivity. Balsamroot has large, thick simple leaves in contrast to the thin, compound leaves (leaflets) of lupine. The surface area per gram of leaf was probably greater in lupine than in balsamroot, and correspondingly, the amount of total fallout accumulated by lupine was greater (Table 1).

The accumulation of fallout by leaves and twigs of understory ninebark was evaluated by comparing shrubs growing on two closely similar habitats with and without trees. One site had an open tree canopy of Douglas fir *(Pseudotsuga menziesii)*; the other was treeless because of a fire during the summer of 1961. The burned site occupied the lower portion of a 35° slope facing NNW at an elevation of about 2500 feet above sea level. The forested site occupied the same hillside at an elevation of about 100 feet higher. The slope angle here was 30°, north-facing. The ninebark growing in association with tall trees had lower total fallout-accumulation values than those plants growing without trees (Table 1). When the fallout content of ninebark twigs and leaves was compared with bluebunch wheatgrass collected on the same day, ninebark contained less

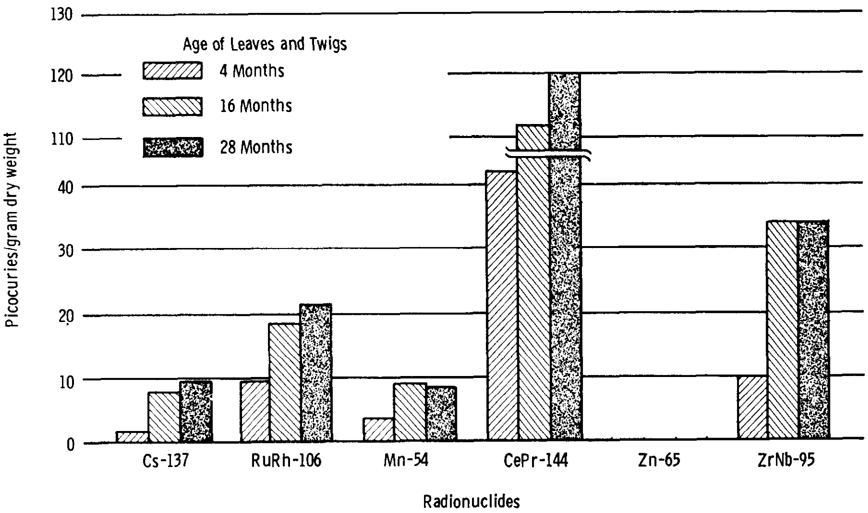

FIGURE 2. Accumulation of gamma emitting radionuclides by ponderosa pine leaves and twigs of different age classes.

Table 1. Gamma emitting radionuclides in plants collected from the lower Cummings Creek Valley, Washington, 1963. Results are expressed as picocuries (micromicrocuries) per gram dry weight.

Grassland Association	Date	Number of Samples	Zr-Nb-95	Zn-65	Ce-Pr-144	Mn-54	Ru-Rh-106	Cs-137	Total
			Picocuries per Gram Dry Weight						
Lupinus serecius	5/15/63	3	119 ± 4.4	0.77 ± 0.77	216 ± 29	15 ± 3.9	44 ± 3.9	6.0 ± 0.82	400
Balsamorhiza sagittata	5/15/63	3	88 ± 7.5	0.47 ± 0.47	160 ± 2.2	9.6 ± 0.20	22 ± 1.4	6.7 ± 0.21	286
Agropyron spicatum	5/15/63	3	256 ± 31	3.7 ± 1.6	471 ± 33	19 ± 1.2	78 ± 5.4	18 ± 0.88	850
Agropyron spicatum	7/25/63	3	167 ± 3.8	ND	465 ± 6.4	18 ± 0	109 ± 3.2	16 ± 1.0	780
Coniferous Forest Association									
[1]*Physocarpus malvaceus*	7/25/63	3	138 ± 2.2	ND	375 ± 9.9	28 ± 0.41	96 ± 1.4	13 ± 0.11	650
Physocarpus malvaceus	7/25/63	3	123 ± 4.4	ND	288 ± 11	18 ± 0.91	92 ± 2.9	12 ± 0.34	530
[1]*Acer glabrum*	7/25/63	2	58	ND	127	6.4	37	5.1	290

[1]No Tree Canopy

ND = Not Detected

fallout than did the grass (Table 1). Although some of the twig material harvested was at least one year old, the leaves of ninebark had been exposed for much less time than were grass leaves.

Long-lived radionuclides such as cesium-137 and strontium-90 have the potential of cycling with other minerals in ecological systems. Only a small amount of radiocesium may be expected to enter plants from soil (Frere et al., 1963). Other modes of entry may be through foliar surfaces with subsequent translocation and storage in persistent tissues. Regardless of the mode of fallout accumulation, knowledge of plant features in conjunction with radiochemical analyses can provide a means of comparing fallout accumulation in different plant communities.

Summary

Fallout accumulation by aboveground plant parts was related to differences in leaf and twig morphology and the amount of time plant organs were exposed to the atmosphere. The presence of trees appeared to lessen fallout accumulation by understory shrubs.

LITERATURE CITED

BUECHNER, H. K. 1952. Winter-range utilization by elk and mule deer in southeastern Washington. J. Range Manage. 5: 76-80.

DAUBENMIRE, R. F. 1942. An ecological study of the vegetation of southeastern Washington and adjacent Idaho. Ecol. Monogr. 12: 53-79.

DAUBENMIRE, R. 1952. Forest vegetation of northern Idaho and adjacent Washington, and its bearings on concepts of vegetation classification. Ecol. Monogr. 22: 301-330.

DAVIS, J. J., D. G. WATSON AND W. C. HANSON. 1963. Some effects of environmental factors upon accumulation of worldwide fallout in natural populations. *In* Radioecology. V. Schultz and A. W. Klement, Jr. (eds.), Reinhold Publ. Corp., N. Y., and A. I. B. S., Washington, D. C., p. 35-38.

FRERE, M. H., R. G. MENZEL, K. H. LARSON, R. OVERSTREET AND R. F. REITEMEIER. 1963. The behavior of radioactive fallout in soils and plants. Nat. Acad. Sci.—Nat. Res. Council, Publication 1092. Washington, D. C. 32 p.

GORHAM, E. 1959. A comparison of lower and higher plants as accumulators of radioactive fallout. Can. J. Botany 37: 327-329.

OSBURN, W. S. 1963. The dynamics of fallout distribution in a Colorado alpine tundra snow accumulation ecosystem. *In* Radioecology, V. Schultz and A. W. Klement, Jr. (eds.), Reinhold Publ. Corp., N. Y. and A. I. B. S., Washington, D. C., p. 51-71.

ROMNEY, E. M., R. A. LINDBERG, H. A. HAWTHORNE, B. A. BYSTROM AND K. H. LARSON. 1963. Contamination of plant foliage with radioactive fallout. Ecology 44: 343-349.

RUSSELL, R. S. 1958. Deposition of strontium-90 and its content in vegetation and in human diet in the United Kingdom. Nature 182: 834-839.