8.6 Radionuclide Sampling in Conifer Forests in the Cascade Mountains of Washington State

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Radioactive debris was injected high into the air during aboveground nuclear detonations in the 1950s and early 1960s. This debris was deposited globally as fallout. Landscapes with higher precipitation generally received more fallout than landscapes with lesser amounts of precipitation. In Washington State, the Cascade Mountains received more precipitation and more fallout than the Hanford Site located in the semiarid interior Columbia River Basin, east of the Cascades.

The natural vegetation of the Cascades is dominated by conifer trees. Fallout particles adhere to tree needles, twigs, and cones that fall to the forest floor. As this material decomposes, fallout particles are incorporated with decomposing organic matter and may migrate downward with percolating rainfall and snowmelt into the underlying mineral soil.

During September 2002, samples of living conifer needles, living moss, organic matter, and surface soil were collected from four locations in the Cascade Mountains, including two locations on the west side of the mountains and two locations on the east side (Figure 8.6.1), and analyzed for fallout radionuclides. The purpose of this work was to compare radionuclide concentration levels in the 2002 samples to concentrations measured in similar samples collected in or near the same forest stands in 1967 through 1969 (Rickard 1971). The 2002 data are useful for comparison to Hanford Site concentrations of fallout radionuclides. All samples collected during 2002 were analyzed for isotopic plutonium, isotopic uranium, strontium-90, and cesium-137. The samples collected during the late 1960s were analyzed for cesium-137. Cesium-137 data obtained from both sampling efforts are compared here. Other radionuclide concentration data obtained during 2002 can be found in PNNL-14295, APP. 1.

It was expected that cesium-137 concentrations in the 2002 samples would be less than half of those measured in the samples collected during the late 1960s because of radioactive decay and reduced rates of deposits from fallout in the interim years. Concentrations of cesium-137 in soil were also expected to be lower because of dilution caused by volcanic ash deposits from the eruption of Mount Saint Helens in 1980. Estimated amounts of ash fall (uncompacted tephra) at the 2002 sampling sites range from 5 to 11 centimeters (2 to 4 inches) (USGS 2003).

The highest concentrations of cesium-137 measured in 2002 samples were measured in forest floor organic matter

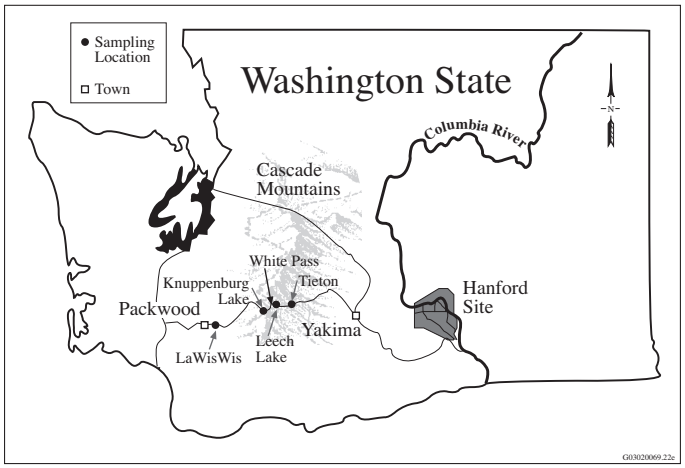

Figure 8.6.1. Soil and Vegetation Sampling Locations Along White Pass (Highway 12) in the Cascade Mountains of Washington State, 2002

at the two highest elevation study sites near the crest of the Cascade Mountains where deep snow cover persists throughout the late autumn, winter, and spring months (Table 8.6.1). These values were three to six times lower than the measurements made in the 1960s (Table 8.6.1). Since the 1960s, cesium-137 concentrations in moss at the lowest elevation on the western slope of the Cascades declined from 36 pCi/g (1.33 Bq/g) dry wt. to 0.56 pCi/g (0.02 Bq/g) dry wt. Cesium-137 concentrations in organic matter at all study sites showed strong declines, but concentrations in mineral soil were not greatly different between the 1960s and the 2002 samples.

The low concentrations of cesium-137 in live conifer needles collected during 2002 indicate that there is only a small amount of recycling of radioactive cesium from the soil to needles in these particular forest stands.

Comparisons to Hanford Site

The Hanford Site, because of its arid climate, is not expected to have concentrations of cesium-137 that exceed those levels observed in the Cascade Mountains. There are also significant differences in the vegetation and soil. Hanford soil generally is sandy and has little or no organic layers. Soil samples collected in 2001 from the Fitzner/Eberhardt Arid Lands Ecology Reserve Unit of the Hanford Reach National Monument can be compared to mineral and organic soil samples from the Cascade Mountains. Cesium-137 concentrations in mineral soil collected from the upper 2.5-centimeter (1-inch) layer at sampling location found on the Fitzner/Eberhardt Arid Lands Ecology Reserve Unit of the Hanford Reach National Monument were similar to concentrations in mineral soil found on White Pass, but generally less than levels present in the upper organic soil layer found in forests (Figure 8.6.2). Rainfall on the Fitzner/Eberhardt Arid Lands Ecology Reserve Unit averages ~17 centimeters (6.7 inches) annually. In comparison, rainfall along White Pass ranges from 50 to 250 centimeters (20 to 100 inches) with the highest rainfall occurring at the summit of the pass (Oregon Climate Services 2003).

Table 8.6.1. Average Concentrations of Cesium-137 (pCi/g dry wt.)[a] and Range of Values (in parentheses) in Conifer Forest Stands on the Western and Eastern Slopes of the Cascade Mountains in Washington State, 1967-1969 and September 2002

	Location (Slope)			
	La Wis Wis (Western)	Knuppenburg Lake (Western)	Leech Lake (Eastern)	Tieton (Eastern)
Elevation (m)	480	1,300	1,400	330
Rainfall (cm)[b]	150-200	150-200	150-200	50-100
	1967-1969[c]			
Moss	36 (23-31)	NA[d]	NA	NA
Organic matter	27 (23-31)	27 (15-35)	15 (11-18)	10 (8-14)
Soil	0.64 (0.54-0.72)	0.40 (0.38-0.40)	0.35 (0.30-0.40)	1.3 (1.1-1.4)
	September 2002			
Moss (n=2)	0.56	NA	NA	NA
Organic matter (n=2)	1.1 (0.85-1.4)	4.2 (3.8-4.6)	3.5 (3.4-3.6)	0.98 (0.53-1.4)
Soil (n=2)	0.16 (0.13-0.18)	0.89 (0.21-1.6)	0.37 (0.33-0.40)	0.33 (0.31-0.33)
Live needles (n=1)	1.0	0.78	0.53	0.04

(a) To convert to becquerels per gram, multiply by 0.037.
(b) Oregon Climate Services (2003).
(c) Modified from Rickard (1971).
(d) NA = Not available.

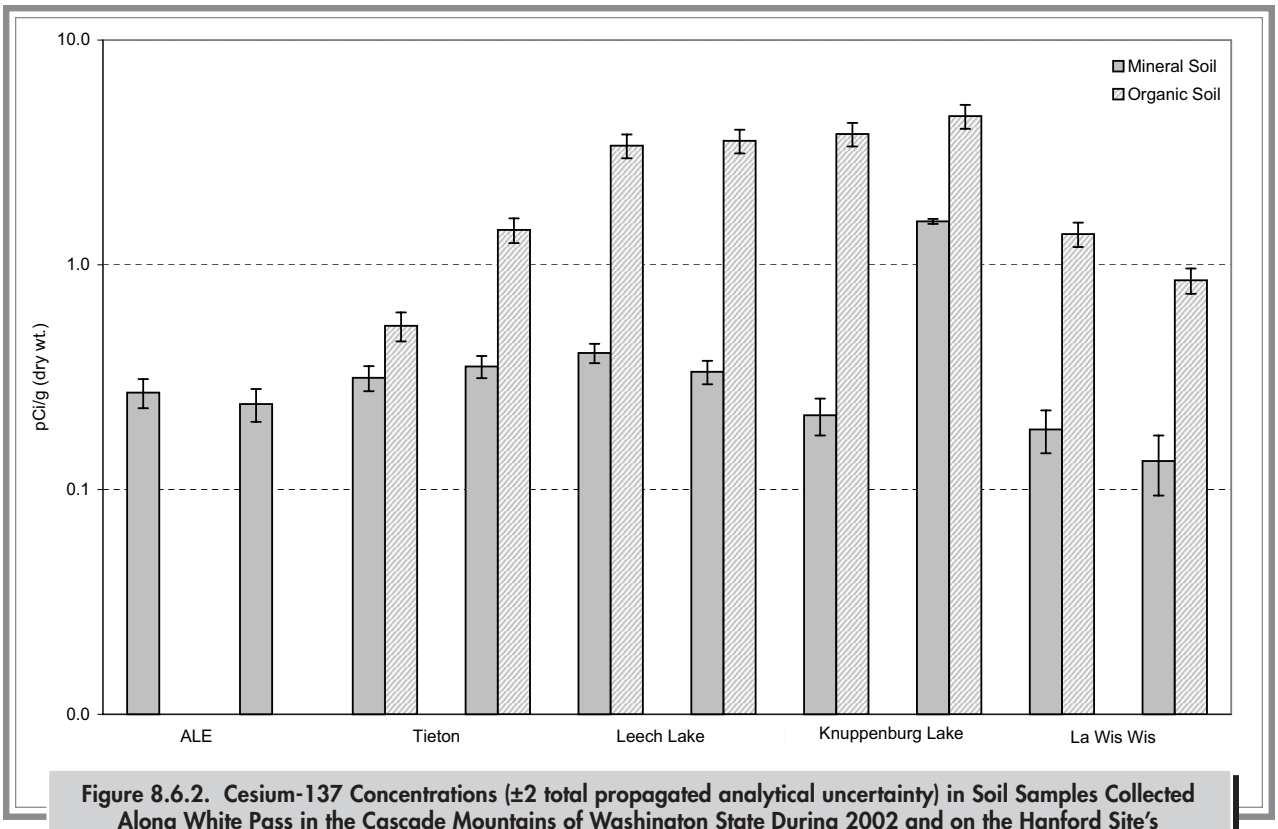

Figure 8.6.2. Cesium-137 Concentrations (±2 total propagated analytical uncertainty) in Soil Samples Collected Along White Pass in the Cascade Mountains of Washington State During 2002 and on the Hanford Site's Fitzner/Eberhardt Arid Land Ecology (ALE) Reserve Unit During 2001