INTERNAL REPORT 47

SOILS AND PARENT MATERIALS OF FINDLEY LAKE, SNOQUALMIE NATIONAL FOREST, WASHINGTON

J. G. Bockheim and F. C. Ugolini

University of Washington

ABSTRACT

Findley Lake watershed is located in the Snoqualmie National Forest and has a surface area of 259 ha (1 mi^2). The lake is at an elevation of 1128 m (3701 ft) but the ridges attain elevations of 1450 m (4750 ft). The Cougar Mountain Formation, consisting of lava flows, conglomerate, and volcanic sandstone, underlies the basin. The area has been glaciated and covered by a number of volcanic ash layers. Carbon 14 dating of stratified charcoal has shown that tephra are present among the ashes of Mt. St. Helens-W, Mt. St. Helens-Y, and Mazama (300, 3200, and 6700 yr B.P., respectively). An extensive fire occurred 200 years ago. *Abies amabilis* and *Tsuga heterophylla* are the most common tree species of the area. Soils were mapped into groups depending upon parent material and vegetation. The following groups were recognized. Soils of talus (16.2% of total); soils of mixed materials: (1) forested (56.2%), (2) semiforested (4.3%), (3) unforested (1.6%); residual soils of the ridges: (1) forested (17.5%), (2) unforested (4.2%). The soils include the Haplumbrept, yorthod, and Haplaquept, andic and humic.

INTRODUCTION

Findley Lake watershed is a small 259-ha (1-mi^2) cirque located in the Snoqualmie National Forest 17.7 air km (11 air mi) from Snoqualmie Pass in Washington's western Cascade Mountains. Whereas Findley Lake is situated at an elevation of 1128 m (3701 ft), the surrounding ridges attain elevations of over 1450 m (4750 ft). The lake and two ponds are drained by Findley Creek, a tributary of the Cedar River.

The soil parent material in the Findley Lake region is the Cougar Mountain Formation, a thick succession of lava flows with minor amounts of breccia flows, interstratified thick boulder conglomerates, and subordinate volcanic sandstone (Hammond 1963). Dating back to the early Miocene, the Cougar Mountain Formation unconformably overlies the Keechelus Volcanic Group (Keechelus Andesite Series of Smith and Calkins 1906), which ranges in composition from basalt to rhyolite, with pyroxene andesite predominating. Small outcrops of the Snoqualmie granodiorite occur along the southwest and northeast ridges above Findley Lake. An altered pyroxene-hornblende andesite porphyry occurs along the southeast ridge.

The glacial history of Findley Lake has not been studied in detail,[1] although the glacial geology of the Snoqualmie--Cedar River area was examined by Macklin (1941). During the Evans Creek Stade of the Fraser Glaciation, alpine glaciers advanced as far as 80 km (50 mi) down the Cascade front into the Puget Lowland, carving out the Findley cirque and leaving a mantle of alpine till on the slopes leading into the basin. Alpine glaciers began to retreat before 15,000 years ago. Meanwhile a Cordilleran ice sheet had been developing in the mountains of western Canada. It eventually expanded into the Puget Lowland and at its maximum extent dammed valleys in the Cascade Range that had just previously been occupied by alpine glaciers (Crandell 1965). Spillover

[1]Robert Hirsch (now of Johns Hopkins University) is working on such a history.

of glacial-dammed lakes along the eastern margin of the Puget Lobe caused the cutting of spectacular ice-margin channels along the Cascade Range front. During the Vashon Stade of the Fraser Glaciation, ice reached a maximum elevation of 853 m (2800 ft) on Rattlesnake Mountain, approximately 19 km (12 mi) northwest of Findley Lake (Porter 1969). Thus it is unlikely that drift deposited by Vashon ice exists in the Findley basin. There is no evidence for Neoglacial activity in the Findley cirque.

Following glaciation a number of volcanic ash layers were deposited in the Findley basin; at least three major depositions are recorded in well-drained meadow basins. These include the Mazama (6700 years B.P.), Mt. St. Helens-Y (3200 years B.P.), and Mt. St. Helens-W (300 years B.P.).

The vegetation of Findley Lake is typical of the Canadian Zone as defined by Piper (1906). *Abies amabilis* and *Tsuga heterophylla* are the most common tree species. Until now the soils of the Findley Creek area have not been mapped in detail. A reconnaissance survey of the soils of the Snoqualmie National Forest has been recently undertaken (Snyder in press). The soils of Findley Lake may be similar to those mapped on the Snoqualmie Falls Tree Farm (Gilkeson et al. 1961) and the Green River watershed (Iritani 1969).

No climatic data is available for Findley Lake. The nearest high-elevation meteorological station is located at Snoqualmie Pass (elevation 920 m, 3020 ft). At Snoqualmie Pass the mean annual temperature (Table 1) is 5.4°C (41.8°F) (College of Agriculture, Washington State University 1968). January is the coldest month of the year with a mean monthly temperature of -3.2°C (26.3°F) and July the warmest at 14.3°C (57.8°F). Mean annual precipitation (Table 1) at Snoqualmie Pass is 273.3 cm (107.6 in.) most of which falls in the form of snow. An average of 1067.3 cm (420.2 in.) of snow falls at Snoqualmie Pass.

Table 1. Average monthly precipitation and temperature for Snoqualmie Pass, Washington (elevation 920 m).[a]

Month	Precipitation (cm)	(in.)	Temperature (°C)	(°F)
January	37.52	(14.77)	-3.2	(26.3)
February	32.36	(12.74)	-1.7	(28.9)
March	29.77	(11.72)	1.2	(34.4)
April	16.23	(6.39)	4.8	(40.6)
May	11.89	(4.68)	7.9	(46.2)
June	12.34	(4.86)	10.7	(51.2)
July	4.24	(1.67)	14.3	(57.8)
August	5.16	(2.03)	14.0	(57.2)
September	12.22	(4.81)	11.5	(52.7)
October	26.57	(10.46)	6.7	(44.1)
November	39.14	(15.41)	0.9	(33.6)
December	45.87	(18.06)	-1.7	(28.9)
	273.30	(107.60)	5.4	(41.8)

Absolute maximum temperature 38.3°C (101°F)
Absolute minimum temperature -27.2°C (-17°F)

[a]Washington State University, College of Agriculture (1968).

METHODS

Following a reconnaissance tour of the basin, a soil classification scheme was decided upon with parent material as the major division and vegetation as a further subdivision. Regular 9- by 9-in. (23- by 23-cm) stereo pairs of aerial photographs (2.5 cm : 150 m; 1 in. : 500 ft) and an expanded photograph (2.5 cm : 30 m; 1 in. : 100 ft) were employed in the mapping. Soil pits and natural excavations, e.g., cavities from windthrown trees, were used for contrast. The use of a soil auger was precluded by an abundance of coarse fragments within soil profiles.

A soil representing each mapping unit was described in detail, including the following soil characteristics: horizon; depth; thickness; lower boundary; color; mottling; texture; percent volume of gravel, cobbles, and stones; structure; moist and wet consistency; plasticity; cementation; roots; charcoal; and volcanic ash. Site parameters included location, vegetation, parent materials, elevation, aspect, slope, microtopography, and drainage. The soil profile and site were photographed. Samples of volcanic ash were collected from several soil pits for further identification.

Acreage and proportionate extent of soil groups were determined in the following manner. A tracing of the soil map was prepared from the large-scale aerial photograph. Soil groups were excised from the tracing with scissors and a razor blade and soils of a given mapping area were weighed on a precision balance. Sample cutouts of known area were weighed so that weight could be converted to area. It should be remembered that vertical aerial photographs of steep slopes such as those surrounding Findley Lake yield less than actual areas.

RESULTS

Soils of mountainous regions in the United States have been largely ignored. Most classification schemes list these soils as "rockland" or "mountainous." In the western United States, mountain soils of middle elevations are included in the division "soils of the cool to cold, subhumid to humid forested regions" (Western Land Grant Universities and Colleges 1964, p. 33-38). Kubiena (1953) described a number of soils in the Alps of Central Europe. His terminology, however, has not found widespread use in America.

Parent material appears to be the most variable and most useful soil-forming factor for categorizing soils of the upper Canadian Zone in the western Cascade Mountains. In the Findley Lake region, three major groups of soils could be subdivided on the basis of parent material, including talus, mixed materials (alpine till?, volcanic ash, colluvium, and residuum), and residuum. Further subdivision was made depending on the extent of forest cover. Table 2 lists the important classification characteristics of soils in the Findley Lake cirque. Figure 1 is a diagram showing the distribution of soils near Findley Lake.

Acreage and proportionate extent of soil groups mapped in the Findley Lake watershed are included in Table 3. Only those soils occurring within the area bounded by the main ridge and the artificially imposed (see Figure 1) northern boundary are included in the table. Areas occupied by Findley Lake and the two small ponds obviously have not been included. A preliminary summary of Late Pleistocene events in Findley Lake cirque is contained in Table 4.

Table 2. Summary of important classification characteristics of soils in the Findley Lake cirque.

Map symbol	Soil group	Classification	Parent materials	Depth (cm)	Texture	Drainage	Vegetation
I	Soils of talus	Haplumbrept	talus	n.d.	boulders, cobbles	excessive	lichens, mosses some Rubus
II	Soils of mixed materials						
A	Forested	Cryorthod	alpine till, volcanic ash, colluvium, residuum	>100	loamy sand, gravelly loam, gravelly silt loam, very cobbly loam	well drained	Tsuga heterophylla, Abies amabilis
B	Semiforested (avalanche tracks)	...umbrept	alpine till, volcanic ash, colluvium	>90	gravelly loam, very cobbly loam, stony sandy loam	well drained	Valeriana, Veratrum, Ribes, Sorbus, Alnus. Cladothamnus,
C	Unforested (meadows)						
1	Somewhat poorly drained	Haplaquept (andic, humic)	alpine till, volcanic ash, colluvium,	>64	silt loam, sandy loam, loam, cobbly silt loam	somewhat poorly drained	Carex, Saxifragaceae
2	Well drained	...andept	alpine till, volcanic ash, colluvium, residuum	52	loam, sandy loam, gravelly sandy loam	well drained	Carex, some Veratrum
III	Residual soils of the ridges						
A	Forested	Cryorthod (lithic, typic)	residuum	64	silt loam, cobbly loam	well drained	T. heterophylla, T. mertensiana, A. amabilis
B	Unforested	Haplumbrept (lithic)	residuum	13	very cobbly sandy loam, gravelly sandy loam	somewhat excessively drained	Vaccinium, mosses

Table 3. Area and proportionate extent of soil groups mapped in Findley Lake watershed.

Soil group[a]	Map symbol	Rank	Area (ha)	Area (acres)	Percent of total
Soils of talus (4)	I	3	5.2	(12.9)	16.2
Soils of mixed materials					
Forested (2)	IIA	1	18.0	(44.6)	56.2
Semiforested (5)	IIB	4	1.4	(3.4)	4.3
Unforested (1, 8)	IIC	6	0.5	(1.3)	1.6
Residual soils of the ridges					
Unforested (10)	IIIA	5	1.3	(3.3)	4.2
Forested (3)	IIIB	2	5.6	(13.9)	17.5
			32.1	(79.4)	

[a]Numbers refer to sites for which soil descriptions have been taken.

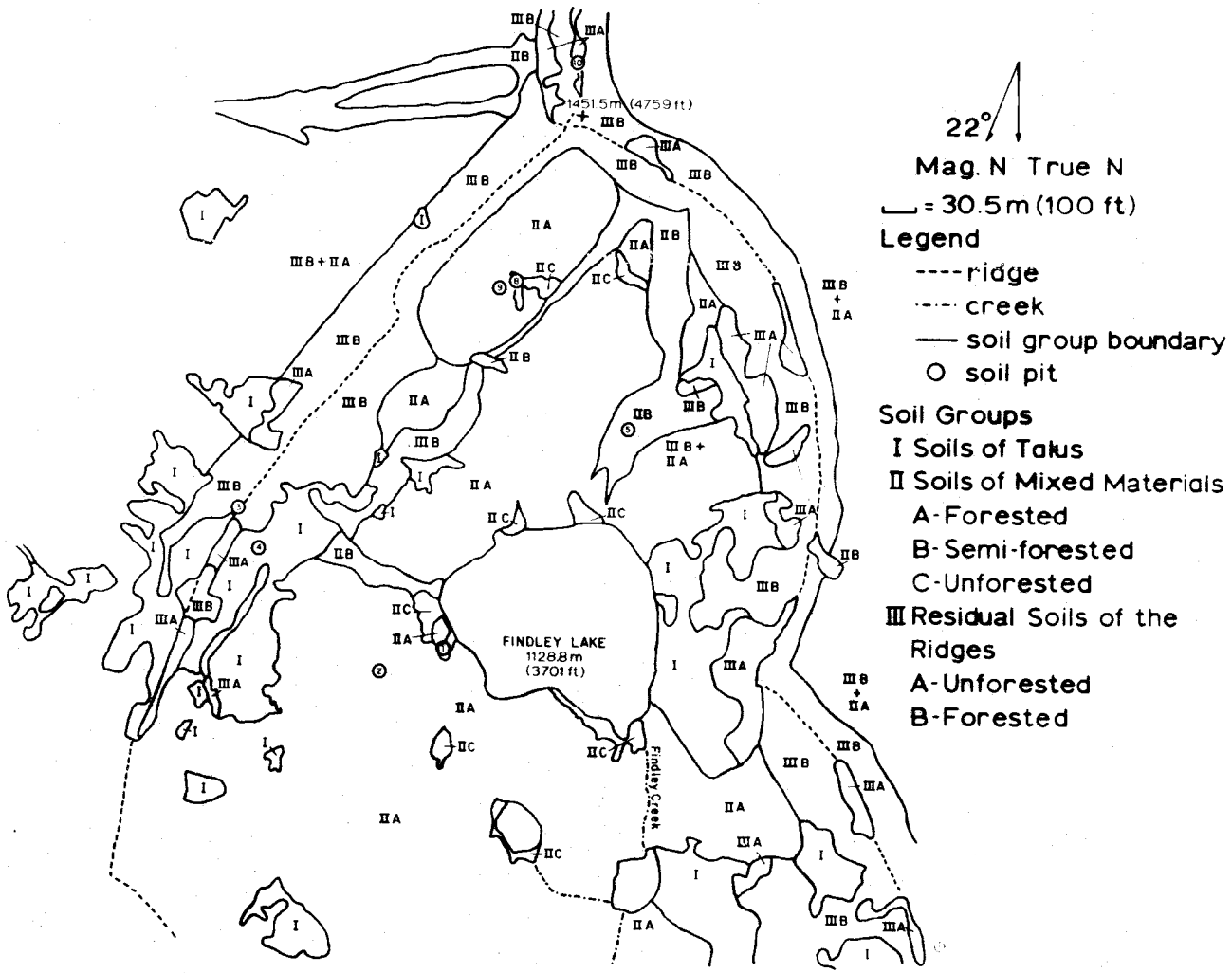

Figure 1. Distribution of soils near Findley Lake, Washington.

Table 4. Preliminary summary of Late Pleistocene events in Findley Lake cirque.

Time (years B.P.)	Event
20,000-15,000	alpine glaciation (Evans Creek Stade, Fraser Glaciation)
15,000-?	widespread colluviation
?	soil formation
?	widespread fire
6,700	Mazama ash deposition
3,200	Mt. St. Helens-Y ash deposition
?	series of fires
300	Mt. St. Helens-W ash deposition
<300	widespread fire

Soils of Mixed Materials

As the name implies, soils of mixed materials have developed from a mixture of parent materials, including residuum, talus, colluvium (excluding talus), volcanic ashes, and alpine till. These soils occur at all elevations and on all aspects except possibly the ridgetops. Soils of mixed materials are most commonly forested with mature *Tsuga heterophylla* and *Abies amabilis* or they may be partially forested as in avalanche tracks. Forest clearings supporting meadow vegetation may also be underlain by mixed soil parent materials.

Forested

Forested soils of mixed materials represent the largest mapping unit on the Findley Lake watershed, accounting for 56.2% of the total area covered by soils. These soils occur on middle and lower slopes on all but the west side of the basin, are well drained and contain well-developed Podzol profiles (Figure 2 and Table 5). Relatively thick organic horizons, which average 5 cm in thickness, overlie a moderately thick (2-16 cm), light gray A2 horizon developed in volcanic ash. The B horizons contain an abundance of organic matter and iron sesquioxides and are indurated and weakly cemented so as to yield an orterde horizon. The sols of forested soils of mixed materials are generally very thick, often surpassing 125 cm in depth.

Tree roots are concentrated in the organic layers and in the A2 horizon. Charcoal is frequently found as a discontinuous layer beneath the O1 and O2 layers and as lenses scattered throughout the bleicherde horizon.

Soils on the southern wall of the cirque (northern exposure) are eroded predominantly by snow creep. Another disturbance is windthrow of shallow-rooted trees, which causes mixing of the surface soil layers and a hummocky microrelief. Most of the fallen trees are directed to the south, indicating destruction by north winds.

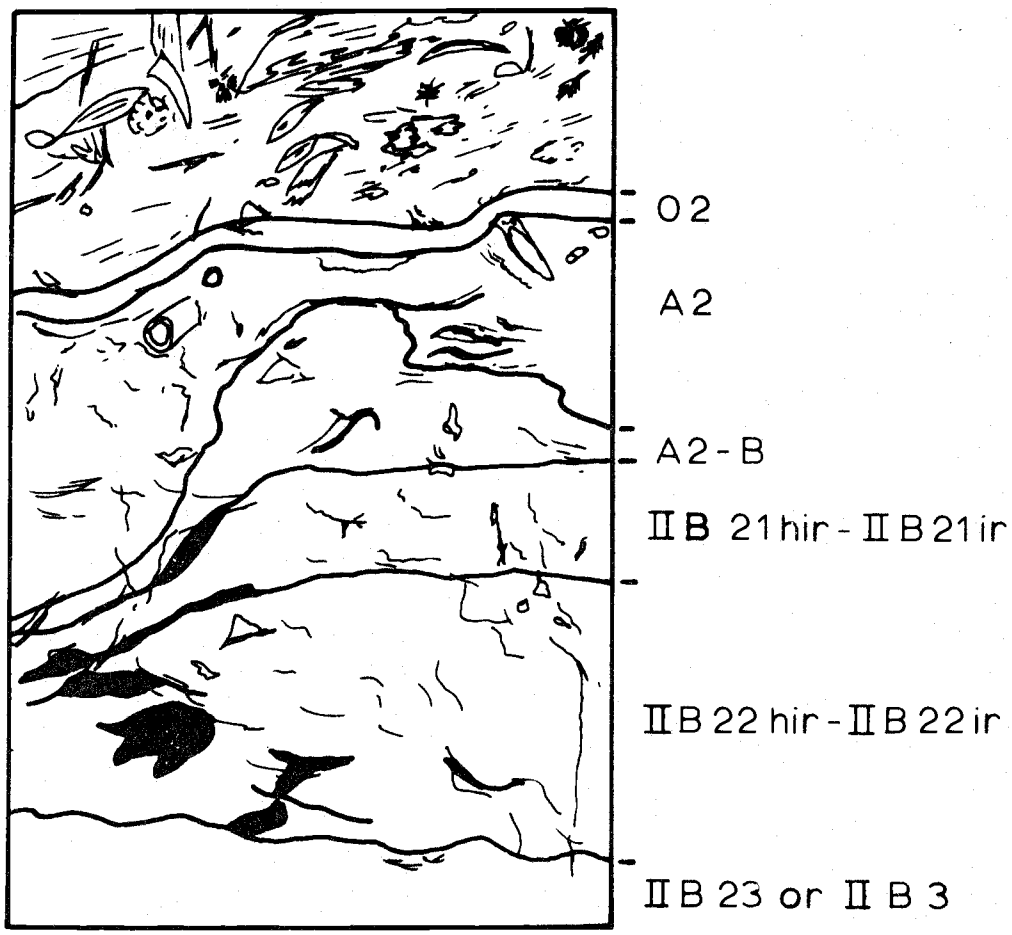

Figure 2. Soil of mixed materials, forested; Findley Lake, Washington (site 2).

Table 5. Description of a soil of mixed materials, forested; Findley Lake, Washington.

Site: 2

Location: east side of Findley Lake in forest, N62E from site 1

Vegetation: *Abies amabilis, Tsuga heterophylla*, with salal *(Gaultheria shallon)* in understory

Parent materials: volcanic ash(es) and colluvium or alpine till

Topography: steep slope, 45%; pit located in middle of slope; slightly concave microtopography; west-facing; elevation 1189 m (3900 ft)

Drainage: well drained

Soil classification: soil of mixed materials, forested (Cryorthod)

Horizon	Depth (cm)	Description
01	6-5	Fresh needles and other forest litter
02	5-0	Partially decomposed forest litter
A2	0-9	Light gray (7.5YR 7/1, moist) loamy sand; structureless, single grained; very friable; nonsticky, nonplastic; clear; irregular boundary; few fine roots; volcanic ash; contains several discontinuous layers of charcoal and partially decomposed organic material; thickness 9-19 cm
A2--B	9-20	Yellowish red (5YR 5/6) loamy sand; structureless, single grained; very friable; nonsticky, nonplastic; abrupt, broken boundary; few fine roots; volcanic ash; mixing due to windthrow(?); thickness 0-10 cm
IIB21hir--IIb2[illegible]ir	20-60	Yellowish red (5YR 5/8) gravelly loam; structureless, massive; friable; slightly sticky, slightly plastic; few fine roots--IIB21ir; dark reddish brown (2.5YR 3/4) gravelly loam to gravelly silt loam; structureless, massive, firm; slightly sticky, slightly plastic; few fine roots--IIB21hir; contains weakly cemented "lenses" of ortstein, comprising 50% of the volume; concretions; 10-15% cobbles by volume; volcanic ash (?); clear, wavy boundary; thickness 7-41 cm

Table 5 (cont.)

IIB22hir-- IIB22ir	60-92	Yellowish red (5YR 5/8) very cobbly loam; structureless, massive; friable; slightly sticky, slightly plastic; few fine roots--IIB22ir; dark reddish brown (5YR 3/3) very cobbly loam; very dusky red (2.5YR 2/2) comprises 20% of volume; structureless, massive; firm; slightly sticky, slightly plastic; few fine roots--IIB22hir; contains weakly cemented "lenses" of ortstein, comprising 50% of the volume; 50-60% cobbles by volume; volcanic ash (?); diffuse, smooth boundary
IIB23 or IIB3	92-127	Strong brown (7.5YR 4/6) very cobbly loam; structureless, massive; friable; slightly sticky, slightly plastic; few fine roots; 60-70% cobbles by volume; reddish brown 2.5YR 4/4) mineral skin on cobbles, 0.48 cm thick; volcanic ash (?)

Semiforested

Semiforested soils of mixed materials occur on steep, well-drained slopes where periodic snowslides have prevented full establishment of the vegetation. Four major avalanche tracks occur in Findley Lake basin. Two avalanche tracks merge at the south end of the basin (Figure 1). The upper track originates below a column of forested bedrock at 1341 m (4400 ft) and joins the lower track at 1219 m (4000 ft). The lower track begins at the base of talus at an elevation of 1280 m (4200 ft) and extends downslope almost to Findley Lake. A long, narrow avalanche scar begins at the south end of the basin in the same area as the upper portion of the previous track and extends down to 1250 m (4100 ft), emptying into a small, well-drained meadow. A fourth avalanche track extends from 1219 m (4000 ft) to Findley Lake on the east side of the cirque. Avalanche scars support a variety of vegetation, including flowers (*Veratrum, Valeriana*), ferns, shrubs (*Sorbus, Alnus, Cladothamnus, Rubus,* and *Ribes*), and occasional trees (*Abies, Tsuga*).

Soils of avalanche tracks are poorly podzolized: A2 horizons are absent and B2 horizons lack prominent cementation by iron and organic compounds (Figure 3 and Table 6). These soils generally contain thick sols with an abundance of gravel, cobbles, and boulders. The A1 horizons are dark reddish brown in color, coarse-textured, and relatively thick (up to 30 cm); B horizons are dark reddish brown to dark brown in color, very coarse-textured, and contain highly weathered fragments of andesite. Horizons buried by more recent colluvial material are common in soil profiles developed on avalanche scars.

Avalanche tracks exhibit considerable snow damage. Trees occur individually or in small clumps within the tracks. They are young and never attain the stature of those in adjacent forested areas. Trees within avalanche tracks are often bent, cracked, or snapped off from 1 to 2.4 m (3 to 8 ft) above the ground. Considerable wildlife traffic (bears, elk, deer) is evident within avalanche tracks.

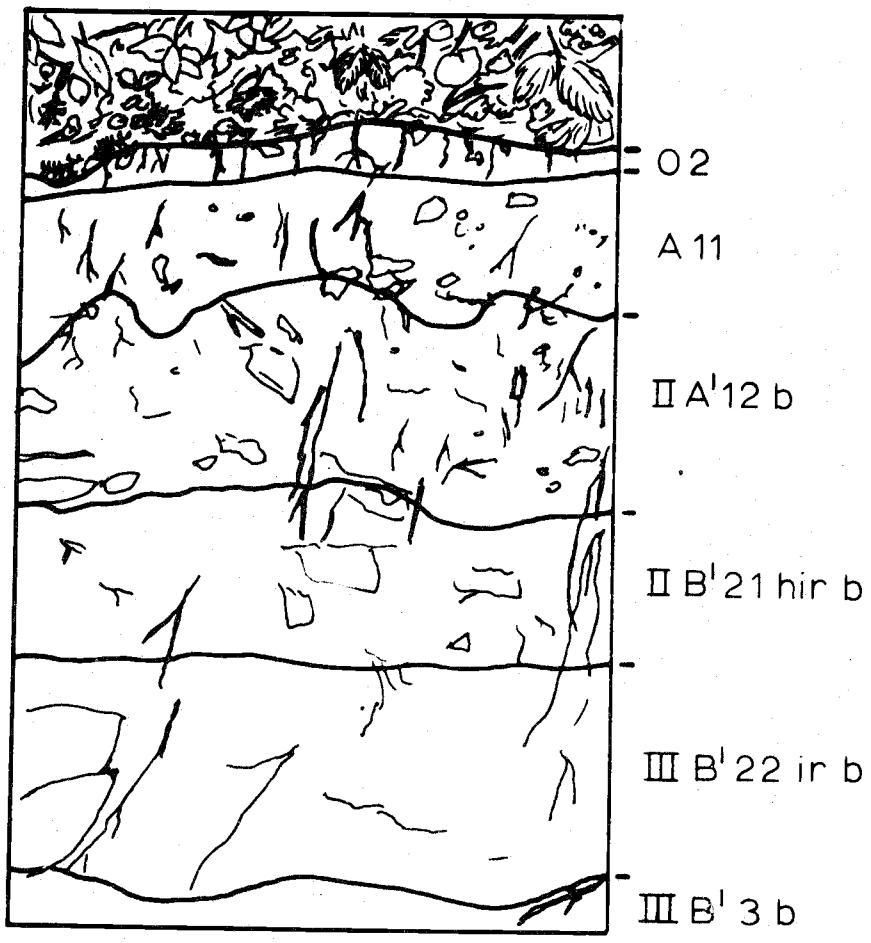

Figure 3. Soil of mixed materials, semiforested; Findley Lake, Washington (site 5).

Table 6. Description of a soil of mixed materials, semiforested; Findley Lake, Washington.

Site: 5

Location: southwest side of Findley Lake

Vegetation: *Ribes, Valeriana,* ferns, occasional trees

Parent materials: colluvium and volcanic ash(es) over colluvium or alpine till

Topography: moderate slope, 52%; pit located in middle of slope; straight slope; northeast-facing; elevation 1219 m (4000 ft)

Drainage: well drained

Soil classifications: soil of mixed materials, semiforested

Horizon	Depth (cm)	Description
01	tr.	
02	3-0	Partially decomposed plant litter
A11	0-13	Dark reddish brown (5YR 2/3) gravelly loam; moderate, very fine crumb structure; friable; slightly sticky, slightly plastic; abundant very fine roots; abrupt, irregular boundary; volcanic ash (?); thickness 8-19 cm
IIA'12b	13-30	Dark reddish brown (5YR 3/3) very cobbly loam; weak, fine crumb structure; very friable; slightly sticky, slightly plastic; abundant very fine roots; abrupt, wavy boundary; volcanic ash (?); thickness 13-17 cm
IIB'21hirb	30-48	Dark reddish brown (5YR 3/4) very cobbly loam; moderate, very fine crumb structure; friable; slightly sticky, slightly plastic; plentiful very fine roots; clear, smooth boundary; volcanic ash (?); pseudomorphs of andesite; thickness 20-22 cm
IIIB'22irb	48-70	Dark brown (7.5YR 4/4) very cobbly loam; moderate, very fine crumb structure; friable; slightly sticky, slightly plastic; plentiful very fine roots; abrupt, wavy boundary; volcanic ash (?); pseudomorphs of andesite; charcoal in lower portion of horizon; pocket of black (10YR 2/1) loam at 65-80 cm measures 10 x 20 cm, resembles A1; thickness 20-25 cm

Table 6 (cont.)

IIIB'3b	70-89	Dark reddish brown (5YR 2.4) stony sandy loam; moderate, fine crumb structure; very friable; slightly sticky, slightly plastic; plentiful very fine roots; abrupt, irregular boundary; thickness 15-20 cm
IVCb		Cobbles of basalt; talus or weathered bedrock

Meadow

Several small forest clearings occur around the margin of Findley Lake and the two small ponds to the north. These meadows are somewhat poorly drained and are dominated by *Carex* spp. and a member of the family Saxifragaceae. At higher elevations well-drained meadows exist at the base of avalanche tracks. Representing runout zones for avalanches, these small basins may remain under snow for at least 10 months of the year. Vegetational zonation similar to that described in the subalpine zone of the Cascades (Douglas 1969, p. 83) occurs in these basins, with *Carex* occupying the basin floor and *Luetka, Vaccinium, Phyllodoce,* and *Tsuga--Abies amabilis* occupying progressively better drained sites up the basin wall.

Well-drained basins of the upper and middle slopes contain a complete stratigraphic record of events following the Fraser Glaciation. Volcanic ash layers and buried soils are well preserved and are often separated by datable layers and lenses of charcoal. At least one of these basins (site 8) may have remained under meadow vegetation since the last major glaciation. Somewhat poorly drained soils of the lower slopes apparently have been disturbed by past episodes of colluviation and alluviation. Ash layers and charcoal are not so well preserved as they are in well-drained soils of the upper and middle slopes.

Soils of well-drained meadows are poorly developed and bear AC profiles (Figure 4 and Table 7). A moderately thick (21 cm), fine-textured, dark-colored A1 horizon overlies Mazama ash, which in turn overlies a soil developed from a diamicton containing weathered andesite. This diamicton may be an alpine till, colluvium, residuum, or a mixture thereof. Soils of somewhat poorly drained meadows contain a moderately thick (20 cm), fine-textured A1 horizon overlying a buried soil developed from mixed colluvium and volcanic ash. Gleying exists at depths below 48 cm (Figure 5 and Table 8).

Forest openings are grazed extensively by elk and bear. Considerable pedoturbation as a result of elk activity is evident particularly in somewhat poorly drained meadows.

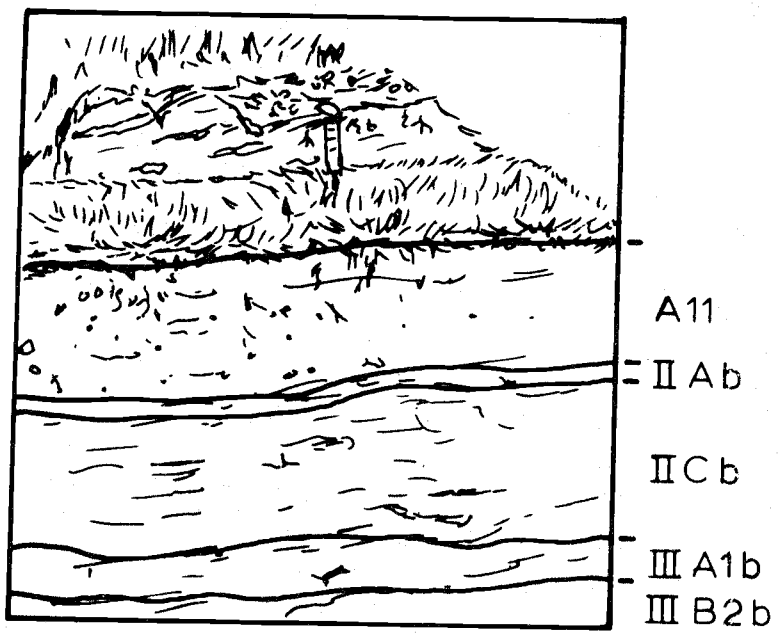

Figure 4. Soil of mixed materials, unforested, well drained; Findley Lake, Washington (site 8).

Table 7. Description of a soil of mixed materials, unforested, well drained; Findley Lake, Washington.

Site: 8

Location: small basin at south end of Findley cirque

Vegetation: *Carex* spp., with occasional *Veratrum* spp.

Parent materials: volcanic ashes, alpine till or residuum composed of andesite

Topography: flat, 2 1/2% slope; elevation 1250 m (4100 ft)

Drainage: well drained

Soil classification: soil of mixed materials, unforested

Horizon	Depth (cm)	Description
01	1-0	Fresh grass litter
A11	0-18	Very dark gray (5YR 3/1) sandy loam; moderate, fine crumb structure; friable; slightly sticky, slightly plastic; abrupt, smooth boundary; plentiful fine roots; thickness 17-18 cm; no gravel or cobbles; includes 1-cm-thick volcanic ash (Mt. St. Helens-W) layer at 5 cm; ash is a brown (7.5YR 5/2) sand; weak, fine crumb structure breaking down to structureless, single grain; abrupt smooth and abrupt broken boundary; layer also contains pieces and small lenses of charcoal; remainder of horizon thought to be Mt. St. Helens-Y ash
IIAb	18-21	Dark brown (7.5YR 3/2) loam; weak, thick platy breaking down to weak, fine crumb structure; friable; slightly sticky, slightly plastic; abrupt, smooth boundary; plentiful very fine roots; thickness 2-3 cm; no gravel or cobbles; developed from Mazama ash
IICb	21-40	Yellowish brown (10YR 5/8) loam; massive breaking down to moderate, medium platy structure; friable to firm; slightly sticky, slightly plastic; abrupt, smooth boundary; few very fine roots; thickness 18-23 cm; no gravel or cobbles
IIIA1b	40-47	Dark brown (7.5YR 3/2) loam; weak, thick platy breaking down to moderate, fine crumb structure; friable; slightly sticky, slightly plastic; abrupt, smooth boundary; some gravel, no cobbles

Table 7 (cont.)

IIIB2b	47-52	Strong brown (7.5YR 5/6) gravelly sandy loam; moderate, fine crumb structure; friable; slightly sticky, slightly plastic; very few very fine roots; clear smooth boundary; 15-20% gravel, no cobbles
IIICb	52-78	Dark yellowish brown (10YR 4/4) gravelly sandy loam; weak, fine crumb structure; friable; nonsticky, nonplastic; no roots; developed from alpine till or residuum

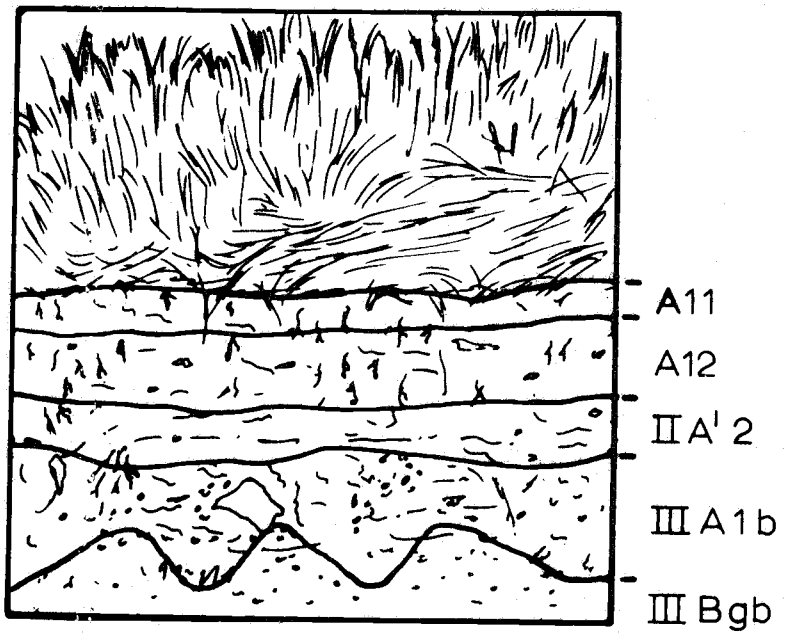

Figure 5. Soil of mixed materials, unforested, somewhat poorly drained; Findley Lake, Washington (site 1).

Table 8. Description of a soil of mixed materials, unforested, somewhat poorly drained; Findley Lake, Washington.

Site: 1

Location: east side of Findley Lake in meadow

Vegetation: *Carex*, Saxifragaceae

Parent materials: colluvium, volcanic ash(es) over alpine till or colluvium (talus?)

Topography: level, 3% slope; pit located in upper portion of slope; straight slope; west-facing; elevation 1131 m (3710 ft)

Drainage: somewhat poorly to moderately well drained

Soil classification: soil of mixed materials, unforested (aquept)

Horizon	Depth (cm)	Description
Ol	tr.	Fresh litter from grass and herbaceous vegetation
A11	0-5	Dark reddish brown (5YR 3/3) silt loam; weak, fine crumb structure; nonsticky, slightly plastic; abrupt, smooth boundary; abundant very fine roots
A12	5-20	Dark reddish brown (5YR 3/3) silt loam; weak, fine crumb structure; nonsticky, slightly plastic; abrupt, smooth boundary; abundant very fine roots
IIA'2	20-27	Dark brown (7.5YR 3/3) sandy loam; structureless, massive; slightly sticky, slightly plastic; abrupt, wavy boundary, plentiful microroots; thickness 7-12 cm; volcanic ash
IIIA1b	27-48	Dark brown (7.5YR 4/2) cobbly silt loam with pocket of light brownish gray (2.5YR 6/2) silty clay loam; structureless, massive; sticky, slightly plastic; abrupt, irregular boundary; plentiful microroots, especially around cobbles; thickness 18-30 cm
IIBgb	48-64	Yellowish brown (10YR 5/4) silty clay loam; many, medium, faint mottles of grayish brown (10YR 5/2); moderate, coarse, subangular blocky structure; slightly sticky to sticky, slightly plastic to plastic; plentiful very fine roots

Residual Soils of the Ridges

Following excavation of Findley cirque by alpine ice during the Evans Creek Stade, freezing and thawing in joints of the Cougar Mountain Formation has resulted in extensive plucking and the formation of large aprons of talus extending out from the main ridge. A stairlike progression of the cirque walls may represent several episodes of cirque cutting or may indicate zones of variably resistant bedrock. Ridgetops are mantled with cobbly residual soils ranging from several centimeters to over 60 cm in depth. A small amount of volcanic ash may exist in the deeper residual soils. These soils are well to somewhat excessively drained. Trees are present along ridges at lower elevations and also along the main ridge in areas somewhat protected from the wind. Major tree species include *Tsuga mertensiana, T. heterophylla,* and *Abies amabilis. Thuja plicata* and *Pinus albicaulis* are also present on the more xeric sites.

Where residual soils are forested, cheluviation has been initiated, resulting in the formation of Podzol soils (Lithic Cryorthod). Unforested soils do not show pronounced eluviation of organic matter and sesquioxides. Forested residual soils of the ridges contain a thick (8-cm) organic layer overlying a brown, fine-textured A2 horizon (Figure 6 and Table 9). This is underlain by a cobbly, dark yellowish brown B2 horizon and a very cobbly, pale brown B3 horizon. Andesite bedrock occurs at a depth of 64 cm. Unforested residual soils do not support an organic layer but contain a dark brown, very cobbly A1 horizon over a thin, gravelly, dark yellowish brown B2 horizon (Figure 7 and Table 10).

Soils of Talus

Widespread areas of talus occur along the east and west slopes of Findley basin at elevations ranging from 1128 to 1341 m (3700 to 4400 ft). Slopes range from 30% to 40%. Drainage through the talus is excessive. Most of the talus is composed of angular and subangular, loosely knit cobbles and boulders of andesite (Figure 8 and Table 11). At 25 cm below the surface the talus becomes somewhat finer textured with a predominance of cobbles interspersed in a matrix of greasy black mineral soil and undecomposed plant litter. Most of the talus is devoid of vegetation other than mosses and lichens. In somewhat stable areas protected by towering rock outcrops, talus is covered by a mat of spreading *Rubus.* Talus may have been more widespread during periglacial conditions. In fact the entire basin may have been surrounded by talus-mantled slopes. Volcanic ash and colluvium have since been added to talus on slopes no longer being recharged with talus, especially on the east side of the basin. These sites have become forested and support Podzol soils classed as "soils of mixed materials."

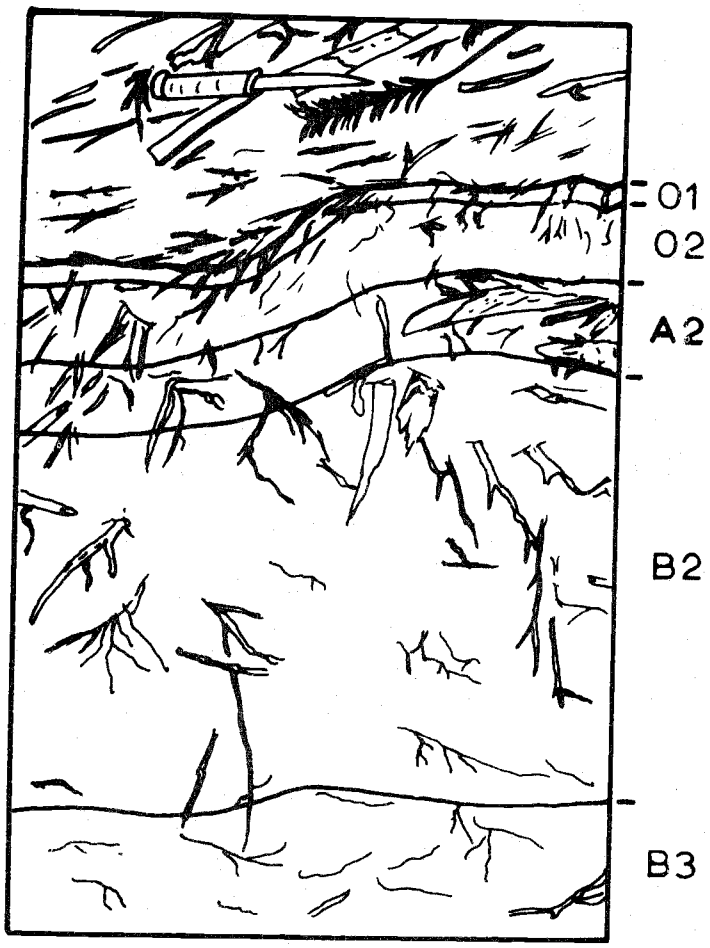

Figure 6. Residual soil of the ridges, forested; Findley Lake, Washington (site 3).

Table 9. Description of a residual soil of the ridges, forested; Findley Lake, Washington.

Site: 3

Location: ridgetop on east side of Findley Lake

Vegetation: *Tsuga mertensiana, Abies amabilis*

Parent materials: residuum from andesite and volcanic ash(es) (?)

Topography: ridgetop, 31% slope; pit located at top of slope; straight slope; elevation 1372 m (4500 ft)

Drainage: well drained

Soil classification: residual soil of ridges, forested

Horizon	Depth (cm)	Description
O1	8-6	Fresh needles and other forest litter
O2	6-0	Partially decomposed forest litter
A2	0-4	Brown (7.5YR 5/2) silt loam; weak, very fine crumb structure; very friable; slightly sticky, slightly plastic; abrupt, smooth boundary; abundant medium and coarse roots; volcanic ash(?); thickness 3-5 cm
B2	4-37	Dark yellowish brown (10YR 4/4) cobbly loam; moderate, medium to coarse subangular blocky structure; friable;slightly sticky, slightly plastic; abundant medium roots; clear, smooth boundary; thickness 33-35 cm
B3	37-64	Pale brown (10YR 6/3) very cobbly loam; moderate, medium subangular blocky structure; friable; slightly sticky, slightly plastic; abundant to plentiful medium roots
R	64	Weathered andesite

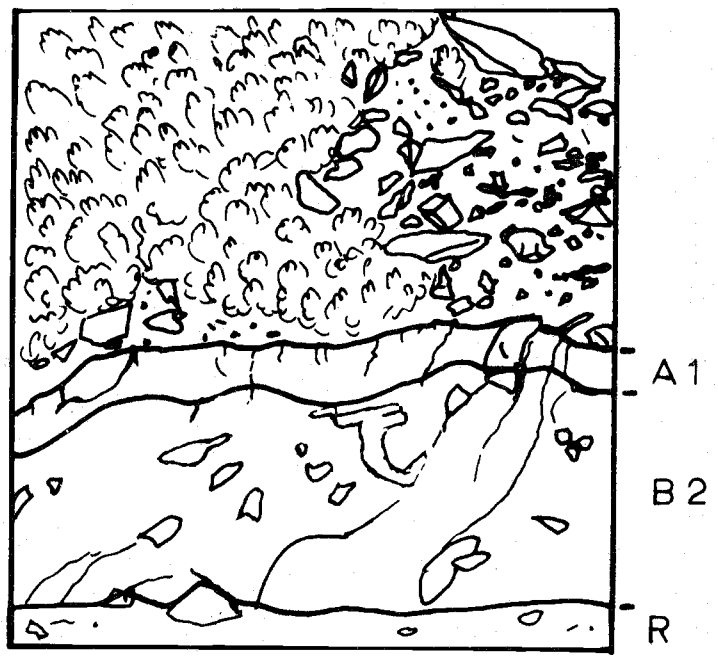

Figure 7. Residual soils of the ridges, unforested; Findley Lake, Washington (site 10).

Table 10. Description of a residual soil of the ridges, unforested; Findley Lake, Washington.

Site: 10

Location: ridgetop at extreme south end of basin

Vegetation: *Vaccinium*, mosses

Parent materials: residuum from basalt

Topography: ridgetop; 38% slope; pit located in upper portion of slope; straight slope; aspect 260°/Az; elevation 1448 m (4650 ft)

Drainage: somewhat excessively drained

Soil classification: residual soil of ridge, unforested

Horizon	Depth (cm)	Description
O1 + O2	tr.	Fresh and partially decomposed herbaceous litter
A1	0-8	Dark brown (7.5YR 3/2)very cobbly sandy loam; moderate, very fine crumb structure; very friable; nonsticky, nonplastic; abrupt wavy boundary; abundant microroots; thickness 5-8 cm; very fine (less than 5 mm diameter) charcoal fragments; 60% cobbles
B2	8-13	Dark yellowish brown (10YR 3/4) gravelly sandy loam; moderate,very fine crumb structure; very friable; abundant micro- and plentiful fine roots; slightly sticky, slightly plastic; very fine charcoal fragments; 5-10% cobbles, 10-15% gravel
R	13+	Fresh basalt bedrock; smooth, sloping surface

Figure 8. Soil of talus; Findley Lake, Washington (site 4).

Table 11. Description of soil of talus; Findley Lake, Washington.

Site: 4

Location: east side of Findley Lake, upper talus below andesite "fortress"

Vegetation: lichens and mosses

Parent materials: talus composed of andesite

Topography: talus cone; 62% slope; pit located in middle of slope; straight slope; west-facing; elevation 1280 m (4200 ft)

Drainage: excessively drained

Soil classification: soil of talus

Horizon	Depth (cm)	Description
C	0-80	Angular and subangular cobbles and boulders of andesite in a loosely knit network with an abundance of voids; at about 25 cm the material becomes predominantly cobbly with a matrix of mineral soil and needles; fine material is a reddish black (10YR 1/1) silt loam; moderate, very fine crumb structure; very friable; slightly sticky, slightly plastic; no roots, volcanic ash(?)

REFERENCES

CRANDELL, D. R. 1965. The glacial history of western Washington and Oregon. IN: Wright, J. E., Jr., and D. G. Frey (eds.), The Quaternary of the United States, p. 341-353. Princeton Univ. Press, Princeton, N.J.

DOUGLAS, G. W. 1969. A preliminary biological survey of the North Cascades National Park and the Ross Lake and Lake Chelan National Recreation Area. Unpubl. report submitted to National Park Service, 1 March 1969. 195 p.

GILKESON, R. H., W. A. STARR, and E. C. STEINBRENNER. 1961. Soil survey of the Snoqualmie Falls Tree Farm. Cooperative publication of Weyerhaeuser Co. For. Res. Cent., Centralia, Wash., and Wash. State Univ. Inst. Agric. Sci., Agric. Exp. Stn., Pullman. 38 p.

HAMMOND, P. E. 1963. Structure and stratigraphy of the Keechelus Volcanic Group and associated Tertiary rocks in the west-central Cascade Range, Washington Unpubl. Ph.D. thesis. (Dept. Geol.), Univ. Washington, Seattle. 264 p.

IRITANI, D. 1969. Soils report, Green River watershed, Snoqualmie National Forest. Unpubl. report, USDA For. Serv.

KUBIENA, W. 1953. The soils of Europe. T. Murby, London. 317 p.

MACKIN, J. H. 1941. Glacial geology of the Snoqualmie-Cedar area, Washington. J. Geol. 49(5):449-481.

PIPER, C. V. 1906. Flora of the State of Washington. Contrib. U.S. Nat. Herb. Vol. 11.

PORTER, S. C. 1969. Pleistocene geology of the east-central Cascade Range, Washington. Guide. 3d Conf. Pac. Friends Pleistocene. 54 p.

SMITH, F. C.,and F. C. CALKINS. 1906. Description of the Snoqualmie quadrangle (Washington). U.S. Geol. Surv. Atlas, Folio 139.

SNYDER, R. ----. Soil resource inventory of the Snoqualmie National Forest. USDA For. Serv. (in press).

WASHINGTON STATE UNIVERSITY, COLLEGE OF AGRICULTURE. 1968. Washington climate for these counties: King, Kitsap, Mason, Pierce, Cooperative Extension Service, College of Agriculture, Washington State University, Pullman, Ecol. Monogr. 2734. 65 p.

WESTERN LAND GRANT UNIVERSITIES AND COLLEGES et al. 1964. Soils of the western United States (exclusive of Hawaii and Alaska). Regional publication by Western Land Grant Universities and Colleges with cooperative assistance by the Soil Conservation Service, U.S. Department of Agriculture published at Washington State Univ., Pullman.