PROPOSAL FOR THE ESTABLISHMENT OF THE 'MCMINNVILLE' AMERICAN VITICULTURAL AREA IN OREGON

With the following proposal and supporting documents we are petitioning the BATF for the establishment in the North Willamette Valley, of an American Viticultural Area (AVA) as defined in section 27 CFR 4.25a(e)(1) with the designation " McMinnville ".

The proposed AVA contains an approximate total acreage of 40,448 acres, and a total vineyard acreage of 523 acres (Exhibit A).

Evidence that the area is known by the proposed name:

The city of McMinnville anchors the Eastern border of the proposed AVA (USGS, McMinnville Quadrangle). In addition, the city of McMinnville serves as the postal code for the majority of the proposed AVA (Exhibit A). As the Yamhill County seat, McMinnville is also the most prominent city in the area.

Evidence Supporting the Proposed Boundary:

Geographical Features: The area for the proposed AVA includes Gopher Valley, Dupee Valley and Muddy Valley. These valleys and the surrounding hills are geologically part of the eastern foothills of the Coast Range. To the west of the area is the Van Duzer Corridor. This is a natural pass through the Coast Range and greatly influences the climate of the proposed area.

The proposed Eastern boundary lies within a saddle marking the transition between the purely sedimentary soils of the Yamhill-Carlton District and the marine based basalts and sandstones of the proposed AVA[2]

The Western and Northern boundaries of the proposed AVA define the upper reaches of the area and mark the transition to the slopes of the Coast Range. Beyond this boundary, temperature and precipitation conditions change significantly (Exhibit B - Willamina, Otis, and Haskins Dam) and create growing conditions substantially different than those experienced within the proposed boundary.

The Southern boundary of the proposed AVA marks the transition to the valley floor. The deep, Willamette silt based soils[3], exhibit restricted internal drainage[4] and greater average fertility[5] that mark them as distinct from the soils present within the proposed AVA. In addition, the valley floor sites experience a greater risk of spring and fall frosts when compared to hill sites[4].

Distinguishing Geographical Features:

Temperature Considerations:

Growing season temperatures in the proposed area are cooler than the areas immediately to the east and south. This is a result of cool marine air passing inland through the Van Duzer Corridor. The Oregon Climate Service 30 year average of temperature (1961-1990) and Weather.Com show that the area within the proposed AVA averages 1838 degree growing days above 50 degrees (Exhibit B - Sheridan). Compare this with valley floor readings to the south-east (Exhibit B - McMinnville) that average 1922 DGG. To the north and west of the AVA, the land makes a rapid transition to the slopes of the Coast Range. Once on the slopes of the Coast Range, degree growing days decrease to 1593 (Exhibit B - Willamina).

Precipitation Considerations:

The influence of the Van Duzer Corridor also creates a unique precipitation profile within the boundaries of the proposed AVA. Within the proposed AVA boundary, normal annual precipitation averages 41.5". Beyond the north and west boundaries, average annual precipitation exceeds 57" (Exhibit B - Haskins Dam, Willamina, Otis).

Geological Considerations:

Within the boundaries of the proposed AVA, the soils are characterized by several types of shallow (<40" deep) silty clay and clay loams (Exhibit G) that exhibit low total available moisture[5]. These soils, primarily Yamhill[20], Nekia[15], Peavine[17], Willakenzie[18], and Hazelair[13] all have typical depth to base materials of between 20" and 40". As well, the average total available moisture for these soils is 4.8" to 6.3"[5].

To the West and Northwest of the proposed AVA, the soils transition to those of the Olyic and Hembre associations (Exhibit G). These soils are also shallow silty clay and clay loams, however they tend to be strongly acidic. As well, annual average precipitation for these soils is 60" to 120"[16](Exhibit G). This is significantly greater than the 40" to 50" of average precipitation that characterizes the soils within the proposed AVA.

To the North (within the boundary of the proposed Yamhill-Carlton AVA), a greater percentage of the soils are of the Woodburn-Willamette association (Exhibit G). These soils are of a greater depth (60")[19] and have a higher total available moisture (12" - 13")[5]. The Woodburn-Willamette soils also predominate to the South and Southwest of the proposed AVA (Exhibit G).

The most singular geologic feature within the proposed AVA is the presence of approximately 2000' of Nestucca Formation[10]. This formation is unique to the AVA, extending west from McMinnville and terminating at the slopes of the coast range.

Elevation Exclusions:

Within the boundaries of the proposed AVA, all lands below 200' are excluded. The deep Willamette silt based soils present below this elevation exhibit several characteristics that create substantially different growing conditions when compared with the soils at the higher elevations. The greater depth, water holding capacity, and fertility of these soils extends the vegetative period of the vine and delays ripening of vineyards planted in these areas. As well, the lower elevations are more prone to frost when compared to hill sites[5].

Within the boundaries of the proposed AVA, all lands above 800' are excluded. The lands lying above this elevation experience far fewer degree growing days than those lying below this elevation. The significant reduction in degree growing days prevents the reliable ripening of wine grapes

SUMMARY OF CLIMATE AND SOIL CHARACTERISTICS
WITHIN AND BEYOND THE BOUNDARY OF
THE PROPOSED "MCMINNVILLE" AVA

Location	Avg. DGD[a]	Ave. Precip.	Soil Depth	TAM[b]
Within AVA	1838	40"-50"	20"-40"	4.8"-6.3"
N of AVA	1922	40"-50"	> 60"	4.8"-13"
W/NW of AVA	1593	60"-120"	20"-40"	4.8"-6.3"
S/SE of AVA	1922	40"-50"	> 60"	12"-13"

a Growing Degree Days > 50 degrees F
b Average Total Available Moisture

Ground Water Considerations:

The seafloor basalts of the proposed AVA (Exhibits C, D) also exhibit significant differences in ground water composition when compared with the Miocene basalts of the areas to the east (Exhibits E, F). Of primary interest are dissolved Sodium (66 mg/L, seafloor vs. 16 mg/L, Miocene); dissolved Potassium (.9 mg/L, seafloor vs. 3.8 mg/L, Miocene); dissolved Boron (230 ug/L seafloor vs. 20 ug/L Miocene). Significant variations in these component materials can result in unique flavor and development characteristics of any resulting fruit.

Description of Boundary for the proposed appellation:

1. The intersection of **Baker Creek Road** and **Hill Road** (USGS, McMinnville Quadrangle) serves as the point of beginning.

✓ 2. From the point of beginning follow **Baker Creek Road** in a westerly direction to the intersection with **Power Plant Hill Road** (locally as Power House Hill Road). map 2

✓ 3. Then Southwest on **Power Plant Hill Road** to the intersection with **Peavine Road.**

✓ 4. Follow **Peavine Road** north-west to the intersection with **Gill Creek**.

✓ 5. Follow **Gill Creek** in a south-westernly direction to the intersection with the **800' contour line**.

✓ 6. Starting in a north-westernly direction, follow the **800' contour line** to the intersection with **Rock Creek Road (west fork)**. Note: East Fork Rock Creek Road know locally as Thompson Mill Road. map 3

✓ 7. Follow **Rock Creek Road** south to the intersection with the **Salmon River Highway (Highway 18 Business Loop)**. map 4

✓ 8. Follow the **Salmon River Highway** east to the intersection with **Oldsville Road**.

✓ 9. Follow **Oldsville Road** north-east to the intersection with **McCabe Chapel Road (unmarked on included USGS map)**.

✓ 10. Follow **McCabe Chapel Road** north to the intersection with **Masonville Road**.

✓ 11. Follow **Masonville Road** east to the intersection with **Old Sheridan Road**.

✓ 12. Follow **Old Sheridan Road** north-east to the intersection with **Peavine Road**.

✓ 13. Follow **Peavine Road** north-west to the intersection with **Hill Road**.

✓ 12. Follow **Hill Road** north to the intersection with **Baker Creek Road** and the point of beginning.

Within the aforementioned boundaries the AVA applies to lands which are at or above 200' in elevation and at or below 800' in elevation.

References:

Roadside Geology of Oregon; David D. Alt, Donald W. Hyndman; Mountain Press Publishing Company; 1991

Geology of Oregon; Elizabeth & William Orr, Ewart M. Baldwin; Kendall/Hunt Publishing Company; 1992

The following U.S.G.S. 7.5" Series Maps
- McMinnville Quadrangle, Oregon, Yamhill County, 1954, Revised 1970
- Muddy Valley Quadrangle, Oregon, Yamhill County, 1979
- Stony Mountain Quadrangle, Oregon, 1979
- Sheridan Quadrangle, Oregon, 1956, Revised 1970
- Ballston Quadrangle, Oregon, 1956, Revised 1970

Oregon Climate Service, www.ocs.orst.edu

Weather.Com, Willamina, OR 97396

Weather.Com, Sheridan, OR 97378

Oregon State, Drinking Water Program.

Random House College Dictionary, Revised Edition; 1984.

Oregon Wine Grape Growers Guide; Oregon Winegrowers Association; 1992.

Soil Survey of Yamhill County, US Department of Agriculture, Soil Conservation Service.

Bibliography

1. Random House College Dictionary, Revised Edition, 1984; page 514.
2. Roadside Geology of Oregon; David D. Alt, Donald W. Hyndman; Mountain Press Publishing Company, 1991; page 100.
3. Geology of Oregon; Elizabeth & William Orr, Ewart M. Baldwin; Kendall/Hunt Publishing Company, 1992; page 213.
4. Oregon Wine Grape Growers Guide; Oregon Winegrowers Association, 1992; page 11.
5. Ibid, page 13.
6. Roadside Geology of Oregon; page 56.
7. Ibid; page 100.
8. Ibid; page 55.
9. Ibid; page 58
10. Geology of Oregon; page 205.
11. Ibid; page 213.
12. Yamhill County Soil Survey; page 21 - Ead Series
13. Ibid; page 22 - Hazelair Series
14. Ibid; page 24 - Jory Series
15. Ibid; page 31 - Nekia Series
16. Ibid; page 32 - Olyic Series
17. Ibid; page 34 - Peavine Series
18. Ibid; page 39 - Willakenzie Series
19. Ibid; page 41 - Woodburn Series
20. Ibid; page 42 - Yamhill Series

Exhibits for McMinnville AVA petition –

A. List of area vineyards.
B. Climate statistics: average high & low temperatures, average degree growing days, average precipitation.
C. Location of sampling sites for Marine rocks of the Coast Range.
D. Descriptive statistics of ground-water quality for the Marine rocks of the Coast Range.
E. Location of sampling sites in the Columbia River Basalt aquifer.
F. Descriptive statistics of ground-water quality for the Columbia River basalt aquifer.
G. General soil map, Yamhill Area, Oregon.

Exhibit A:

Vineyard	Address	Acreage
Anderson	17450 SW Oldsville Rd., McMinnville	12.0
Coleman	22734 SW Latham, McMinnville	22.5
Discovery	SW Latham, McMinnville	19.6
Four Winds	Fox Ridge Rd. , McMinnville	14.5
Fox Ridge	Fox Ridge Rd. , McMinnville	7.1
Hyland	17500 SW Oldsville Rd. , McMinnville	101.5
Lone Oak	2100 SW Eagle Point Rd. , McMinnville	17.7
Meredith-Mitchell	14030 SW McCabe Chapel Rd. , McMinnville	31.6
Momtazi	15765 Muddy Valley Rd. , McMinnville	150.0
Mystic Mountain	22470 SW Benette Rd. , McMinnville	18.4
Schouten	17830 SW Sunnyridge Ln., Sheridan	9.3
Stony Mountain	Thompson Mill Rd., Sheridan	6.8
Yamhill Valley	16250 SW Oldsville Rd. , McMinnville	100.0
Youngberg	10660 SW Youngberg Hill, McMinnville	12.0
	TOTAL	**523.0**

Exhibit B

Average High Temperature

city	january	february	march	april	may	june	july	august	september	october	november	december
dundee	46	51	56	61	68	75	82	82	76	64	52	45
mcminn.	47	51	56	62	69	75	82	83	77	65	53	46
sheridan	46	51	55	61	68	75	82	82	77	65	52	45
willamina	45	50	54	59	66	72	79	81	75	64	52	45
otis	47	51	54	57	61	66	69	71	69	61	52	47

Average Low Temperature

city	january	february	march	april	may	june	july	august	september	october	november	december
dundee	33	35	36	38	42	47	49	49	46	41	37	33
mcminn.	34	36	37	39	43	47	49	50	47	42	38	34
sheridan	32	34	36	37	42	46	48	48	46	41	37	33
willamina	31	33	34	36	40	46	48	48	45	40	35	32
otis	36	38	38	39	43	48	50	50	48	45	40	37

Average Degree Growning Days @ 50 degrees

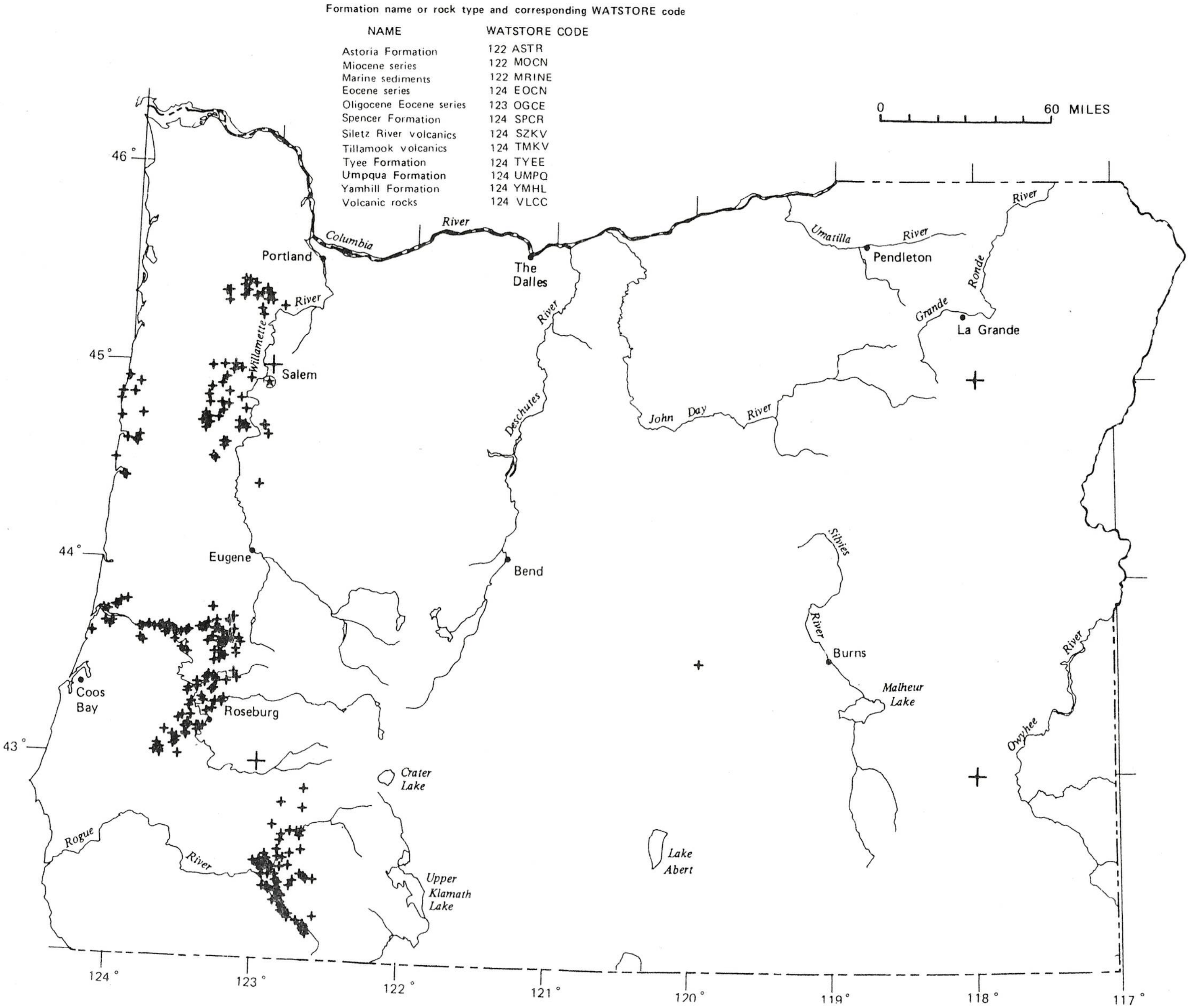
city	january	february	march	april	may	june	july	august	september	october	november	december	total year
dundee	0	0	0	0	155	330	481	481	330	78	0	0	1854
mcminn.	0	0	0	0	186	330	481	512	360	109	0	0	1977
sheridan	0	0	0	0	155	315	465	465	345	93	0	0	1838
willamina	0	0	0	0	93	270	419	450	300	62	0	0	1593
otis	0	0	0	0	62	210	295	326	255	93	0	0	1240

Method: DGD = (Average Monthly Temperature -50)* # of days in month

Average Precipitation

city	january	february	march	april	may	june	july	august	september	october	november	december	total year
haskins dam													75.3
dundee	7.2	5.2	4.9	2.6	1.9	1.0	0.5	0.7	1.6	3.2	6.7	7.8	43.3
mcminn.	6.5	5.1	4.8	2.6	1.8	1.0	0.5	0.7	1.6	3.0	6.2	7.7	41.5
sheridan	8.1	6.0	5.6	2.7	1.9	1.2	0.5	0.7	1.6	3.3	7.7	9.1	48.4
willamina	8.4	9.0	8.1	3.7	2.4	1.3	0.5	0.9	1.7	4.6	7.6	9.4	57.6
otis	14.9	11.1	11.1	6.8	4.8	3.7	1.7	1.9	3.9	7.7	14.3	15.6	97.5

EXHIBIT C



Formation name or rock type and corresponding WATSTORE code

NAME	WATSTORE CODE
Astoria Formation	122 ASTR
Miocene series	122 MOCN
Marine sediments	122 MRINE
Eocene series	124 EOCN
Oligocene Eocene series	123 OGCE
Spencer Formation	124 SPCR
Siletz River volcanics	124 SZKV
Tillamook volcanics	124 TMKV
Tyee Formation	124 TYEE
Umpqua Formation	124 UMPQ
Yamhill Formation	124 YMHL
Volcanic rocks	124 VLCC

Figure 10.--Location of sampling sites for Marine rocks of the Coast Ranges.

EXHIBIT D

Table 8.--Descriptive statistics of ground-water quality for the Marine rocks of the Coast Ranges (271 total analyses)

[Units are mg/L except as noted.]

Number of samples	Constituent analyzed	Minimum	25 percentile	Median-50 percentile	75 percentile	Maximum
267	Calcium, dissolved	0.3	6.7	20	48	5,000
263	Magnesium, dissolved	.1	1.1	3.3	9.5	210
260	Sodium, dissolved	2.4	24	66	160	3,000
253	Potassium, dissolved	.1	.6	.9	1.5	73
248	Sulfate, dissolved	.1	3.9	8.6	20	395
178	Nitrite + Nitrate, dissolved (as N)	.01	.02	.10	.37	5.0
259	Chloride, dissolved	1	5	17	120	11,000
256	Alkalinity, total (as $CaCO_3$)	2	78	148	230	3,570
266	pH (units)	5.3	7.3	7.8	8.3	10.6
268	Specific conductance (micromhos/cm at 25°C)	9	263	460	849	24,300
266	Hardness, total (as $CaCO_3$)	1	24	68	161	13,000
252	Dissolved solids (sum of constituents)	30	170	282	487	7,050
204	Temperature (°Celsius)	8	12	14	16	63
222	Bicarbonate (as HCO_3)	3	103	180	274	4,353
184	Iron, dissolved (ug/L)	9	30	60	278	19,000
130	Arsenic, dissolved (ug/L)	1	1	1	2	150
197	Boron, dissolved (ug/L)	1	40	230	705	16,000
256	Fluoride, dissolved	.1	.2	.3	.6	10
259	Silica, dissolved (as SiO_2)	3.2	13	21	30	110
161	Collection depth (feet)	14	80	112	173	735

EXHIBIT E

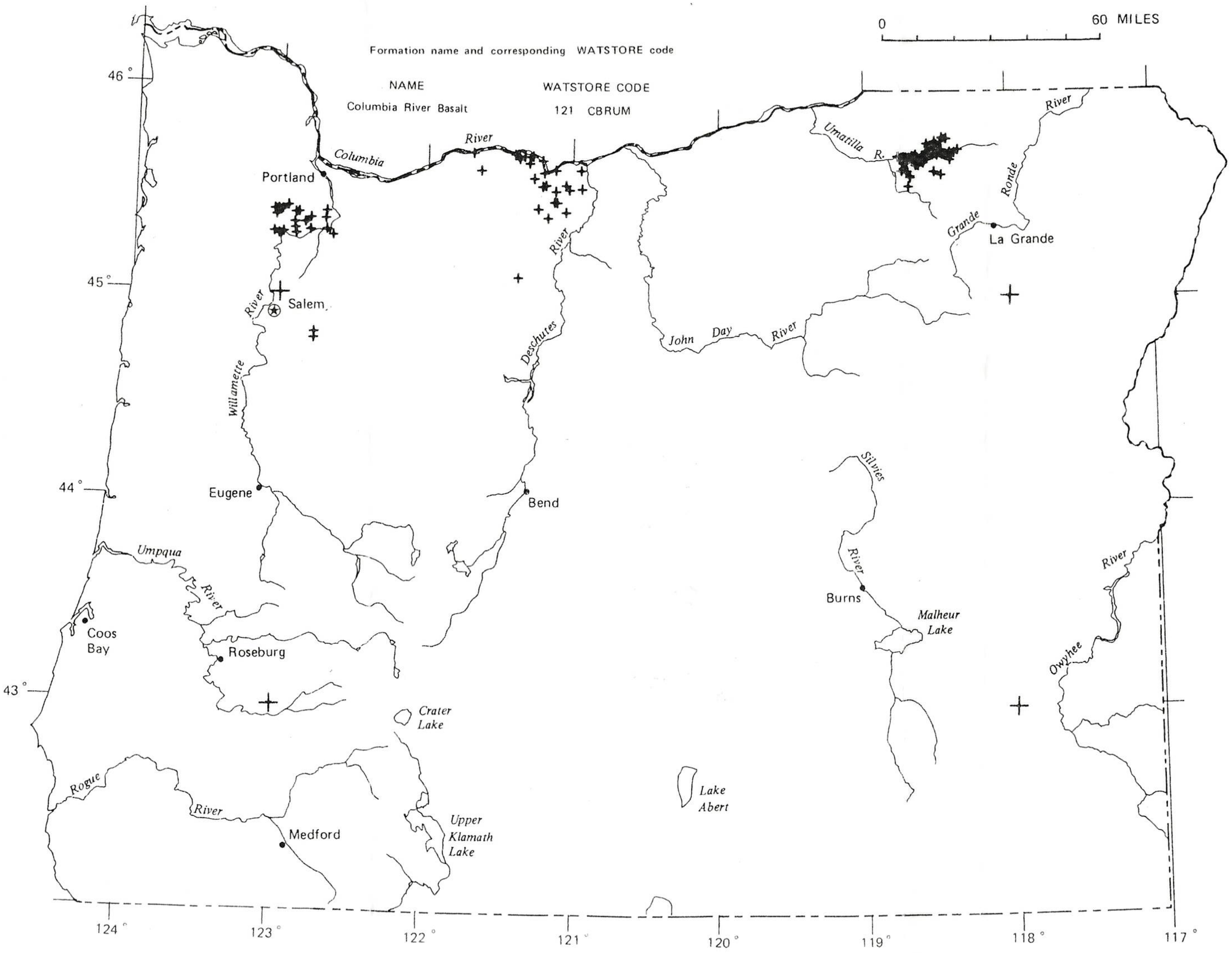


Figure 18.--Location of sampling sites in the Columbia River Basalt aquifer.

EXHIBIT F

Table 11.--Descriptive statistics of ground-water quality for the Columbia River basalt aquifer (95 total analyses)

[Units are mg/L except as noted.]

Number of samples	Constituent analyzed	Minimum	25 percentile	Median-50 percentile	75 percentile	Maximum
91	Calcium, dissolved	0.4	14	19	27	140
90	Magnesium, dissolved	1.0	5.4	7.8	12	36
89	Sodium, dissolved	3.6	9.2	16	32	100
92	Potassium, dissolved	.8	2.5	3.8	5.1	18
95	Sulfate, dissolved	.1	2.6	6.0	11	150
90	Nitrite + Nitrate, dissolved (as N)	.01	.08	.18	1.1	19
92	Chloride, dissolved	1	2	3	7	400
93	Alkalinity, total (as $CaCO_3$)	11	92	115	144	234
91	pH (units)	5.9	7.2	7.8	8.0	8.6
93	Specific conductance (micromhos/cm at 25°C)	69	187	261	333	1,200
91	Hardness, total (as $CaCO_3$)	1	57	82	120	430
89	Dissolved solids (sum of constituents)	51	156	200	238	768
93	Temperature (°Celsius)	8	12	14	16	30
71	Bicarbonate (as HCO_3)	14	104	132	170	285
91	Iron, dissolved (ug/L)	10	20	30	110	8,100
75	Arsenic, dissolved (ug/L)	1	1	1	1	4
86	Boron, dissolved (ug/L)	2	9	20	30	140
95	Fluoride, dissolved	.1	.1	.3	.6	1.7
95	Silica, dissolved (as SiO_2)	6.6	48	55	60	99
87	Collection depth (feet)	10	150	315	500	1,103

Ex

SOIL ASSOCIATIONS

AREAS DOMINATED BY SOMEWHAT EXCESSIVELY DRAINED TO POORLY DRAINED, NEARLY LEVEL AND GENTLY SLOPING SOILS ON BOTTOM LANDS

1 Chehalis-Cloquato-Newberg association: Well-drained and somewhat excessively drained silty clay loams, silt loams, and fine sandy loams

Wapato-Cove association: Poorly drained silty clay loams and clays

AREAS DOMINATED BY WELL-DRAINED TO POORLY DRAINED, NEARLY LEVEL TO MODERATELY STEEP SOILS ON TERRACES

3 Woodburn-Willamette association: Moderately well drained and well drained, nearly level to moderately steep silt loams and silt loams over silty clay loam

4 Amity-Dayton association: Somewhat poorly drained and poorly drained, nearly level silt loams over silty clay loam and clay

AREAS DOMINATED BY WELL-DRAINED TO SOMEWHAT POORLY DRAINED, GENTLY SLOPING TO VERY STEEP SOILS ON LOW FOOTHILLS OF THE OREGON COAST RANGE

5 Laurelwood association: Well-drained, gently sloping to steep silt loams over silty clay loam; formed in mixed material

6 Jory-Yamhill-Nekia association: Well-drained, gently sloping to very steep, clay loams over clay and silt loams over silty clay; formed in basaltic colluvium

7 Willakenzie-Hazelair association: Well-drained and somewhat poorly drained, gently sloping to steep silty clay loams and silty clay loams over clay; formed over sedimentary rock

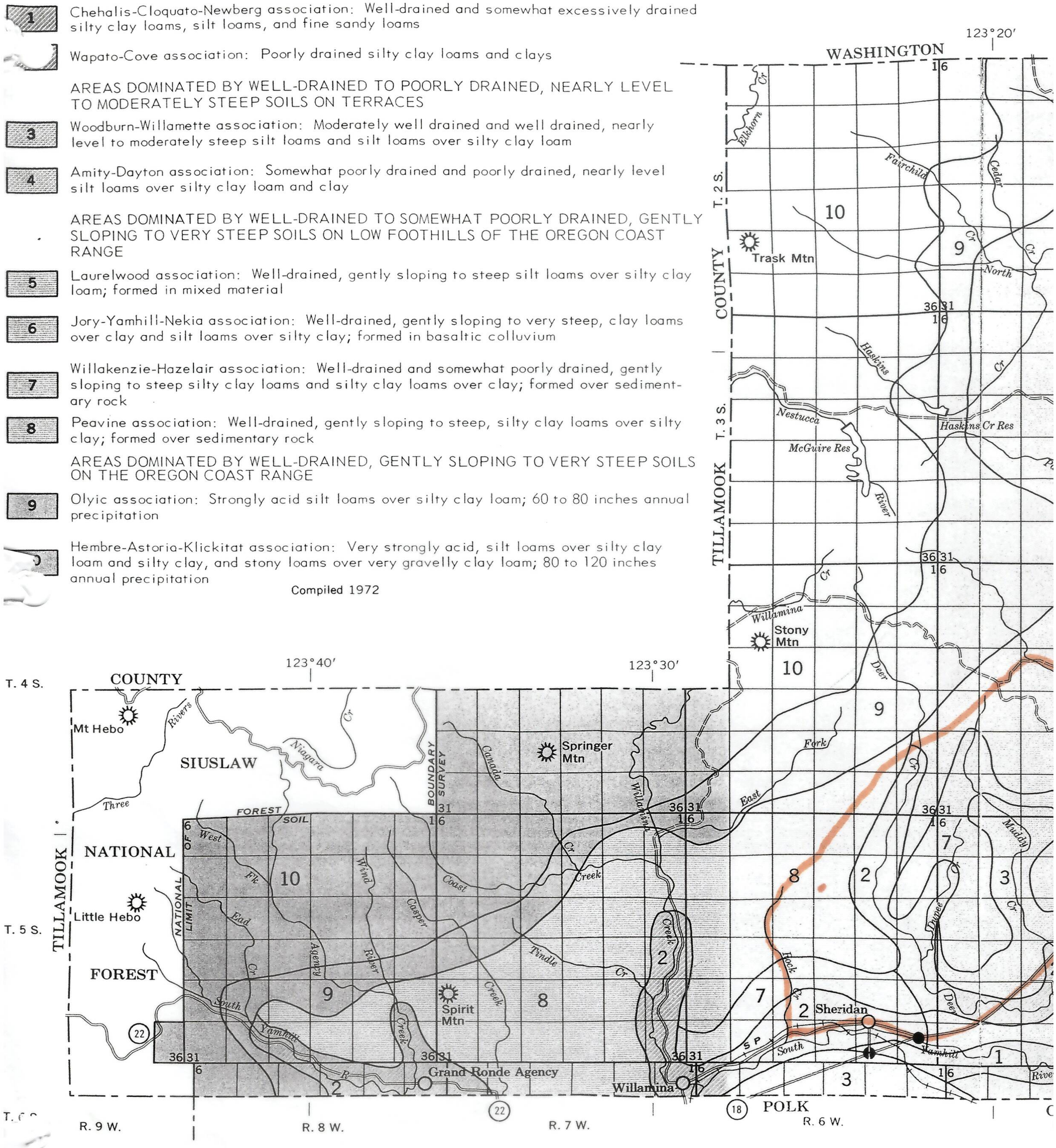
8 Peavine association: Well-drained, gently sloping to steep, silty clay loams over silty clay; formed over sedimentary rock

AREAS DOMINATED BY WELL-DRAINED, GENTLY SLOPING TO VERY STEEP SOILS ON THE OREGON COAST RANGE

9 Olyic association: Strongly acid silt loams over silty clay loam; 60 to 80 inches annual precipitation

0 Hembre-Astoria-Klickitat association: Very strongly acid, silt loams over silty clay loam and silty clay, and stony loams over very gravelly clay loam; 80 to 120 inches annual precipitation

Compiled 1972



…IT G

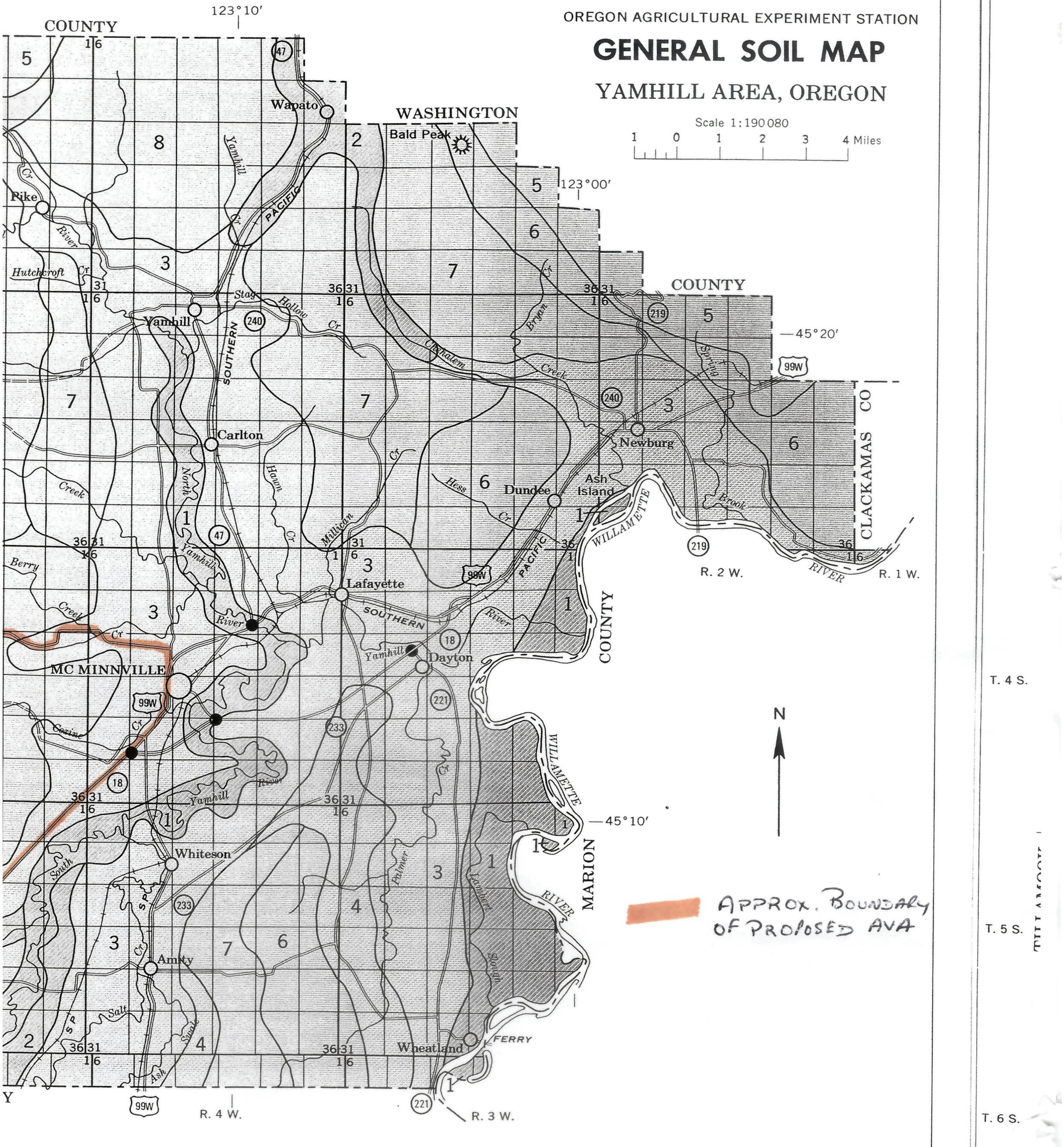
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

OREGON AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP

YAMHILL AREA, OREGON

Scale 1:190 080



APPROX. BOUNDARY OF PROPOSED AVA

This map is for general planning. It shows only the major soils and does not contain sufficient detail for operational planning.

Ead Series

The Ead series consists of well-drained soils that formed over sedimentary rock in the Coast Range. Slopes are 5 to 60 percent. Elevations are 400 to 1,000 feet. Annual precipitation is 60 to 70 inches, average annual air temperature is 49° F., and the frost-free season is 145 to 200 days. The vegetation is Douglas-fir, vine maple, alder, and swordfern. Ead soils are associated with Astoria and Peavine soils that also formed over sedimentary rock and with Knappa and Grande Ronde soils on terraces.

In a representative profile, the surface layer is very dark brown silty clay loam about 7 inches thick. The subsoil is dark-brown, firm, silty clay or light clay about 15 inches thick. The substratum is firm, strong-brown silty clay. Very pale brown, pinkish-gray and reddish-yellow siltstone is at a depth of about 33 inches.

Ead soils are used for timber, water supply, wildlife habitat, and recreation.

Ead silty clay loam, 5 to 30 percent slopes (EAE).—This soil is on the tops and sides of ridges in the eastern part of the Coast Range.

Representative profile on cutover land near Grand Ronde, about 15 feet north of a fire road, 150 yards southeast of fire road junction; NW¼NE¼NW¼ sec. 5, T. 6 S., R. 8 W.:

A1—0 to 7 inches, very dark brown (10YR 2/2) silty clay loam, dark grayish brown (10YR 4/2) when dry: moderate and strong, very fine, subangular blocky structure; friable, hard, slightly sticky, plastic; many medium, fine, and very fine roots; many very fine irregular pores; very strongly acid (pH 5.0); abrupt, smooth boundary. (6 to 7 inches thick)

B21—7 to 13 inches, dark-brown (7.5YR 3/2) silty clay, dark brown (7.5YR 4/3) when dry; moderate, fine, subangular blocky structure; firm, hard, sticky, very plastic; common fine irregular pores; many fine roots; very strongly acid (pH 4.8); clear, smooth boundary. (5 to 8 inches thick)

B22—13 to 22 inches, dark-brown (7.5YR 3/3) light clay, dark brown (7.5YR 4/4) when dry; moderate, fine and very fine, subangular blocky structure; firm, hard, sticky, very plastic; many very fine irregular pores; common fine roots; few very fine siltstone fragments; very strongly acid (pH 4.6); clear, wavy boundary. (8 to 11 inches thick)

C—22 to 33 inches, strong-brown (7.5YR 5/6) silty clay, reddish yellow (7.5YR 6/6) when dry; weak, fine, subangular blocky structure; firm, hard, sticky, plastic; common fine irregular pores; few fine roots; 40 percent of the horizon is fragments of pinkish-gray (7.5YR 7/2) and reddish-yellow (7.5YR 6/6) siltstone; few yellowish-red (5YR 5/6) stains and coatings as much as 3 inches in diameter; extremely acid (pH 4.4); gradual, wavy boundary. (1 to 16 inches thick)

R—33 to 40 inches, very pale brown (10YR 7/3), pinkish-gray (7.5YR 7/2), and reddish-yellow (7.5YR 6/6) siltstone that has a few roots and thin dark-brown (7.5YR 4/4) films in fractures.

Moist value for the A horizon is dominantly 2 but ranges to 3. Chromas are 2 or 3 dry and moist. Hue ranges from 10YR to 7.5YR. Moist values of the B horizon are 3 but range to 4 in the lower part. Moist chromas are 2 and 3 but range to 4 in the lower part of the thicker sola; dry chromas range from 3 to 4. Hue is predominantly 7.5YR, but ranges to 10YR. Texture ranges from silty clay to clay. Content of fine sedimentary rock fragments is 0 to 15 percent by volume. Hue in the C horizon generally is 7.5YR but ranges to 5YR. Moist values are 4 and 5, and chromas are 4 and 6. The boundary between the C and R horizons is gradual, commonly diffuse, and difficult to distinguish in some profiles. Depth to bedrock ranges from 20 to 40 inches, but is dominantly 25 to 35 inches.

Included with this soil in mapping are areas of Astoria, Hembre, and more steeply sloping Ead soils. These areas are less than 5 acres in size and occupy less than 15 percent of the total acreage.

This soil has moderate permeability. Roots can penetrate to depths of less than 40 inches. The available water capacity is 3 to 7 inches. Fertility is moderately low. The erosion hazard is moderate. Runoff is medium where the soil is cleared.

This soil is used mainly for timber. Douglas-fir is the major species. Capability unit VIe-2, woodland group 2c2; wildlife group 5.

Ead silty clay loam, 30 to 60 percent slopes (EAF).—This steep soil is on the eastern part of the Coast Range. Runoff is rapid in cleared areas, and the hazard of erosion is severe. Douglas-fir is the important tree species. Capability unit VIe-3; woodland group 2c3; wildlife group 5.

Fresh Water Marsh

Fresh water marsh (FW) is low-lying areas on the narrow stream bottoms in the Coast Range. It consists of a variety of soil materials and rock fragments mixed with roots, tree limbs, and other organic material. The water stands at or near the surface. The vegetation is sedges, skunk cabbage, and other water-tolerant plants. A few alder, willow, and cedar trees also grow on this land type. Capability unit VIIIw-1; not placed in a woodland group; wildlife group 5.

Grande Ronde Series

The Grande Ronde series consists of somewhat poorly drained soils that formed in old alluvium on terraces in small valleys. Slopes are 0 to 2 percent. Elevations are 300 to 500 feet. Annual precipitation is 60 to 80 inches, average annual air temperature is 49° F., and the frost-free period is 165 to 210 days. In areas that are not cultivated, the vegetation is oak, alder, willow, and grasses. Grande Ronde soils are associated with well-drained Knappa soils on terraces and Peavine and Ead soils on uplands.

In a representative profile, the surface layer is dark-brown silty clay loam about 6 inches thick. The subsoil is mottled dark-brown, yellowish-brown, and pale-brown, firm silty clay about 18 inches thick. It is underlain by yellowish-brown and light brownish-gray clay that extends to a depth of 60 inches or more.

Grande Ronde soils are used mainly for spring grain, grass seed, hay, and pasture. They are also used for water supply, wildlife habitat, and recreation.

Grande Ronde silty clay loam (0 to 2 percent slopes) (Gr).—This nearly level soil is on terraces.

Representative profile half a mile north of the Grand Ronde Agency store, 75 feet east of the road; NW¼NW¼ NE¼ sec. 1, T. 6 S., R. 8 W.:

Ap—0 to 6 inches, dark-brown (10YR 4/3) silty clay loam, pale brown (10YR 6/3) when dry; many, very fine, distinct, dark reddish-brown mottles; moderate, fine, subangular blocky structure; friable, slightly hard, slightly sticky, plastic; many fine irregular pores; many fine roots; very strongly acid (pH 5.0); abrupt, smooth boundary. (5 to 10 inches thick)

B1—6 to 11 inches, dark-brown (10YR 4/3) heavy silty clay loam, pale brown (10YR 6/3) when dry; many, very fine, distinct, dark reddish-brown and reddish-brown mottles; moderate, fine, subangular blocky structure; friable, slightly hard, sticky, plastic; many fine irregular pores; common fine roots; very strongly acid (pH 4.8); clear, smooth boundary. (4 to 8 inches thick)

B21—11 to 18 inches, yellowish-brown (10YR 5/4) silty clay, very pale brown (10YR 7/3) when dry; many, fine, distinct, dark yellowish-brown mottles; moderate, fine, subangular blocky structure; firm, hard, sticky, plastic; many very fine and fine irregular and tubular pores; few fine roots; thin, patchy, dark-colored coatings on some ped surfaces; continuous gray coatings on some ped surfaces; continuous gray coatings of clean silt and fine sand grains on ped surfaces; very strongly acid (pH 4.6); clear, smooth boundary. (4 to 10 inches thick)

B22—18 to 24 inches, pale-brown (10YR 6/3) silty clay, very pale brown (10YR 7/3 and 8/3) when dry; many, fine, distinct, dark yellowish-brown mottles; weak, fine, subangular blocky structure; firm, hard, very sticky, plastic; many very fine tubular pores; few fine roots; many black coatings; continuous gray coatings of clean silt and fine sand grains on ped surfaces; very strongly acid (pH 4.6); clear, smooth boundary, (4 to 10 inches thick)

IIC1—24 to 34 inches, yellowish-brown (10YR 5/6) clay, light yellowish brown (10YR 6/4) when dry; many, distinct, gray mottles; massive; coarse prismatic structure when dry; very firm, very hard, very sticky, very plastic; few very fine pores; very strongly acid (pH 4.5); clear, smooth boundary. (8 to 15 inches thick)

IIC2—34 to 60 inches, light brownish-gray (2.5Y 6/2) clay, light gray (2.5Y 7/2) when dry; many, fine distinct, yellowish-brown mottles; massive; very firm, very hard, very sticky, very plastic; few very fine pores; common fine fragments of sedimentary rock; few pebbles of igneous rock; few, small, black coatings on some vertical fractures; very strongly acid (pH 4.6).

The A horizon has no or few faint or distinct mottles, a 10YR hue, and moist chromas of 2 or 3. The B horizon has moist values of 4 to 6. Texture ranges from silty clay to clay, and the structure is weak or moderate. Mottles are distinct or prominent at depths of less than 20 inches. The underlying IIC horizon is massive or has weakly prismatic structure. In some places it contains fragments of siltstone and shale and pebbles of basalt. These fragments and pebbles generally are most abundant in the deepest horizons, where they make up as much as 20 percent of the soil by volume.

This Grande Ronde soil has slow permeability. Roots can penetrate readily to the very firm clay, which is at depths of 22 to 36 inches. The available water capacity is 5 to 7.5 inches. Tilth is moderate, but cultivation is restricted during winter and spring by a perched water table. Surface runoff is slow. Slight sheet erosion occurs during rainy periods. Fertility is low.

Most of the acreage is cultivated. Grass seed, hay, and pasture plants are the principal crops. Spring grain is also grown. Capability unit IIIw-4; not placed in a woodland group; wildlife group 2.

Hazelair Series

The Hazelair series consists of somewhat poorly drained soils that formed in mixed material over sedimentary rock. These soils are on low hills. Slopes are 2 to 20 percent. Elevations are 250 to 650 feet. Annual precipitation is 40 to 60 inches, average annual air temperature is 52° to 54° F., and the frost-free season is 165 to 210 days. In areas that are not cultivated, the vegetation is oak, poison-oak, and grasses. Hazelair soils are assoicated with Willakenzie, Steiwer, Dupee, and Panther soils.

In a representative profile, the surface layer is dark-brown and dark yellowish-brown silty clay loam about 11 inches thick. The subsoil is mottled in the lower part and is dark-brown silty clay about 7 inches thick. It is underlain by light olive-brown and grayish-brown clay. Sandstone is at a depth of about 30 inches.

Hazelair soils are used mainly for spring grain, hay, and pasture. They are also used for wildlife habitat and water supply.

Hazelair silty clay loam, 2 to 7 percent slopes (HcB).—This gently sloping soil is on low hills.

Representative profile 100 yards east of the road in the northwest corner of NW¼NW¼NE¼ sec. 29, T. 2 S., R. 4 W.:

Ap—0 to 7 inches, dark-brown (10YR 3/3) silty clay loam, brown (10YR 5/3) when dry; moderate, fine, subangular blocky structure; friable, hard, sticky, plastic; many very fine pores; many fine roots; medium acid (pH 5.8); abrupt, smooth boundary. (6 to 10 inches thick)

A1—7 to 11 inches, dark yellowish-brown (10YR 3/4) silty clay loam, brown (10YR 5/3) when dry; moderate, fine, subangular blocky structure; friable, hard, sticky, plastic; many very fine pores; many fine roots; medium acid (pH 5.6); abrupt, smooth boundary. (3 to 6 inches thick)

B2—11 to 18 inches, dark-brown (10YR 4/3) silty clay, brown (10YR 5/3) when dry; few, fine, distinct mottles in the lower part; moderate, fine, subangular blocky structure; firm, hard, very sticky, plastic; many very fine pores; many fine roots; few thin clay films in some pores; few fine fragments of siltstone and sandstone; strongly acid (pH 5.4); abrupt, smooth boundary. (3 to 10 inches thick)

IIC1—18 to 24 inches, light olive-brown (2.5Y 5/4) clay, light gray (2.5Y 7/2) and pale yellow (2.5Y 7/4) when dry; many, fine, faint and distinct, yellowish-brown (10YR 5/4) and grayish-brown (10YR 5/2) mottles; weak, coarse, prismatic structure; very firm, very hard, very sticky, very plastic; common very fine pores; few fine roots; many, fine and very fine, yellowish-brown, weathered fragments of siltstone and sandstone; strongly acid (pH 5.2); clear, smooth boundary. (5 to 7 inches thick)

IIC2—24 to 30 inches, grayish-brown (2.5Y 5/2) clay, light gray (2.5Y 7/2) when dry; massive; very firm, very hard, very sticky, very plastic; few fine pores; few fine and medium roots; common, fine and very fine, weathered fragments of siltstone and sandstone; strongly acid (pH 5.2); abrupt, wavy boundary. (5 to 6 inches thick)

IIIR—30 inches, brownish-yellow (10YR 6/6) sandstone that has light-gray (10YR 7/1) lenses and light brownish-gray (10YR 6/2) clay in fracture planes.

Texture of the A horizon ranges from silt loam to silty clay loam. The A horizon has hues of 10YR and 7.5YR. Moist values are 2 or 3 and chromas are 2 or 3 in the upper 7 inches, and 3 or 4 below 7 inches. Dry chromas are 2 to 4. The B horizon has moist values of 3 or 4 and chromas of 2 to 4. Hue is predominantly 10YR, but ranges to 7.5YR and 2.5Y. In places a few fine fragments of siltstone and sandstone are embedded in the lower part of the B horizon. Hue in the underlying clay horizons is predominantly 2.5Y, but ranges to 7.5YR where the sandstone and siltstone are more red than typical. Moist values are 4 to 6.

silty clay loam about 32 inches thick. It is underlain by hard basalt bedrock at a depth of about 44 inches.

Hembre soils are used for timber, water supply, recreation, and wildlife habitat.

Hembre silt loam, 3 to 30 percent slopes (HBE).—This soil is rolling to steep. It is on ridgetops and on side slopes in the Coast Range.

Representative profile a quarter mile north of Neverstill junction with the Turner Creek Road, 50 feet east of road; NW¼SE¼SE¼ sec. 1, T. 2 S., R. 6 W.:

0—⅛ inch to 0, needles, twigs, leaves.

A1—0 to 5 inches, dark reddish-brown (5YR 3/2) silt loam, dark brown (7.5YR 4/4) when dry; strong, fine, granular structure; friable, soft, slightly sticky, slightly plastic; many fine roots; many very fine irregular pores; common very fine fragments of basalt; common very fine concretions (shot); strongly acid (pH 5.2); clear, smooth boundary. (4 to 6 inches thick)

A3—5 to 12 inches, dark reddish-brown (5YR 3/2) silt loam, brown (7.5YR 5/4) when dry; moderate, fine, subangular blocky structure; friable, soft, slightly sticky, slightly plastic; many fine roots; many very fine pores; common very fine fragments of basalt; common very fine concretions (shot); very strongly acid (pH 5.0); clear, smooth boundary. (6 to 8 inches thick)

B21—12 to 19 inches, dark reddish-brown (5YR 3/4) silty clay loam, reddish yellow (7.5YR 6/6) when dry; moderate, fine, subangular blocky structure; friable, slightly hard, slightly sticky, plastic; common fine roots; common very fine pores; few fine concretions (shot); very strongly acid (pH 4.8); clear, smooth boundary. (7 to 10 inches thick)

B22—19 to 30 inches, reddish-brown (5YR 4/4) silty clay loam, reddish yellow (7.5YR 6/6) when dry; moderate, fine, subangular blocky structure; friable, slightly hard, slightly sticky, plastic; few fine roots; common very fine pores; few fine fragments of basalt; few fine concretions (shot); very strongly acid (pH 4.8); clear, smooth boundary. (9 to 12 inches thick)

B3—30 to 44 inches, yellowish-red (5YR 4/6) gravelly silty clay loam, reddish yellow (5YR 6/6) when dry; weak, fine, subangular blocky structure; firm, hard, slightly sticky, plastic; few medium roots; common very fine pores; 40 percent coarse fragments of basalt; very strongly acid (pH 4.8); abrupt, wavy boundary. (14 to 16 inches thick)

R—44 inches, basalt bedrock that has a few fractures.

The A horizon has moist values of 2 and 3; chromas are 2 to 3 moist and 3 or 4 dry; hues are 7.5YR and 5YR. The B horizon has chromas of 4 and 6 in hues of 7.5YR and 5YR. Pebbles and cobblestones of basalt make up as much as 15 percent of the A and B2 horizons and up to 40 percent of the B3 horizon.

Included with this soil in mapping are areas of Klickitat soils and more steeply sloping Hembre soils of as much as 10 acres in size, and areas of Astoria and Kilchis soils of less than 5 acres. These areas make up less than 15 percent of the total acreage.

Hembre soils have moderate permeability. Roots can penetrate to bedrock. The available water capacity is 7 to 10 inches. Organic-matter content is moderately high, and fertility is moderate. Surface runoff is slow to medium, and the erosion hazard is moderate.

This soil is used primarily for timber. The important trees are Douglas-fir and hemlock in the cooler, more moist areas and noble fir at high elevations. Management can be intensive (fig. 9). Capability unit VIe-2; woodland group 2o2; wildlife group 5.

Hembre silt loam, 30 to 60 percent slopes (HBF).—This soil is on the Coast Range. Runoff is rapid in cleared areas, and the erosion hazard is severe. Douglas-fir and hemlock are the important trees. Management is moderately difficult. Capability unit VIe-3; woodland group 2r2; wildlife group 5.

Hembre silt loam, 60 to 90 percent slopes (HBG).—This soil is on the rough mountainous part of the Coast Range. Runoff is rapid in cleared areas, and the erosion hazard is severe.

Included with this soil in mapping are areas along the lower slopes that are deeper than normal, and other areas that are shallow and stony throughout. These inclusions range to 10 acres in size and occupy as much as 20 percent of the total acreage.

Douglas-fir and hemlock are the important trees. Management is very difficult. Capability unit VIIe-1; woodland group 2r3; wildlife group 5.

Jory Series

The Jory series consists of well-drained soils that formed in colluvium derived from basalt rock. These soils on low foothills and have slopes of 2 to 90 percent. Elevations range from 250 to 1,200 feet. Annual precepitation is 40 to 60 inches. Average annual air temperature is 52° to 54° F., and the frost-free period is 165 to 210 days. In areas that are not cultivated, the vegetation is Douglas-fir, oak, poison-oak, and grasses. Jory soils are associated with Nekia, Yamhill, Peavine, and Willakenzie soils.

In a representative profile, the surface layer is dark reddish-brown clay loam or silty clay loam about 21 inches thick. The subsoil is dark reddish-brown clay about 47 inches thick. Depth to basalt is more than 40 inches.

Jory soils are used mainly for orchards, berries, grain, hay, pasture, and timber. They are also used for wildlife habitat, water supply, recreation, and homesites.

Jory clay loam, 2 to 7 percent slopes (JrB).—This gently sloping soil is on smooth ridgetops.

Representative profile on the Dundee Hills about 60 feet northeast of road junction; NW¼NW¼SW¼ sec. 26, T. 3 S., R. 3 W.:

Ap—0 to 7 inches, dark reddish-brown (5YR 3/3) clay loam, reddish brown (5YR 4/3) when dry; moderate, fine, granular structure; friable, slightly hard, sticky, plastic; many fine roots; many very fine irregular pores; common fine and very fine concretions; medium acid (pH 5.8); abrupt, smooth boundary. (5 to 8 inches thick)

A1—7 to 15 inches, dark reddish-brown (5YR 3/3) silty clay loam, reddish brown (5YR 4/4) when dry; strong, fine, granular structure; friable, slightly hard, sticky, plastic; common fine roots; many very fine irregular pores; many fine concretions; medium acid (pH 5.8); clear, smooth boundary. (4 to 12 inches thick)

A3—15 to 21 inches, dark reddish-brown (5YR 3/3) heavy silty clay loam, reddish brown (5YR 4/4) when dry; strong, fine, granular and subangular blocky structure; friable, slightly hard, sticky, plastic; common fine roots; many very fine irregular pores; common fine concretions; medium acid (pH 5.6); clear, smooth boundary. (3 to 7 inches thick)

B21t—21 to 28 inches, dark reddish-brown (5YR 3/4) clay, reddish brown (5YR 4/4) when dry; moderate, fine, subangular blocky structure; very firm, very hard, very sticky, very plastic; common fine roots; many nantly silty clay but ranges from silty clay loam to light clay. A few fine fragments of siltstone are scattered throughout the profile, and normally increase in amount with an increase in depth.

Included with this soil in mapping are areas of Olyic and Peavine soils. These areas are as much as 5 acres in size and occupy 15 percent of the total acreage.

This soil has moderately slow permeability. Roots can penetrate to depths of more than 3 feet. The bedrock generally is soft and pervious to large roots and water. The available water capacity is 7 to 11 inches. Fertility is moderate. Runoff is medium in cleared areas and the erosion hazard is moderate.

This soil is used mainly for timber. Douglas-fir is the major species. Capability unit VIe-2; woodland group 2c2; wildlife group 4.

Melby silt loam, 30 to 60 percent slopes (MEF).—This soil is on the eastern part of the Coast Range. Runoff is rapid in cleared areas, and the erosion hazard is severe. This soil is used for timber. Douglas-fir is the major species. Capability unit VIe-3; woodland group 2c3; wildlife group 4.

Nekia Series

The Nekia series consists of well-drained soils that formed over basalt rock on low hills. Slopes are 2 to 20 percent. Depth to basalt is 20 to 40 inches. Elevations range from 250 to 1,200 feet. Annual precipitation is 40 to 60 inches, the average annual air temperature is 52° to 54° F., and the frost-free period is 165 to 210 days. In areas that are not cultivated, the vegetation is Douglas-fir, oak, poison-oak, and grass. Nekia soils are associated with Jory, Yamhill, Peavine, and Willakenzie soils.

In a representative profile, the surface layer is dark reddish-brown clay loam about 7 inches thick. The upper part of the subsoil is dark reddish-brown silty clay loam about 9 inches thick. The lower part of the subsoil is dark reddish-brown silty clay and clay about 17 inches thick. The substratum is dark reddish-brown silty clay loam. Depth to fractured basalt is about 36 inches.

Nekia soils are used mainly for orchards, berries, grain, hay, pasture, and timber. They are also used for wildlife habitat, recreation, homesites, and water supply.

Nekia clay loam, 2 to 7 percent slopes (NcB).—This gently sloping soil is on smooth ridgetops and side slopes. Depth to bedrock ranges from 20 to 40 inches but is mostly 20 to 30 inches.

Representative profile on the Dundee Hills, about 400 feet west of junction and 30 feet north of road; NE¼NE¼SE¼ sec. 27, T. 3 S., R. 3 W.:

Ap—0 to 7 inches, dark reddish-brown (5YR 3/3) clay loam, reddish brown (5YR 4/3) when dry; moderate, fine, subangular blocky structure; friable, hard, sticky, plastic; many fine roots; many very fine and few fine pores; 5 percent fine concretions; medium acid (pH 6.0); abrupt, smooth boundary. (5 to 10 inches thick)

B1—7 to 16 inches, dark reddish-brown (5YR 3/3) silty clay loam, reddish brown (5YR 4/3) when dry; weak, fine, subangular blocky structure; friable, hard, sticky, plastic; common fine roots; many very fine pores; 2 percent fine concretions; medium acid (pH 5.8); clear, smooth boundary. (3 to 12 inches thick)

B21t—16 to 25 inches, dark reddish-brown (5YR 3/3) silty clay, reddish brown (5YR 4/3) when dry; moderate, fine, subangular blocky structure; friable, hard, sticky, very plastic; few fine roots; common very fine pores; few thin clay films on ped surface and pores; 1 percent fine concretions; medium acid (pH 5.6); clear, smooth boundary, (4 to 10 inches thick)

B22t—25 to 33 inches, dark reddish-brown (5YR 3/4) clay, reddish brown (5YR 4/4) when dry; moderate, fine, subangular blocky structure; firm, hard, very sticky, very plastic; few fine roots; many very fine pores; few thin clay films on ped surfaces and in pores; few fine black stains; few fine concretions; strongly acid (pH 5.4); clear, smooth boundary. (8 to 12 inches thick)

C—33 to 36 inches, dark reddish-brown (5YR 3/4) silty clay loam, reddish brown (5YR 4/4) when dry; weak, fine, subangular blocky structure; firm, hard, sticky, plastic; common very fine pores; 20 percent fine fragments of basalt; few fine black stains; strongly acid (pH 5.4); abrupt, wavy boundary. (0 to 5 inches thick)

R—36 inches, fractured basalt bedrock; black stains and dark reddish-brown (5YR 3/4) films in fractures.

The A horizon has moist values of 2 and 3 and chromas of 2 and 3. The B horizon has hues of 5YR and 2.5YR. A few basalt pebbles and stones are scattered throughout the profile.

Included with this soil in mapping are areas of Jory, Willakenzie, Yamhill, and more steeply sloping Nekia soils. These areas are less than 2 acres in size and occupy less than 5 percent of the total acreage.

This Nekia soil has moderately slow permeability. Roots can penetrate to the bedrock. The available water capacity is 3 to 7 inches. Tilth is good, and the soil can be cultivated throughout the year except during stormy periods in winter and spring. Surface runoff is slow, and erosion is a slight hazard in unprotected areas during rainy periods. Fertility is moderate.

Most of the acreage is cultivated. Orchard fruit, grain, hay, and pasture plants are the principal crops. Berries and grass for seed are also grown. Capability unit IIIe-4; woodland group 3c1; wildlife group 3.

Nekia clay loam, 7 to 20 percent slopes (NcD).—This soil is used for crops similar to those grown on Nekia clay loam, 2 to 7 percent slopes. Runoff is slow to medium. Erosion is a moderate hazard in unprotected areas during rainy periods. Capability unit IVe-1; woodland group 3c1; wildlife group 3.

Newberg Series

The Newberg series consists of somewhat excessively drained soils that formed in recent alluvium. These slightly undulating soils are on bottom lands along the larger streams. Elevation ranges from 30 to 300 feet. Annual precipitation is 40 to 60 inches, average annual temperature is 53° F., and the frost-free season is 165 to 210 days. In areas that are not cultivated, the vegetation is willow, ash, and cottonwood. These soils are associated with Cloquato and Chehalis soils.

In a representative profile, the surface layer is very dark grayish-brown fine sandy loam about 8 inches thick. The next layer is dark-brown sandy loam about 10 inches thick. It is underlain by very dark grayish-brown and dark-brown coarse sandy loam to loamy fine sand that is 42 or more inches thick.

Newberg soils are used mainly for vegetable crops, small grain, hay, and pasture. They are also used for wildlife habitat and recreation.

Newberg fine sandy loam (0 to 3 percent slopes) (Nu).—This soil is along the larger streams and is hummocky because of overflow erosion.

Representative profile in an orchard on Grand Island, northeast corner of NE¼NW¼NW¼ sec. 26, T. 5 S., R. 3 W.:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, grayish brown (10YR 5/2) when dry; weak, fine, subangular blocky structure; very friable, soft, nonsticky, nonplastic; common fine roots; many very fine irregular pores; medium acid (pH 6.0); abrupt, smooth boundary. (7 to 10 inches thick)

AC—8 to 18 inches, dark-brown (10YR 3/3) sandy loam, brown (10YR 5/3) when dry; weak, very fine, subangular blocky structure; very friable, soft, nonsticky, nonplastic; many very fine irregular pores; common fine and few very fine roots; slightly acid (pH 6.2); clear, wavy boundary. (6 to 12 inches thick)

C1—18 to 28 inches, very dark grayish-brown (10YR 3/2) coarse sandy loam, brown (10YR 5/3) when dry; massive; very friable, soft, nonsticky, nonplastic; many very fine irregular pores; few fine roots; slightly acid (pH 6.4); clear, smooth boundary. (8 to 14 inches thick)

C2—28 to 60 inches, dark-brown (10YR 3/3) loamy fine sand, dark yellowish brown (10YR 4/4) when dry; single grain; loose when moist or dry; many very fine irregular pores; slightly acid (pH 6.4).

Dry values are 4 or 5 to a depth of at least 10 inches. Below 10 inches dry values are 4 to 6; moist values are 3 or 4 and chromas are 2 to 4. Thin, finer textured lenses are in the C horizon. Gravel layers are at depths below 40 inches.

Included with this soil in mapping are areas of Cloquato soils, Newberg soils that have a silty surface layer, and riverwash. These included areas are less than 2 acres in size and occupy less than 12 percent of the total acreage.

This soil has moderately rapid permeability. Roots can penetrate to depths of more than 60 inches. The available water capacity is 5 to 7.5 inches. Tilth is good, and the soil can be cultivated any time except during periods of overflow that occur several times during winter. Surface runoff is slow. The erosion hazard is slight to severe. Fertility is moderate.

Vegetable crops, orchard fruit, and small grain are the principal crops. Alfalfa, grass and legumes for seed, hay, and pasture plants are also grown. Mint is grown occasionally. Plant nutrients leach away rapidly because the soil is porous. Capability unit IIw-3; not placed in a woodland group; wildlife group 1.

Newberg silt loam (0 to 3 percent slopes) (Nw).—This soil is farther from the streambanks than Newberg fine sandy loam but is also subject to a few periods of overflow each year. It has a profile similar to that of Newberg fine sandy loam, but the surface layer is silt loam 10 to 14 inches thick. Thin lenses of silt loam are common in the sandy substratum. The available water capacity is 6 to 7.5 inches. The infiltration rate is moderate, and the rate of evaporation is less than that of Newberg fine sandy loam. This soil is more fertile and holds plant nutrients better. The same crops are grown on both soils. Capability unit IIw-1; not placed in a woodland group; wildlife group 1.

Olyic Series

The Olyic series consists of well-drained soils that formed over basalt in the Coast Range. These soils have slopes of 5 to 90 percent and are in rough mountainous areas. Elevations range from 500 to 2,000 feet. Annual precipitation is 60 to 80 inches, average annual air temperature is 49° F., and the frost-free period is 145 to 200 days. The vegetation is Douglas-fir, bigleaf maple, alder, and vine maple. Olyic soils are associated with Melby and Peavine soils.

In a representative profile, the surface layer is dark reddish-brown silt loam about 13 inches thick. The subsoil is firm, dark reddish-brown silty clay loam about 29 inches thick. It is underlain by basalt at a depth of about 42 inches.

Olyic soils are used for timber, water supply, wildlife habitat, and recreation.

Olyic silt loam, 5 to 30 percent slopes (OLE).—This soil is on rolling ridgetops and strongly sloping to steep side slopes in the eastern part of the Coast Range.

Representative profile about 60 feet from the High Heaven Road; NW¼NE¼SW¼ sec. 32, T. 3 S., R. 5 W.:

O—¼ inch to 0, needles, leaves, twigs.

A1—0 to 8 inches, dark reddish-brown (5YR 2/2) silt loam, dark brown (7.5YR 4/2) when dry; strong, fine, granular structure; friable, soft, slightly sticky, slightly plastic; many fine and medium roots; many fine pores; many fine concretions; medium acid (pH 5.6); clear, smooth boundary. (6 to 10 inches thick)

A3—8 to 13 inches, dark reddish-brown (5YR 3/3) silt loam, brown (7.5YR 5/4) when dry; strong, fine, granular structure; friable, soft, slightly sticky, slightly plastic; many fine and few medium roots; many fine pores; common fine concretions; strongly acid (pH 5.4); clear, smooth boundary. (4 to 7 inches thick)

B1—13 to 20 inches, dark reddish-brown (5YR 3/4) silty clay loam, brown (7.5YR 5/4) when dry; moderate, fine, subangular blocky structure; friable, slightly hard, sticky, plastic; common fine and few large roots; many very fine pores; few thin clay films in some pores; strongly acid (pH 5.4); clear, smooth boundary. (6 to 10 inches thick)

B21t—20 to 33 inches, dark reddish-brown (5YR 3/4) silty clay loam, brown (7.5YR 5/4) when dry; moderate, fine, subangular blocky structure; firm, slightly hard, sticky, plastic; few fine roots; many very fine and few fine pores; few thin clay films on some ped surfaces and in some pores; few pebbles of basalt; very strongly acid (pH 4.8); clear, smooth boundary. (12 to 15 inches thick)

B22t—33 to 42 inches, dark reddish-brown (5YR 3/4) heavy silty clay loam, strong brown (7.5YR 5/6) when dry; weak, fine, subangular blocky structure; firm, hard, sticky, very plastic; few fine roots; common fine pores; few thin clay films on ped surfaces and in pores; few very fine fragments of basalt and few pebbles; very strongly acid (pH 4.8); clear, irregular boundary. (8 to 14 inches thick)

R—42 to 50 inches, fractured basalt.

The A horizon has hues of 5YR or 7.5YR. The Bt horizon has moist values of 3 and 4 and chromas of 4 to 6. Only a few stones generally are in the upper 40 inches. Bedrock is hard, fractured basalt.

Included with this soil in mapping are areas of Melby, Peavine, and more steeply sloping Olyic soils. These areas are as much as 5 acres in size and occupy less than 15 percent of the total acreage.

This Olyic soil has moderately slow permeability. Roots can penetrate to depths of more than 4 feet. The available precipitation is 55 to 70 inches, average annual air temperature is 51° F., and the frost-free period is 165 to 210 days. In areas that are not cultivated, the vegetation is Douglas-fir, bigleaf maple, oak, and poison-oak. Peavine soils are associated with Willakenzie, Melby, Ead, Panther, Nekia, Jory, and Olyic soils.

In a representative profile, the surface layer is very dark brown and dark-brown silty clay loam about 10 inches thick. The subsoil is dark reddish-brown and yellowish-red, firm silty clay about 26 inches thick. It is underlain by fractured strongly weathered shale at a depth of about 36 inches.

Peavine soils are used mainly for orchards, small grains, hay, pasture, and timber. They are also used for water supply, wildlife habitat, recreation, and homesites.

Peavine silty clay loam, 2 to 12 percent slopes (PcC).—This gently sloping to strongly sloping soil is on ridgetops, on side slopes of low hills, and on foot slopes of the Coast Range. Slopes are commonly more than 5 percent.

Representative profile about 50 yards north on field road from county road along ridgetop in the southeastern corner of Moores Valley; SW¼SW¼SE¼ sec. 10, T. 3 S., R. 5 W.:

A1—0 to 4 inches, very dark brown and dark-brown (7.5YR 2/2 and 7.5YR 3/2) silty clay loam, dark brown (7.5YR 4/2 and 4/3) when dry; moderate, fine, subangular blocky structure; friable, slightly hard, sticky, plastic; many very fine and fine roots; common very fine tubular pores; few fine fragments of shale; medium acid (pH 5.6); clear, smooth boundary. (3 to 7 inches thick)

A3—4 to 10 inches, dark-brown (7.5YR 3/2) silty clay loam, brown (7.5YR 4/4) when dry; moderate, fine, subangular blocky structure; firm, hard, sticky, plastic; many very fine and fine roots; many very fine tubular pores; few fine fragments of shale; very strongly acid (pH 5.0); clear, wavy boundary. (0 to 8 inches thick)

B1t—10 to 15 inches, dark reddish-brown (5YR 3/4) silty clay, yellowish red (5YR 4/6) when dry; moderate, fine, subangular blocky structure; firm, hard, very sticky, very plastic; many fine and medium roots; few fine tubular pores; few thin clay films on ped surfaces and in pores; very strongly acid (pH 4.6); clear, wavy boundary. (0 to 8 inches thick)

B2t—15 to 26 inches, yellowish-red (5YR 4/6) silty clay, yellowish red (5YR 5/6) when dry; moderate, medium, subangular blocky structure; firm, hard, very sticky, very plastic; many medium roots; many very fine tubular pores; common, thin clay films on ped surfaces and in pores; many very fine fragments of shale; very strongly acid (pH 4.5); clear, wavy boundary. (8 to 15 inches thick)

B3t—26 to 36 inches, yellowish-red (5YR 4/6) silty clay, yellowish red (5YR 5/6) when dry; moderate, fine, subangular blocky structure; firm, very hard, very sticky, very plastic; common fine roots; many very fine pores; thin nearly continuous clay films on ped surfaces and in pores; many, very fine and fine, variegated brown and yellow fragments of shale; very strongly acid (pH 4.5); gradual, wavy boundary. (4 to 10 inches thick)

C1—36 to 49 inches, light yellowish-brown to brownish-yellow fractured, strongly weathered shale with yellowish-red (5YR 4/6) silty clay loam in fractures, yellowish red (5YR 5/6) when dry; massive; firm, very hard, sticky, plastic; common fine roots in fractures; common very fine pores in soil material; many thin clay films coat the shale; very strongly acid (pH 4.5); gradual, wavy boundary. (0 to 20 inches thick)

C2—49 to 64 inches, light yellowish-brown to brownish-yellow fractured strongly weathered shale with light yellowish-brown (10YR 6/4) to brownish-yellow (10YR 6/6) silty clay loam in factures, yellow (10YR 7/6) when dry; massive; few medium roots in fractures; many, moderately thick, yellowish-red (5YR 4/6) clay films coat the shale; extremely acid (pH 4.3); gradual, wavy boundary. (0 to 20 inches thick)

R—64 to 84 inches, light yellowish-brown (10YR 6/4) to brownish-yellow (10YR 6/6) very hard fractured bedrock.

The A horizon has moist chromas and values of 2 and 3. Hue is mainly 7.5YR but in places is 5YR and 10YR. Structure is moderate or strong subangular blocky or granular. The upper part of the Bt horizon has moist chromas of 4 to 6. The lower part has moist values of 4 and 5 and chromas of 6 to 8. Texture of the Bt horizon ranges from silty clay to clay. Structure is fine, medium, and in places coarse, subangular blocky. Fine siltstone and shale fragments are scattered throughout the solum and make up as much as 35 percent of the B3 horizon.

Included with this soil in mapping are areas of Panther, Willakenzie, Jory, Nekia, and more steeply sloping Peavine soils. Included areas are less than 2 acres in size in cultivated areas and less than 5 acres in woodland areas. They occupy less than 10 percent of the total acreage.

This Peavine soil has moderately slow permeability. Roots can penetrate to bedrock. Tilth is moderate, and the soil can be cultivated most of the year except during winter and early in spring. The available water capacity is 5 to 7 inches. Surface runoff is slow to medium, and erosion is a moderate hazard in unprotected areas during rainy periods. Fertility is moderate.

Less than half the acreage is cultivated. Orchard trees, small grain, hay, and pasture plants are grown. Douglas-fir grows in wooded areas. This soil may slide and slump on the steeper slopes during periods of sustained rain. Capability unit IIIe–2; woodland group 2c1; wildlife group 3.

Peavine silty clay loam, 12 to 20 percent slopes (PcD).—Runoff on this soil is medium, and erosion is a severe hazard in unprotected areas during rainy periods. Orchard fruit, small grain, hay, and pasture plants are the major crops. Douglas-fir is grown on the woodland. This soil may slide and slump during periods of sustained rain. Capability unit IIIe–2; woodland group 2c1; wildlife group 3.

Peavine silty clay loam, 20 to 30 percent slopes (PcE).—On this soil runoff is medium and the erosion hazard is severe. Orchard fruit, small grain, hay and pasture plants are the main crops. Douglas-fir is grown on the woodland. This soil may slide and slump during periods of sustained rain. More intensive management practices, such as stripcropping and establishing terraces and diversions, are required. Capability unit IVe-2; woodland group 2c1; wildlife group 3.

Peavine silty clay loam, 2 to 30 percent slopes (PCE).—This soil was mapped at medium intensity. It is used mainly for timber. Douglas-fir is the important tree species. Most of the acreage would be suitable for cultivation if cleared. Woodland can be managed intensively Capability unit IVe–2; woodland group 2c1; wildlife group 4.

Peavine silty clay loam, 30 to 60 percent slopes (PCF).—This soil was mapped at medium intensity. Runoff is rapid in cleared areas, and the erosion hazard is severe

Douglas-fir is the principal crop, but some pasture plants re also grown. This soil may slide and slump during eriods of sustained rain. Management is moderately difficult. Capability unit VIe-5; woodland group 2r1; wildlife group 4.

Peavine silty clay loam, moderately shallow, 2 to 7 percent slopes (PeB).—This soil has a profile similar to that of Peavine silty clay loam, 2 to 12 percent slopes, except that depth to sedimentary rock is 20 to 30 inches. The available water capacity is 3 to 5 inches. Surface runoff is slow, and the erosion hazard is moderate in unprotected areas during rainy periods.

Small grain, hay, and pasture plants are the major crops. Douglas-fir is grown on the woodland. Capability unit IIIe-4; woodland group 2c1; wildlife group 3.

Peavine silty clay loam, moderately shallow, 7 to 20 percent slopes (PeD).—This soil is strongly sloping to moderately steep. The available water capacity is 3 to 5 inches. Surface runoff is slow to medium, and the erosion hazard is severe in uprotected areas during rainy periods.

Small grain, hay, and pasture plants are the major crops. Douglas-fir is grown on the woodland. Capability unit IVe-1; woodland group 2c1; wildlife group 3.

Shale Rock Land

Shale rock land (SH) is 50 to 75 percent rock outcrops. The rest is well-drained soils that are too variable to identify and map separately. The soils are less than 20 inches deep over siltstone, sandstone, and shale. They are strongly sloping to very steep. In areas that are not ltivated, the vegetation is oak, poison-oak, grasses, nd some Douglas-fir.

The soils are loam to clay in texture and contain few to many sedimentary rock fragments. In some cultivated fields, these soils are very severely eroded. Moist hues are 5YR to 10YR, and values and chromas are 2 through 4.

Included in mapping are areas of soils that are deeper than 20 inches. These included areas are less than an acre in size and occupy less than 10 percent of the total acreage.

The soils of this mapping unit have moderate to slow permeability. Roots penetrate to a depth of 20 inches. Tilth is poor to moderate. The available water capacity is 2 to 5 inches. Surface runoff is medium to rapid, and erosion is a severe hazard in unprotected areas during heavy rains. Fertility is low.

Less than a third of the acreage is cultivated. Hay and pasture plants are the principal crops. Small grain can be grown where slopes are favorable and rock outcrops are of limited extent. Uncultivated areas are in natural oak-grass and pasture. Capability unit VIe-4; not placed in a woodland group; wildlife group 6.

Steiwer Series

The Steiwer series consists of well-drained soils that formed from old alluvium and colluvium. These soils have 5 to 50 percent slopes. Depth to bedrock is 20 to 40 inches. Elevations range from 250 to 650 feet. Annual precipitation is 40 to 50 inches, average annual air temp- ture is 53° F., and the frost-free period is 165 to 210 ys. In areas that are not cultivated, the vegetation is grasses, oak, and poison-oak. Steiwer soils are associated with moderately fine textured Willakenzie, Hazelair, and Yamhill soils and Shale rock land.

In a representative profile, the surface layer is dark-brown silty clay loam about 6 inches thick. The subsoil is clay loam that is dark brown in the upper part, dark yellowish brown in lower part, and about 21 inches thick. Shale that has sandstone lenses is at a depth of about 27 inches.

Steiwer soils are used primarily for grain, hay, and pasture. They are also used for wildlife habitat, recreation, water supply, and homesites.

Steiwer silty clay loam, 5 to 20 percent slopes (StD).—This soil is on low hills.

Representative profile in a pasture northeast of Sheridan, 1,000 feet east and 540 feet north of the Sheridan City dump; NW¼SW¼SW¼ sec. 25, T. 5 S., R. 6 W.:

Ap—0 to 6 inches, dark-brown (10YR 3/3) silty clay loam, brown (10YR 5/3) when dry; moderate, fine, subangular blocky structure that parts to moderate, fine, granular; firm, hard, sticky, plastic; many very fine roots; common very fine tubular and irregular pores; few, very fine, weathered fragments of shale; strongly acid (pH 5.4); abrupt, smooth boundary. (4 to 8 inches thick)

B1—6 to 10 inches, dark-brown (10YR 3/3) clay loam, brown (10YR 5/3) when dry; moderate, very fine, subangular blocky structure; friable, hard, sticky, plastic; many very fine roots; many very fine tubular pores; many, very fine, weathered fragments of shale; strongly acid (pH 5.3); clear, wavy boundary. (3 to 8 inches thick)

B21—10 to 19 inches, dark-brown (10YR 3/3) clay loam, brown (10YR 5/3) when dry; moderate, very fine, subangular blocky structure; friable, hard, sticky, plastic; common fine roots; many fine and very fine pores; few, fine strongly weathered fragments of shale; strongly acid (pH 5.3); gradual, wavy boundary. (6 to 15 inches thick)

B22—19 to 27 inches, dark yellowish-brown (10YR 3/4) clay loam, brown (10YR 5/3) when dry; moderate, fine, subangular blocky structure; firm, hard, sticky, plastic; few fine roots; many very fine pores; 15 percent very fine strongly weathered fragments of shale; strongly acid (pH 5.2); abrupt, irregular boundary. (6 to 12 inches thick)

IIC—27 inches, strong-brown (7.5YR 5/6) to reddish-yellow (7.5YR 6/6) variegated shale that has sandstone lenses; reddish-brown clay coatings in the fractures; very strongly acid (pH 4.9).

The A horizon ranges in texture from silt loam to silty clay loam or clay loam. Moist values are 2 and 3, and chromas are 2 or 3. The B2 horizon is silty clay loam or clay loam. Moist values are 3 or 4, and dry values are 5 or 6; chromas are 3 or 4. Hues range from 10YR to 7.5YR. Content of siltstone and shale fragments ranges from a few in the upper part of the solum to as much as 30 percent in the lower part. These fragments are weathered to some degree. Depth to bedrock ranges from 20 to 40 inches, but is commonly 24 to 32 inches.

Included with this soil in mapping are areas of Yamhill and Willakenzie soils, more steeply sloping Steiwer soils, and Shale rock land. Also included are areas that contain a few scattered stones, and areas of Stony land. The included areas are less than 2 acres in size and occupy as much as 10 percent of some mapped areas.

This soil has moderately slow permeability. Roots can penetrate to depths of 20 to 40 inches. The available water capacity is 3.5 to 8 inches. Surface runoff is medium, and the erosion hazard is severe in unprotected areas during rainy periods. Fertility is low.

B21g—16 to 22 inches, dark grayish-brown (10YR 4/2) silty clay loam, grayish brown (10YR 5/2) when dry; many, fine, distinct, dark reddish-brown (5YR 3/2) mottles; few, fine, black stains; moderate, medium and fine, subangular blocky structure; friable, hard, sticky, plastic; many very fine and few fine pores; few fine roots; medium acid (pH 5.8); clear, smooth boundary. (5 to 8 inches thick)

B22g—22 to 32 inches, dark grayish-brown to grayish-brown (10YR 4/2-5/2) silty clay loam; many, fine, distinct, dark reddish-brown (5YR 4/4) mottles; common, fine, black stains; moderate, medium, fine, subangular blocky structure; firm, hard, sticky, plastic; many very fine and few fine pores; medium acid (pH 5.8); clear, smooth boundary. (9 to 22 inches thick)

B3g—32 to 60 inches, grayish-brown (10YR 5/2) silty clay, light gray (10YR 7/2) when dry; many, fine, distinct, dark-brown (7.5YR 4/4) mottles; common, medium and fine, black stains; weak, subangular blocky structure; firm, very sticky, plastic; few fine pores; medium acid (pH 5.6).

The A horizon has moist values of 2 and 3, dry values of 4 or 5, and chromas of 2 or 3. In places, distinct mottles occur throughout the A horizon or only in the lower part. The A horizon is dominantly silty clay loam but is silt loam in places. The B2 horizon has moist values of 4 and 5 and chromas of 1 and 2; hue is 10YR to 2.5Y, and in places it is 5Y. Mottles are distinct to prominent. Texture is dominantly silty clay loam, but ranges to a silty clay in the lower part below a depth of 30 inches. A few waterworn pebbles are embedded in the solum. In places the solum is underlain by stratified layers that contain pebbles and stones below a depth of 40 inches.

Included with this soil in mapping are areas of Cove and Chehalis soils, narrow, steeper sided drainageways, and in the Sheridan area, some unnamed gravelly soils. These included areas are as much as an acre in size and ke up less than 5 percent of the total acreage.

This Wapato soil is moderately slowly permeable to roots and water. During winter and early in spring, a temporary water table restricts root growth. The available water capacity is 10 to 12 inches. Tilth is moderately good, but seedbed preparation can be difficult if the soil is worked when too wet or too dry. Surface runoff is slow, and water ponds for short periods during winter. The erosion hazard is slight. This soil is subject to occasional to frequent overflow. Fertility is moderate.

Most of the acreage has been cleared for cultivation. Small grain, hay, and pasture plants are the principal crops. Corn, other late-planted vegetable crops, and grass and legumes for seed are also important. Drainage either by open ditches or tile is needed in order to lower the water table in spring. Because of the low-lying position of the soil, drainage outlets are often difficult to establish. Capability unit IIIw-5; not placed in a woodland group; wildlife group 2.

Willakenzie Series

The Willakenzie series consists of well-drained soils that are 20 to 40 inches deep over sedimentary rock. These soils are on low hills and have slopes of 2 to 45 percent. Elevations range from 250 to 800 feet. Annual precipitation is 40 to 50 inches, average annual air temperature is 53° F., and the frost-free period is 165 to 210 days. In areas that are not cultivated, the vegetation is oak, poison-oak, rosebush, and widely spaced uglas-fir. Willakenzie soils are associated with Dupee, zelair, Panther, Nekia, and Carlton soils.

In a representative profile, the surface layer is dark-brown silty clay loam about 4 inches thick. The subsoil is friable to firm, dark-brown silty clay loam about 28 inches thick. The underlying material is yellowish-red loam. Fractured siltstone is at a depth of about 36 inches.

Willakenzie soils are used mainly for orchards, small grain, hay, and pasture. They are also used for timber, wildlife habitat, recreation, homesites, and water supply.

Willakenzie silty clay loam, 2 to 12 percent slopes (WeC).—This soil is on ridgetops and sides of low hills. Slopes are dominantly more than 5 percent. Depth to sedimentary rock is 30 to 40 inches.

Representative profile about 200 feet north of the Carlton-Panther Creek Road and about 600 feet east of road junction along the southern line of SE¼NW¼ SW¼ sec. 24, T. 3 S., R. 5 W.:

A1—0 to 4 inches, dark-brown (7.5YR 3/2) silty clay loam, brown (7.5YR 5/3) when dry; weak, medium and fine, subangular blocky structure; friable, hard, slightly sticky, slightly plastic; many very fine pores; many fine roots; very few fine concretions; medium acid (pH 6.0); clear, smooth boundary. (3 to 9 inches thick)

B1—4 to 12 inches, dark-brown (7.5YR 3/4) silty clay loam, strong brown (7.5YR 5/6) when dry; moderate, medium and fine, subangular blocky structure; friable, hard, sticky, plastic; many very fine pores; many fine roots; medium acid (pH 6.0); clear, wavy boundary. (7 to 10 inches thick)

B21t—12 to 18 inches, dark-brown (7.5YR 4/4) silty clay loam, strong brown (7.5YR 5/6) when dry; moderate, fine and very fine, subangular blocky structure; friable, hard, sticky, very plastic; common medium and fine pores; many fine roots; few thin clay films in pores and on some ped surfaces; medium acid (pH 6.0); clear, smooth boundary. (5 to 8 inches thick)

B22t—18 to 26 inches, dark-brown (7.5YR 4/4) silty clay loam, strong brown (7.5YR 5/6) when dry; weak, medium, subangular blocky that breaks to moderate, fine, subangular blocky structure; firm, hard, very sticky, very plastic; many very fine pores; common fine roots; few very thin clay films on ped surfaces; medium acid (pH 5.6); gradual, wavy boundary. (6 to 12 inches thick)

B23t—26 to 32 inches, dark-brown (7.5YR 4/4) silty clay loam, strong brown (7.5YR 5/6) when dry; weak, medium and fine that breaks to moderate, very fine, subangular blocky structure; firm, hard, very sticky, very plastic; many very fine pores; common fine roots; many thin clay films; strongly acid (pH 5.4); abrupt, wavy boundary. (5 to 7 inches thick)

IIC—32 to 36 inches, yellowish-red (5YR 4/6) loam; weak, fine, angular blocky structure; friable, sticky, plastic; few fine pores; few fine roots; common thick clay films on the coarse fragments; 80 percent strongly weathered siltstone fragments; very strongly acid (pH 4.7); abrupt, smooth boundary. (3 to 4 inches thick)

IIR—36 inches, hard, fractured siltstone bedrock.

The solum generally has hue of 7.5, but hue grades from 10YR in the A horizon to 5YR in the lower part of the B horizon. Soils that formed from siltstone have redder hues than soils that formed from sandstone. The A horizon has moist values of 2 and 3 and chromas of 2 or 3. Dry values are 5 or 6. Texture is loam to silty clay loam. The B horizon generally has chromas of 4 when moist, but in places chromas are 6 in the lower part. The B horizon ranges from clay loam to silty clay loam. The lower part of the Bt horizon is heavy silty clay loam or silty clay in some areas. The upper 20 inches of the Bt horizon is 27 to 35 percent clay. Strongly weathered rock fragments are commonly abundant below acid (pH 6.2); clear, smooth boundary. (6 to 12 inches thick)

C—46 to 60 inches, dark-brown (10YR 4/3) light silty clay loam, pale brown (10YR 6/3) when dry; massive, that parts to weak, coarse, prismatic structure; firm, slightly hard, sticky, plastic; trace of fine roots; many very fine tubular pores; few thin and medium clay films in pores; slightly acid (pH 6.2).

In places the A horizon is very dark brown, dark brown, or very dark grayish brown when moist. The Bt horizon is heavy silt loam to silty clay loam. In places it has weak or moderate, medium prismatic and moderate, subangular blocky structure. The C horizon is silt loam or silty clay loam that has some coarser textured strata. This horizon has a few faint mottles and gray streaks in places.

Included with this soil in mapping are areas of Woodburn, Amity, and more steeply sloping Willamette soils. These included areas are less than an acre in size and occupy less than 5 percent of the total acreage.

This soil is moderately permeable to water, and roots can penetrate to depths of more than 60 inches. The available water capacity is 11 to 13 inches. Tilth is good, and the soil can be cultivated throughout the year, except during winter and spring storms. Surface runoff is slow, and unprotected areas are slightly susceptible to sheet erosion during heavy rains. Fertility is high.

Most of the acreage is cultivated. Orchard fruit, vegetables, berries, alfalfa, and small grain are the most important crops. This soil is also used for hay, pasture, and legumes grown for seed. Capability unit I-1; not placed in a woodland group; wildlife group 1.

Willamette silt loam, 3 to 12 percent slopes (WIC).—This soil is similar to Willamette silt loam, 0 to 3 percent slopes, except that it has short, gentle and strong slopes along small drainageways. Similar crops are grown. Runoff is slow to medium, and erosion is a slight to moderate hazard in unprotected areas during rainy periods. Capability unit IIe-1; not placed in a woodland group; wildlife group 1.

Willamette silt loam, 12 to 20 percent slopes (WID).—This soil is along the large, deep draws. It has a profile similar to that of Willamette silt loam, 0 to 3 percent slopes, but it has short, moderately steep slopes. Runoff is medium, and erosion is a moderate hazard in unprotected areas during rainy periods. Orchards, alfalfa, small grain, legumes for seed, hay, and pasture plants are the most important crops. Berries and vegetable crops also are grown, but management is more difficult than on less steep Willamette soils. Capability unit IIIe-1; not placed in a woodland group; wildlife group 1.

Woodburn Series

The Woodburn series consists of moderately well-drained soils that formed in silty alluvium. These soils are on the Willamette Valley terraces and have slopes of 0 to 20 percent. Elevations range from 150 to 400 feet. Annual precipitation is 40 to 50 inches, average annual air temperature is 53° F., and the frost-free season is 165 to 210 days. In areas that are not cultivated, the vegetation is grass, Oregon white oak, and Douglas-fir. Woodburn soils are associated with the well-drained Willamette soils and the somewhat poorly drained Aloha and Amity soils.

In a representative profile, the surface layer is very dark-grayish-brown silt loam about 10 inches thick. The subsoil is distinctly mottled in the lower part and is dark yellowish-brown, dark grayish-brown, and brown, firm heavy silt loam about 48 inches thick. It is underlain by brown silt loam that extends to a depth of more than 65 inches.

Woodburn soils are used mainly for vegetable crops, berries, orchards, small grains, and hay and pasture. They are also used for wildlife habitat, recreation, and homesites.

Woodburn silt loam, 0 to 7 percent slopes (WuB).—This is the most extensive soil on the Willamette Valley terraces. Slopes are dominantly 0 to 3 percent.

Representative profile in a field near McMinnville; about 40 feet north of county road; SE¼SE¼SW¼ sec. 15, T. 4 S., R. 4 W.:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam, brown (10YR 5/3) when dry; moderate, fine, subangular blocky structure; friable, hard, slightly sticky, slightly plastic; many very fine roots; many very fine pores; slightly acid (pH 6.2); abrupt, smooth boundary. (6 to 10 inches thick)

A1—7 to 10 inches, very dark grayish-brown (10YR 3/2) silt loam, brown (10YR 5/3) when dry; weak, fine, subangular blocky structure; firm, hard, slightly sticky, slightly plastic; many very fine roots; common very fine and few fine pores; medium acid (pH 6.0); abrupt, smooth boundary. (0 to 8 inches thick)

B1—10 to 19 inches, very dark grayish-brown (10YR 3/2) heavy silt loam, grayish brown (10YR 5/2) when dry; moderate, fine, subangular blocky structure; firm, hard, slightly sticky, plastic; common fine roots; many fine and very fine pores; few thin clay films; medium acid (pH 6.0); clear, smooth boundary. (0 to 10 inches thick)

B21t—19 to 28 inches, dark yellowish-brown (10YR 3/4) heavy silt loam, brown (10YR 5/3) when dry; moderate, fine, subangular blocky structure; firm, hard, slightly sticky, plastic; common fine roots; many very fine, common fine and few medium pores; thin continuous clay films on most ped surfaces; few medium and thick clay films in larger pores; medium acid (pH 5.8); clear, smooth boundary. (7 to 9 inches thick)

B22t—28 to 38 inches, dark grayish-brown (10YR 4/2) heavy silt loam, grayish brown (10YR 5/2) when dry; few, fine and medium, light-gray coatings outlined in dark reddish brown; few, fine, distinct, dark reddish-brown mottles; weak, medium and coarse, subangular blocky structure; very firm, very hard, slightly sticky, plastic; few fine roots; many very fine and few fine pores; thin, continuous, very dark grayish-brown (10YR 3/2) clay films on ped surfaces and in pores; peds brittle; medium acid (pH 5.8); clear, smooth boundary. (6 to 10 inches thick)

B3—38 to 58 inches, brown (10YR 5/3) heavy silt loam, pale brown (10YR 6/3) when dry; few, fine, distinct, dark reddish-brown and gray mottles; weak, coarse, subangular blocky structure; firm, hard, slightly sticky, plastic; few very fine and fine pores; medium and thick clay films in larger pores and on some ped surfaces; medium acid (pH 5.8); gradual, smooth boundary. (15 to 27 inches thick)

C—58 to 65 inches, brown (10YR 5/3) silt loam, pale brown (10YR 6/3) when dry; massive; firm, hard, slightly sticky, slightly plastic; common very fine and fine pores; few thin clay films in pores; medium acid (pH 5.8).

The A horizon has moist values of 2 and 3, chromas of 2 and 3, and hue of 10YR. Dry values are 4 and 5 and chromas are 2 and 3. Between depths of 10 and 20 inches, moist values and chromas range to 4. Distinct mottles are within a depth of 30 inches. The B2 horizon ranges from heavy silt loam to silty clay loam. Horizons below a depth of 30 inches are firm to very firm and are brittle.

Included with this soil in mapping are areas of Aloha, Amity, Willamette, and Dayton soils and more steeply sloping Woodburn soils. These areas are as much as an acre in size and make up less than 5 percent of the total acreage.

This soil is moderately permeable to water in the upper part and slowly permeable in the lower part. Roots can penetrate to depths of more than 60 inches. The available water capacity is 11 to 13 inches. Fertility is high. Tilth is good, and the soil can be cultivated throughout the year, except during storms in winter and spring. Surface runoff is slow. Erosion is a slight hazard in the nearly level areas during heavy rains and in gently sloping areas near shallow draws during rainy periods.

Most of the acreage is cultivated. Small grain and legume seed are the most important crops. Orchard trees, vegetable crops, berries, alfalfa, and hay and pasture plants are also grown. Capability unit IIw-6; not placed in a woodland group; wildlife group 1.

Woodburn silt loam, 7 to 12 percent slopes (WuC).—This soil is similar to Woodburn silt loam, 0 to 7 percent slopes, except that it has short, strong slopes on sides of drainageways. Runoff is slow to medium, and erosion is a slight to moderate hazard in unprotected areas during rainy periods. Crops grown are similar to those grown on the more nearly level Woodburn soils. Intensive drainage is required to control seepage from adjacent soils. Included with this soil in mapping are Amity or Dayton soils on the bottom of the draws. Capability unit IIe-4; not placed in a woodland group; wildlife group 1.

Woodburn silt loam, 12 to 20 percent slopes (WuD).—This soil is along the large, deep draws. Runoff is medium, and erosion is a moderate hazard in unprotected areas during rainy periods. The soil has seep spots and "wet-weather springs" that require intensive drainage. Included with this soil in mapping was a narrow strip of a somewhat poorly drained Amity soil along the bottom of the draws. Capability unit IIIe-5; not placed in a woodland group; wildlife group 1.

Yamhill Series

The Yamhill series consists of well-drained soils that formed over basalt on low hills. These soils have 2 to 50 percent slopes. Depth to basalt rock is 20 to 40 inches. Elevations range from 260 to 600 feet. Annual precipitation is 40 to 50 inches, average annual air temperature is 52° F., and the frost-free season is 165 to 210 days. In areas that are not cultivated, the vegetation is oak, rosebush, poison-oak, and some Douglas-fir. Yamhill soils are associated with Nekia, Jory, Steiwer, and Willakenzie soils.

In a representative profile, the surface layer is dark-brown silt loam about 7 inches thick. The subsoil is dark-brown friable silty clay loam in the upper 9 inches and dark reddish-brown, firm silty clay and gravelly clay in the lower part. Hard, partly weathered, fractured basalt rock is at a depth of about 39 inches.

Yamhill soils are used mainly for orchards, small grain, hay, and pasture. They are also used for wildlife habitat, recreation, and homesites.

Yamhill silt loam, 2 to 7 percent slopes (YaB).—This soil has gentle slopes. It is 30 to 40 inches deep over bedrock.

Representative profile on a northwest slope 257 feet east of road about 600 feet north of road curve; SW¼ NW¼NW¼ sec. 16, T. 5 S., R. 5 W.:

Ap—0 to 7 inches, dark-brown (7.5YR 3/2) silt loam, brown (7.5YR 5/4) when dry; moderate, fine and very fine, subangular blocky structure; friable, hard, slightly sticky, slightly plastic; many very fine pores; many fine roots; slightly acid (pH 6.2); abrupt, smooth boundary. (6 to 8 inches thick)

B1—7 to 16 inches, dark-brown (7.5YR 3/2) silty clay loam, brown (7.5YR 5/4) when dry; moderate, fine, subangular blocky structure; friable, hard, sticky, plastic; many very fine pores; common fine roots; medium acid (pH 6.0); clear, smooth boundary. (0 to 11 inches thick)

B21—16 to 24 inches, dark reddish-brown (5YR 3/3) silty clay, reddish brown (5YR 5/4) when dry; strong, medium and fine, subangular blocky structure; firm, very hard, very sticky, plastic; common very fine pores; few fine roots; medium acid (pH 5.8); clear, smooth boundary. (5 to 15 inches thick)

B22—24 to 36 inches, dark reddish-brown (5YR 3/3) silty clay, reddish brown (5YR 5/4) when dry; moderate, medium, subangular blocky structure; firm, very hard, very sticky, very plastic; common very fine pores; few fine roots; few fine fragments of basalt; medium acid (pH 6.0); clear, smooth boundary. (9 to 14 inches thick)

IIB23t—36 to 39 inches, dark reddish-brown (5YR 3/4) gravelly clay, reddish brown (5YR 5/4) when dry; weak, medium, subangular blocky structure; very firm, very hard, very sticky, very plastic; common, fine pores; common, thin, continuous clay films and few moderately thick clay films on ped surfaces and in pores and channels; 30 percent fine fragments of strongly weathered basalt; medium acid (pH 6.0); abrupt, wavy boundary. (0 to 3 inches thick)

IIR—39 inches, very hard partly weathered fractured basalt rock; dark-red soil coatings and clay films on fracture surfaces.

The A horizon has 7.5YR hue, but in places hue is 10YR. Moist chromas are 2 and 3. Dry chromas are 3 or 4. The A horizon contains a few fine concretions in places, but generally is free of concretions. Texture is silt loam, but in places it ranges to silty clay loam. The B horizon has hues of 7.5YR to 5YR and is redder in the lower part. Moist chromas range from 2 through 4. Dry values are 4 or 5. In places, a few fine basalt fragments are embedded in the lower part of the B horizon. The IIB2 horizon has color characteristics similar to those of the B2 horizons. It is heavy silty clay or clay in texture, and is 10 to 50 percent fine strongly weathered basalt fragments.

Included with this soil in mapping are areas of Nekia, Jory, Steiwer, Willakenzie, and more steeply sloping Yamhill soils. These areas are less than 2 acres in size and occupy less than 10 percent of the total acreage. Also included are areas of Stony land and of rock outcrop. These areas are less than an acre in size and occupy less than 2 percent of the total acreage.

This soil has moderately slow permeability. Roots can penetrate to depths of 30 to 40 inches. Tilth is good, and the soil can be cultivated most of the year except during winter and spring storms. The available water capacity is 5 to 7.5 inches. Surface runoff is slow, and the erosion hazard is slight in unprotected areas. Fertility is moderate.

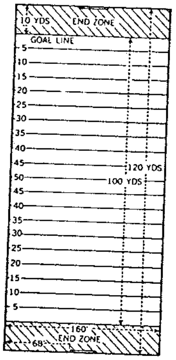
Most of the acreage has been cultivated. Orchards, small grain, hay, and pasture plants are the principal constituting a metrical unit of a verse. **14.** Usually, **foots.** sediment or dregs. **15.** **foots,** *Th*[illegible]ootlights. **16.** *Naut.* the lower edge of a sail. **17.** **fall** [illegible]**d on one's feet,** to be successful in spite of unfavora[illegible]rcumstances. **18.** **feet first, a.** with one's feet going [illegible]re: *We plunged into the river feet first.* **b.** dead: *The only way you'll get out of there is feet first.* **19.** **get off on the right** or **wrong foot,** to begin favorably or unfavorably. **20.** **on foot,** by walking or running, rather than by riding. **21.** **put one's best foot forward,** to attempt to make as good an impression as possible. **22.** **put one's foot down,** to take a firm stand; be decisive or determined. **23.** **put one's foot in it** or **into it,** *Informal.* to make an embarrassing blunder. Also, **put one's foot in one's mouth.** **24.** **set foot on** or **in,** to go on or into; enter (used in negative constructions): *Never set foot on our property again!* —*v.i.* **25.** to walk; go on foot (often fol. by *it*): *We'll have to foot it.* **26.** to move the feet rhythmically, as in dance (often fol. by *it*). **27.** (of vessels) to move forward; cover distance. —*v.t.* **28.** to walk or dance on. **29.** to perform (a dance). **30.** to traverse on or as if on foot. **31.** to make or attach a foot to: *to foot a stocking.* **32.** *Informal.* to pay or settle, as a bill. **33.** *Archaic.* to establish. **34.** *Obs.* to set foot on. **35.** *Obs.* to kick, esp. to kick away. **36.** **foot up,** to total, or add up, as an account or bill. [ME; OE *fōt;* c. G *Fuss;* akin to L *pēs,* Gk *poûs*]

-foot, a combining form of **foot** used with numerals to form compound adjectives: *ten-foot; two-foot.*

foot·age (fo͝ot′ij), *n.* **1.** length or extent in feet: *the footage of lumber.* **2.** a motion-picture scene or scenes: *newsreel footage; jungle footage.*

foot′-and-mouth′ disease′ (fo͝ot′ᵊn mouth′), *Vet. Pathol.* an acute, contagious disease of cattle, and other hoofed animals, characterized by vesicular eruptions in the mouth and about the hoofs, teats, and udder. Also called **hoof-and-mouth disease.**

foot·ball (fo͝ot′bôl′), *n.* **1.** *U.S.* **a.** a game in which two opposing teams of 11 players each defend goals at opposite ends of a field, points being scored chiefly by carrying the ball across the opponent's goal line and by place-kicking or drop-kicking the ball over the crossbar between the opponent's goal posts. Cf. **conversion** (def. 10), **field goal** (def. 1), **safety** (def. 4), **touchdown.** **b.** the ball used in this game, an inflated oval with a bladder contained in a casing usually made of leather. **2.** *Brit.* Rugby (def. 2). **3.** *Brit.* soccer. **4.** any person, subject, or thing treated roughly, casually, etc.: *They're making a political football out of the tax reform bill before it even comes up for a vote.* [late ME *fut ball*]



Football field
(Intercollegiate)

foot·board (fo͝ot′bōrd′, -bôrd′), *n.* **1.** a board or small platform on which to support the foot or feet. **2.** an upright piece across the foot of a bedstead. **3.** a treadle.

foot·boy (fo͝ot′boi′), *n.* a boy in livery employed as a servant; page.

foot·bridge (fo͝ot′brij′), *n.* a bridge intended for pedestrians only. [ME *fotbrigge*]

foot-can·dle (fo͝ot′kan′dᵊl), *n.* *Optics.* a unit of illuminance or illumination, equivalent to the illumination produced by a source of one candle at a distance of one foot and equal to one lumen incident per square foot. *Abbr.:* ft-c Also, **foot′ can′dle.**

foot·cloth (fo͝ot′klôth′, -kloth′), *n.*, *pl.* **-cloths** (-klôthz′, -klothz′, -klôths′, -kloths′). **1.** a carpet or rug. **2.** a richly ornamented caparison for a horse, hanging to the ground.

foot·ed (fo͝ot′id), *adj.* having a foot or feet (often used in combination): *a four-footed animal.* [late ME]

foot·er (fo͝ot′ər), *n.* **1.** a person who walks; walker; pedestrian. **2.** *Brit. Informal.* **a.** Rugby (def. 2). **b.** soccer.

foot·fall (fo͝ot′fôl′), *n.* **1.** a footstep. **2.** the sound of a footstep.

foot·gear (fo͝ot′gēr′), *n.* covering for the feet, as shoes or boots.

foot·hill (fo͝ot′hil′), *n.* a low hill at the base of a mountain or mountain range.

foot·hold (fo͝ot′hōld′), *n.* **1.** a hold or support for the feet; a place where a person may stand or tread securely. **2.** a secure position, esp. a firm basis for further progress or development.

foot·ing (fo͝ot′ing), *n.* **1.** a secure and established position; foothold. **2.** the basis or foundation on which anything is established. **3.** a place or support for the feet. **4.** the act of a person who moves on foot, as in walking or dancing. **5.** a firm placing of the feet; stability: *He regained his footing.* **6.** *Building Trades, Civ. Eng.* the part of a foundation bearing directly upon the earth. **7.** position or status assigned to a person, group, etc., in estimation or treatment. **8.** mutual standing; reciprocal relation: *to be on a friendly footing with someone.* **9.** entrance into a new position or relationship: *to gain a footing in society.* **10.** the act of adding a foot to something, as to a stocking. **11.** that which is added as a foot. **12.** the act of adding up a column of figures. **13.** the total of such a column. [ME]

foot-lam·bert (fo͝ot′lam′bərt), *n.* *Optics.* a unit of luminance or photometric brightness, equal to the luminance of a surface emitting a luminous flux of one lumen per square

1. Usually, **footlights,** **foots.** *Theat.* the lights at the front of a stage th on a level with the feet of the performers. **2.** the acting profession; the stage.

foot·ling (fo͝ot′ling), *adj.* *Informal.* foolish;

foot·lock·er (fo͝ot′lok′ər), *n.* a small trun containing the personal effects of a soldier and foot of his bed.

foot-loose (fo͝ot′lo͞os′), *adj.* free to go or not confined by responsibilities.

foot·man (fo͝ot′mən), *n.*, *pl.* **-men.** **1.** a livered who attends the door or carriage, waits on tab *Rare.* an infantryman. [ME *fotman*]

foot·mark (fo͝ot′märk′), *n.* a footprint.

foot·note (fo͝ot′nōt′), *n.*, *v.*, **-not·ed, -not·ing.** explanatory comment or reference note at the bo page, keyed to a specific part of the text on the minor or tangential comment added to a main —*v.t.* **3.** to add footnotes to (a text); annotate.

foot·pace (fo͝ot′pās′), *n.* **1.** a walking pace. portion of a floor; platform.

foot·pad (fo͝ot′pad′), *n.* a highwayman or goes on foot.

foot·path (fo͝ot′path′, -päth′), *n.*, *pl.* **-paths** -päthz′, -paths′, -päths′). **1.** a path for pedes *Brit.* footway (def. 2).

foot-pound (fo͝ot′pound′), *n.* *Physics.* a foo second unit of work or energy, equal to the work do force of one pound when its point of application through a distance of one foot in the direction of *Abbr.:* ft-lb

foot-pound·al (fo͝ot′poun′dᵊl), *n.* *Physics.* a foo second unit of work or energy equal to the work do force of one poundal when its point of application through a distance of one foot in the direction of *Abbr.:* ft-pdl

foot-pound-sec·ond (fo͝ot′pound′sek′ənd), *adj.* pertaining to the system of units in which the foo and second are the principal units of length, mass, *Abbr.:* fps, f.p.s.

foot·print (fo͝ot′print′), *n.* **1.** a mark left by the unshod foot, as in earth, sand, etc. **2.** an impression sole of a person's foot, esp. one taken for purposes of fication.

foot·rest (fo͝ot′rest′), *n.* a support for a person's

foot·rope (fo͝ot′rōp′), *n.* *Naut.* **1.** the portion of the rope to which the lower edge of a sail is sewn. **2.** suspended a few feet beneath a yard, bowsprit, jib boom spanker boom to give a footing for men handling sails

foot′ rot′, **1.** *Bot.* a disease of plants, esp. the genus affecting the base of the stem or trunk. **2.** *Vet. Pathol.* infection of sheep, causing inflammatory changes in the area of the hoofs and lameness. Also called **fouls.**

foot·scrap·er (fo͝ot′skrā′pər), *n.* a metal bar, set in a small frame and attached to a doorstep, used in cleaning the bottoms of the shoes before entering a house.

foot·sie (fo͝ot′sē), *n.* **1.** *Informal.* the act of flirting sharing a surreptitious intimacy. **2.** **play footsie with,** to flirt with, esp. by clandestinely touching someone's or leg; be furtively intimate with. **b.** to curry favor with esp. by surreptitious means. [childish dim. of FOOT]

foot′ sol′dier, an infantryman.

foot·sore (fo͝ot′sōr′, -sôr′), *adj.* having sore or tender as from much walking. —**foot′sore′ness,** *n.*

foot·stalk (fo͝ot′stôk′), *n.* *Bot., Zool.* a pedicel; peduncle.

foot·stall (fo͝ot′stôl′), *n.* **1.** the stirrup of a woman's sidesaddle. **2.** *Archit.* a pedestal, plinth, or base, as of a statue, column, or pier.

foot·step (fo͝ot′step′), *n.* **1.** the setting down of a foot, or the sound so produced; footfall; tread. **2.** the distance covered by a step in walking; pace. **3.** a footprint. **4.** a step by which to ascend or descend. **5.** **follow in someone's footsteps,** to succeed or imitate another person. [ME *foote steppe*]

foot·stone (fo͝ot′stōn′), *n.* a stone placed at the foot of a grave.

foot·stool (fo͝ot′sto͞ol′), *n.* a low stool upon which to rest one's feet while seated.

foot-ton (fo͝ot′tun′), *n.* *Physics.* a unit of work or energy equal to the energy expended in raising one ton a distance of one foot.

foot·way (fo͝ot′wā′), *n.* **1.** a way or path for pedestrians. **2.** Also called **footpath.** *Brit.* a sidewalk. [ME *fotewey*]

foot·wear (fo͝ot′wâr′), *n.* articles to be worn on the feet, as shoes or slippers.

foot·work (fo͝ot′wûrk′), *n.* **1.** the use of the feet, as in tennis or boxing. **2.** travel by foot from one place to another, as in fulfilling an assignment; legwork. **3.** the act or process of maneuvering, esp. in a skillful manner: *It took a bit of fancy footwork to avoid the issue.*

foot·worn (fo͝ot′wōrn′, -wôrn′), *adj.* **1.** worn away by footsteps: *a footworn pavement.* **2.** footsore.

foo·ty (fo͞o′tē), *adj.*, **-ti·er, -ti·est.** *Chiefly Dial.* poor; worthless; paltry. [var. of *foughty* musty, OE *fūht* moist, damp (c. G *feucht*); see -Y¹]

foo·zle (fo͞o′zəl), *v.*, **-zled, -zling,** *n.* —*v.t.*, *v.i.* **1.** to bungle; play clumsily: *to foozle a stroke in golf; to foozle on the last hole.* —*n.* **2.** the act of foozling, esp. of making a bad stroke in golf. [? < dial. G *fuseln* to work badly, clumsily, hurriedly]

fop (fop), *n.* a man who is excessively vain and concerned about his manners and appearance. [ME *foppe, fop;* akin to FOB²]

fop·per·y (fop′ə rē), *n.*, *pl.* **-per·ies.** **1.** the clothes, manners, actions, etc., of a fop. **2.** something foppish.

fop·pish (fop′ish), *adj.* resembling or befitting a fop; ex-

tive or responsive to: *an eye for beauty;* directed to; centered or focused upon: *a taste for fancy clothes.* **8.** in con- return for: *three for a dollar; to be thanked* appropriate or adapted to: *a subject for winter.* **10.** with regard or respect *too warm for April.* **11.** during the *for a long time.* **12.** in favor of; on the side *government.* **13.** in place of; instead of: **14.** in the interest of, or on behalf of: **15.** in exchange for; as an offset to: *blow for goods.* **16.** in punishment of: *payment* in honor of: *to give a dinner for a person.* of reaching: *to start for London.* **19.** *the advantage of everybody.* **20.** in order *for one's life.* **21.** in order to become: *to* **22.** in assignment or attribution to: *an the afternoon; That's for you to decide.* allow of or to require: *too many for separate* as results in: *his reason for going.* **25.** in interests or circumstances of: *bad for one's* proportion or with reference to: *He is tall for* the character of; as being: *to know a thing for* reason of; because of: *to shout for joy; a city* **29.** in spite of: *He's a decent guy for all* extent or amount of: *to walk for a mile.* **31.** an infinitive phrase equivalent to a con- relative clause): *It's time for me to go.* **32.** in (def. 20). —*conj.* **33.** seeing that; since. ME, OE; c. OS *for;* akin to FORE¹, L *per* before, ahead]

meaning "away," "off," "to the uttermost," wrongly," or imparting a negative or priva- in verbs and nouns formed from verbs of English origin, many of which are now obso- *forbid; forbear; forswear; forbearance.* [ME, Gk *peri-*, L *per-*]

2. forester. **3.** forestry.

on rails. Also, **f.o.r.**

for′-), *n.*, *v.*, **-aged, -ag·ing.** —*n.* **1.** food cattle; fodder; provender. **2.** the seeking or such food. **3.** the act of searching for provisions **4.** a raid. —*v.i.* **5.** to wander or go in search **6.** to search about; rummage: *He went foraging for old mementos.* **7.** to make a raid. —*v.t.* **8.** forage from; strip of supplies; plunder: *to forage* **9.** to supply with forage. **10.** to obtain by ME < OF *fourrage* < *fuerre* FODDER (< Gmc)] *n.* —**Syn.** **1.** See **feed.**

(fôr′ə kər, for′-), *n.* **Mount,** a mountain in Alaska, in the Alaska Range, near Mt. McKinley.

(fôr′əm), *n.* a foraminifer. [by shortening]

(fō rā′mən, fô-, fə-), *n.*, *pl.* **-ram·i·na** (-ram′ə- opening, orifice, or short passage, as in a bone or integument of the ovule of a plant. [< L: hole, *forā(re)* (to) bore, pierce + *-men* resultative n. —**fo·ram·i·nal** (fə ram′ə nᵊl), *adj.*

mag′num (mag′nəm), the large hole in the bone forming the passage from the cranial cavity canal. [< NL: lit., great hole]

in·i·fer (fôr′ə min′ə fər, for′-), *n.* any chiefly rhizopod of the order *Foraminifera*, typically having ous shell perforated by small holes or pores. [< (s. of *forāmen*) FORAMEN + -I- + -FER] —**fo- er·al** (fō ram′ə nif′ər əl, fô-, fə-), **fo·ram′i- ous,** *adj.*

much (fôr′əz much′, fər-), *conj.* in view of the seeing that; since. [ME]

(fôr′ā, for′ā), *n.* **1.** a quick raid, usually for the of taking plunder. **2.** a quick, sudden attack. to make a raid; forage; pillage. —*v.t.* **4.** to ravage of plunder. [ME *forraie(n)*, back formation from < OF < *forrier* forager. See FORAGE, -ER¹] —**for′-**

(ôrb), *n.* any herb that is not a grass or grasslike. *phorbē* food, fodder < *phérbein* to feed; akin to OE *birgan* to taste, eat, OIcel *bergja* to taste]

ade (fər bad′, -bād′, fôr-), *v.* a pt. of **forbid.** Also, **ad′.**

ear¹ (fôr bâr′), *v.*, **-bore, -borne, -bear·ing.** —*v.t.* **1.** rain or abstain from; desist from. **2.** to keep back; hold. **3.** to endure. —*v.i.* **4.** to refrain; hold back. **5.** to tient or self-controlled when subject to annoyance or ocation. [ME *forbere(n)*, OE *forberan*] —**for·bear′er,** —**for·bear′ing·ly,** *adv.* —**Syn.** **1.** forgo, renounce.

bear² (fôr′bâr′), *n.* forebear.

bear·ance (fôr bâr′əns), *n.* **1.** the act of forbearing refraining. **2.** forbearing conduct or quality; patient urance; leniency. **3.** an abstaining from the enforce- of a right. —**Syn.** **1.** abstinence. **2.** tolerance, tolera- sufferance.

bes-Rob·ert·son (fôrbz′rob′ərt sən), *n.* **Sir John-** 1853–1937, English actor and theatrical manager.

bid (fər bid′, fôr-), *v.t.*, **-bade** or **-bad, -bid·den** or **-bid·ding.** **1.** to command (a person) not to do some- have something, etc., or not to enter some place: *forbid him entry to the house.* **2.** to prohibit (something); an interdiction against: *to forbid the use of lipstick; forbid smoking.* **3.** to hinder or prevent; make impossible: *steepness of the slope forbade ascent.* **4.** to exclude; bar: *Burlesque is forbidden in many cities.* [ME *forbede(n)*, OE *forbēodan*] —**for·bid′der,** *n.*

—**Syn.** **1, 2.** interdict. FORBID, INHIBIT, PROHIBIT, TABOO indicate a command to refrain from some action. FORBID, a

associated with primitive superstition, means to prol common disapproval an[illegible]y social custom: *to taboo a in polite conversation* [illegible] preclude, stop, obviate —**Ant.** **1.** permit.

for·bid·dance (fər b[illegible], fôr-), *n.* **1.** the act bidding. **2.** the state o[illegible]eing forbidden.

for·bid·den (fər bid′ᵊn, fôr-), *v.* **1.** a pp. of —*adj.* **2.** not allowed; prohibited.

Forbid′den Cit′y, a walled section of Peking con the imperial palace and other buildings of the former Empire.

forbid′den fruit′, **1.** the fruit of the tree of kno of good and evil, tasted by Adam and Eve against prohibition. Gen. 2:17; 3:3. **2.** any unlawful pl esp. illicit sexual indulgence.

for·bid·ding (fər bid′ing, fôr-), *adj.* **1.** grim; unfr hostile; sinister: *a forbidding countenance.* **2.** dan threatening: *forbidding clouds.* —**for·bid′ding·ly** —**for·bid′ding·ness,** *n.*

for·bore (fôr bōr′, -bôr′), *v.* pt. of **forbear¹.**

for·borne (fôr bōrn′, -bôrn′), *v.* pp. of **forbear¹.**

for·by (fôr bī′), *prep.*, *adv.* *Chiefly Scot.* **1.** clo near. **2.** besides. Also, **for·bye′.** [ME]

force (fōrs, fôrs), *n.*, *v.*, **forced, forc·ing.** —*n.* **1.** st energy; power. **2.** efficacious power; power to inf affect, or control: *the force of circumstances; a force and order.* **3.** physical power or strength possessed living being: *He shoved with all his force.* **4.** strength or exerted upon an object; physical coercion; violence: *force to open the window; to use force on a person.* **5** unlawful violence threatened or committed against or property. **6.** persuasive power; power to convin *force of his arguments.* **7.** mental or moral strength: *th of one's mind.* **8.** might, as of a ruler or realm; stren war. **9.** Often, **forces.** a large body of armed men; **10.** any body of persons combined for joint action: *a force; an office force.* **11.** intensity or strength of effe *force of her acting; the force of his writing.* **12.** *Physics* influence on a body or system, producing or tending duce a change in movement or in shape or other **b.** the intensity of such an influence. *Symbol:* F, f **13.** ing power, as of an agreement. **14.** value; signifi meaning. **15.** **in force, a.** in operation; effective. large numbers; at full strength. —*v.t.* **16.** to compel, constrain, or oblige (oneself or son to do something: *to force a suspect to confess.* **17.** to or propel against resistance: *They forced air into his* **18.** to bring about or effect by force; bring about of nec or as a necessary result: *to force a passage; The strength position forced his opponent to resign.* **19.** to put or i (something or someone) forcibly on or upon a pers *force something on someone's attention.* **20.** to com force; overcome the resistance of: *to force acceptance of thing.* **21.** to obtain or draw forth by or as if by force; e *to force a confession.* **22.** to overpower; enter or ta force: *They forced the town after a long siege.* **23.** to open (a door, lock, etc.). **24.** to cause (plants, fruits to grow or mature at an increased rate by artificial n **25.** to press, urge, or exert (an animal, person, etc.) to v effort or to the utmost. **26.** to use force upon. **27.** *Ba* to advance or put out a runner on a force play. **28.** **a.** to compel (a player) to trump by leading a suit of he has no cards. **b.** to compel a player to play (a part card). **c.** to compel (a player) to play so as to make k the strength of the hand. —*v.i.* **29.** to make one's way by force. [ME < MF **fortia* < L *fortis* strong] —**force′a·ble,** *adj.* —**force** *adj.* —**forc′er,** *n.* —**forc′ing·ly,** *adv.*

—**Syn.** **1.** vigor. See **strength.** **6.** efficacy, effectiv **16.** coerce. **17.** impel. **22.** overcome; violate, ravish, —**Ant.** **1.** weakness. **6.** impotence.

forced (fōrst, fôrst), *adj.* **1.** enforced or compu *forced labor.* **2.** strained, unnatural, or affected: *a smile.* **3.** subjected to force. **4.** emergency: *a forced la* —**forc·ed·ly** (fōr′sid lē, fôr′-), *adv.* —**forc′ed·ness,** *n*

force de frappe (fôʀs də fʀäp′), *French.* France' clear power or capability, esp. as an independent mi deterrent.

forced′ march′, *Mil.* any march that is longer troops are accustomed to and maintained at a faster than usual.

force′ feed′, lubrication under pressure, as fro pump, used esp. in internal-combustion engines.

force-feed (fōrs′fēd′, fôrs′-), *v.t.*, **-fed, -feed·ing.** compel or force to eat or take food into the body. compel to absorb or accept, as propaganda.

force·ful (fōrs′fəl, fôrs′-), *adj.* **1.** full of force; pow vigorous; effective: *a forceful plea for peace.* **2.** acti driven with force. —**force′ful·ly,** *adv.* —**force′ful·nes**

force ma·jeure (*Fr.* fôʀs mȧ zhœʀ′), *pl.* **forces jeures** (*Fr.* fôʀs mȧ zhœʀ′). *Law.* an unexpected disruptive event that may operate to excuse a party fr contract. [< F: lit., superior force]

force·meat (fōrs′mēt′, fôrs′-), *n.* *Cookery.* a mixtu finely chopped and seasoned foods, usually containing white, meat or fish, etc., used as a stuffing or served a Also, **farcemeat.** [*force,* var. of FARCE + MEAT]

force-out (fōrs′out′, fôrs′-), *n.* *Baseball.* a put-out base runner on a force play.

force′ play′, *Baseball.* a situation in which a play forced to advance to a base or to home plate, either result of having batted a fair ball or in order to make r for another base runner.

for·ceps (fôr′səps, -seps), *n.*, *pl.* **-ceps, -ci·pes** (-sə p an instrument, as pincers or tongs, for seizing and hol

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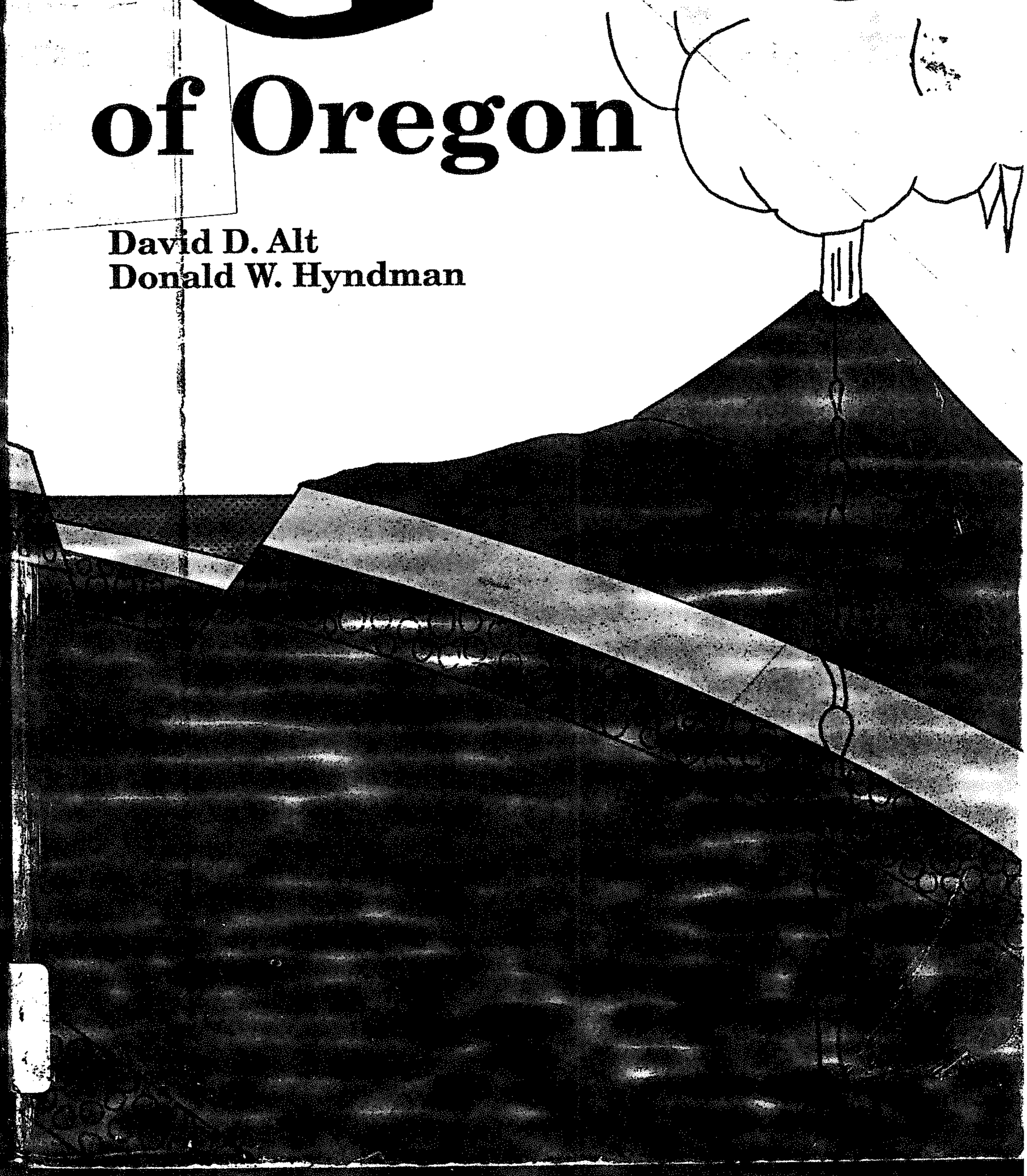
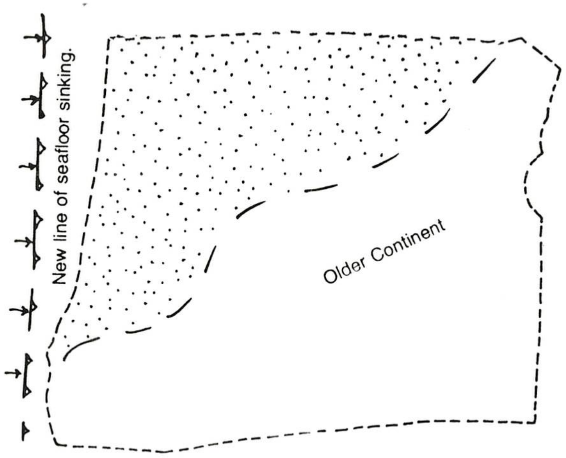


the coast range and willamette valley

The stage was set for the formation of the Coast Range and Willamette Valley about 35 million years ago when the line of seafloor sinking jumped from its old course curving inland to its present position offshore. A large slab of seafloor that had been moving in towards the continent was isolated between the old and new lines of sinking and quit moving to become the stationary platform on which most of northwestern and western Oregon is built. The Coast Range is simply the uplifted western edge of that slab of seafloor. Had the line of sinking not jumped, that slab would long since have sunk into the earth.



The stippled area shows the slab of seafloor that stopped moving about 35 million years ago when it was isolated between the old and new lines of seafloor sinking. Map is distorted to compensate for later movements.

Odd as it may seem, it is the sinking seafloor offsh that raised the Coast Range above sea level. As the sinking seafloor slides past the broken edge of the old slab that is the Coast Range, it scrapes off its load of muddy sediments, stuffing some of them under the edge of the old slab thus jacking it up. The Coast Range will rise as long as this continues.

When the seafloor finally quits sinking along its present line, the part of the Coast Range now offshore will rise above sea-level exposing the rocks now being stuffed under the edge of the Coast Range slab. Those will be the chaotically confused kind of rocks we see today in the Blue, Wallowa, and Klamath Mountains and in the Coast Range of California.

Except for its deformed southern end, the Coast Range is essentially an intact slab of seafloor. From a geologic point of view, studying the rocks in the Coast Range is the equivalent of taking an expedition to the bottom of the ocean. Better, actually, because streams have cut deep valleys into the Coast Range exposing its internal anatomy. All we can see of the modern seafloor is its upper surface.

Seafloor forms at rifts where two crustal plates are pulling away from each other. Basalt magma rises into the opening crack, fills it to make a dike, and pours out over the nearby seafloor as a lava flow. Basalt flows erupted under water look entirely different from those that erupt on land; they form a mass of bulging, lumpy forms that suggest a pile of oversized sofa pillows. An advancing lobe of lava chills quickly in contact with the cold sea water forming an outer skin of solid rock that bursts and lets the lava run out to do the same thing over again. The whole process is similar to the behavior of dripping candle wax and the forms produced are similar too. As flow after flow erupts from the rift that keeps opening between the separating plates, they pile up on each other to depths of hundreds or even thousands of feet to make the uppermost layer of hard bedrock beneath the seafloor. Meanwhile, the newly created seafloor is slowly moving away from the rift toward the continent and eventually to a zone of seafloor sinking. In the Coast Range we have a generous sample of seafloor that escaped its predestined doom of sliding back into the interior of the earth whence it came.

Of course the seafloor constantly receives sediments eroded from the continent and slowly carries them back to the continent and stuffs them into a coastal range. Were it not for the fact that new seafloor constantly forms while old seafloor constantly scrapes its sediments back onto the continent, the oceans would long since have filled with mud and the continents eroded to featureless plains. It is this constant creation and destruction of the restlessly moving seafloor that keeps our planet in business.

If the rift where the seafloor forms is not too far offshore, the sediments washing in from the continent will reach it and bury some of the lava flows almost as soon as they form. The result will be interlayered sediments and lava flows, something we often see in the Oregon Coast Range. Sometimes the molten basalt may not erupt onto the seafloor as a lava flow but instead inject itself between beds of sediment to make a sill — a layer of basalt sandwiched between layers of sediment. Some parts of the Coast Range are full of sills, many of them as much as several hundred feet thick.

The lava flows in the Coast Range erupted during Eocene time, perhaps 50 or 60 million years ago, so that must have been when this expanse of seafloor formed. Most of the dirty sandstones and mudstones that are interlayered in the seafloor lava flows and also deeply cover them in many parts of the Coast Range also date from Eocene time. Some parts of the Coast Range still contain younger Oligocene sediments deposited about 35 or 50 million years ago which presumably once blanketed the entire surface before erosion removed most of them.

It was near the middle of Oligocene time, about 35 million years ago, when the line of seafloor sinking jumped from its old course to its present one off the modern coastline. Evidently most of the Coast Range was jacked above sealevel very shortly thereafter because we find no sedimentary rocks deposited

since then anywhere except in the Astoria and Tillamook areas. There we find mudstones deposited during Miocene time, some perhaps as recently as 20 million years ago, so evidently those areas remained submerged a few million years longer. Ever since middle Oligocene time, the seafloor sinking offshore has been jamming younger sedimentary rocks against and beneath the edge of the Coast Range slab.

Those Miocene mudstones in the northern end of the Oregon Coast Range contain a large variety of distinctly tropical fossil seashells nearly identical to those of the same age in southernmost California. Obviously the water along the Oregon coast was much warmer during Miocene time than it is now. Those seashells lived while red tropical soils were forming over most of Oregon and leaves of tropical plants were being preserved in eastern Oregon lake beds. Oregon was truly tropical during Miocene time.

In most of the Coast Range, the older sedimentary rocks are the kind of dark gray mudstones and dirty sandstones that accumulate on deep-sea floor far from shore, the same kind of sediments that come up in most deep-sea cores cut by oceanographic research vessels. But things are different at the southern end of the Coast Range, in the vicinity of Coos Bay and Coquille. There the sedimentary pile is very thick, tightly crumpled, and contains rocks deposited along the shoreline as well as some that appear to have been laid down in deep water.

The region around Coos Bay and Coquille is at the narrow southern tip of the big slab of seafloor isolated between the old and new lines of seafloor sinking. And it is also adjacent to the Klamath Mountains. It is easy to imagine that the Klamaths may have been a source of abundant sediment back in Eocene time which would have dumped onto the nearby seafloor to build a large continental shelf and coastal plain. Along that seashore there must have been big coastal marshes filled with lush jungles because we find thick coal seams in the area today. It is probably quite reasonable to imagine genuinely tropical jungles growing along the Oregon coast then because there is abundant evidence in many parts of the world to indicate that usual warmth and wetness.

So imagine a large coastal plain and continental shelf built adjacent to the Klamaths and then remember that this is still Eocene time and the seafloor on which it is built is moving landward as though it were a ponderously slow conveyor belt. The effect will be to telescope the rocks in that thick coastal accumulation, jamming the ones deposited offshore under those deposited nearshore and crumpling the whole pile into tight folds. The Eocene rocks in the southern end of the Coast Range are tightly folded simply because they were colliding with the Klamaths while those farther north were still riding peacefully along on their part of the seafloor.

The Willamette Valley probably rose above sea level along with the Coast Range and indeed there was probably nothing to distinguish it from the Coast Range at that early stage in its development. The Willamette Valley was dry land by the middle of Miocene time, about 20 million or so years ago. Some of the big flood-basalt flows erupted from the Grande Ronde volcano in the northeastern corner of Oregon made it all the way to the mouth of the Columbia River to cover parts of the north end of the Coast Range and the northern part of the Willamette Valley. We can be quite sure that the Willamette Valley was above sea level then because those flows are solid, not pillow basalts as they would have been had they poured into water. The same flows did reach the ocean and become pillow basalts in the north end of the Coast Range.

It seems far more likely that the Willamette Valley did not become a lowland until long after the flood basalts had covered its northern part. In fact, the Willamette Valley is not a simple lowland at all but a series of broad basins filled with gravelly sediment and separated by tracts of low hills eroded into the basalt flows. The easiest way to imagine these basins forming is to relate them to the northward movement of the west coast during the past 15 million or so years.

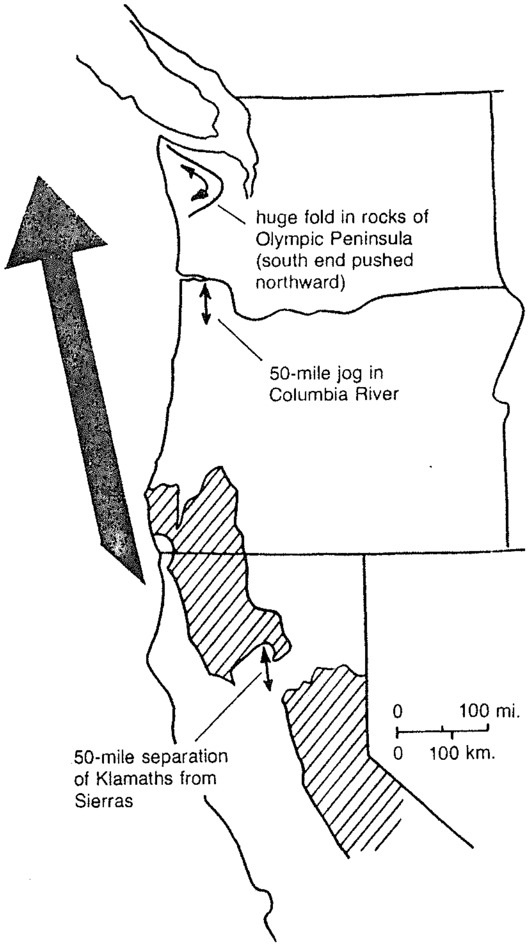
There is no doubt that the Pacific plate is indeed moving northward, tearing the western edge of our continent into big

expressed in California where the famous

carrying a western slice of the state northward at an average rate of about 2 inches per year. That is fast enough to move something 300 miles in a little less than 10 million years and the slice of California west of the San Andreas fault seems to have moved approximately 350 miles since Miocene time. The situation in Oregon is considerably more complicated, making the rate of movement and total displacement much less and its geologic expression quite different.

Just a few hundred miles offshore from the Pacific northwest there is an active rift in the ocean floor where two seafloor plates are pulling away from each other. The rift trends towards the northeast and, as it happens, the seafloor is pulling away from it and heading toward our coast, moving towards the southeast, away from the rift. If this were the whole story, the coast of Oregon would be carried southeastward. But the entire ocean floor, rifts and all, is moving northward and the two directions of movement tend to cancel each other. Evidently, the rate of northward movement of the entire ocean floor must be somewhat greater than the rate of southeastward movement away from the rift because the western part of Oregon does seem to be moving very slowly northward.

We can't be sure just how far north the western part of Oregon has moved but several observations suggest that the distance may be fairly close to 50 miles. In northern California the southern edge of the Klamaths is about 60 miles west and 50 miles north of the northern edge of the Sierra Nevada and there is every reason to believe that the two ranges were originally one. The 60-mile offset to the west is at least 100 million years old and obviously has nothing to do with our present problem. But the 50 mile separation to the north may well be much more recent. In Washington we find the northern end of the Coast Range slab curled into a tight fold in the Olympic Mountains just south of where it jammed into the much thicker crust of Vancouver Island. If that fold were straightened out, it would make the Coast Range tens of miles longer. And in Oregon we find the Columbia River abruptly terly path to the ocean. If the entire Coast Range slab could be slid 50 [illegible]s southward, the fold in the Olympic Mountains would straighten out, the Columbia River would flow straight into the ocean, and the southern edge of the Klamaths would be directly west of the northern edge of the Sierra Nevada. Everything would fit back together into a much simpler pattern. These observations certainly don't prove that the Coast Range has moved 50 miles northward; because such things are hardly ever proveable in any final sense, but they do make it seem plausible.



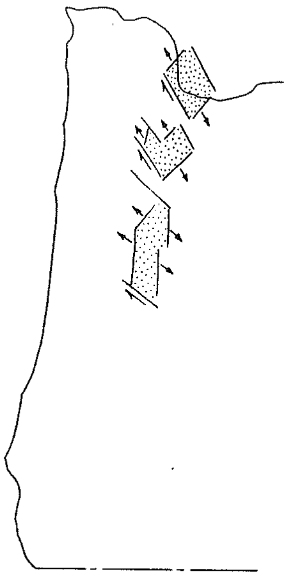
Map of the western Pacific Northwest showing relations that suggest northward movement of the coast.

northward as a reasonably intact slab because it is close enough to the descending slab of seafloor beneath i[illegible]at the two are probably fairly closely coupled together. B[illegible] as the descending slab moves east it also sinks deeper so its linkage to the Oregon plate must become looser eastward. We can imagine the Coast Range moving northward, leaving the area east of it behind with a zone of tearing between them. The Willamette Valley appears to encompass that zone of tearing.

Usually a shearing motion between two parts of the earth's crust is expressed in long, straight faults which move horizontally; the San Andreas fault in California is a good example. But sometimes such shearing motion is distributed through a complex pattern of numerous smaller faults some moving horizontally and others vertically. The shearing motion between the northward moving Coast Range and the relatively stationary area east of it seems to be distributed through the Willamette Valley in a complex pattern of faults resembling that in southeastern Oregon.

It is difficult to be as confident about those faults because very few have been recognized in the Willamette Valley where they aren't as obvious as in the desert. Faults are hard to find in the rather nondescript lava flows and loose gravelly sediments that floor the Willamette Valley and the fact that they are all covered by deep soils and dense vegetation makes a difficult situation nearly impossible. But enough faults are known to faintly suggest a pattern similar to that in southeastern Oregon and the distribution and outlines of the areas underlain by young basalt and basin-fill deposits also suggest such a pattern.

The southern end of the Willamette Valley is defined by a northwest-trending fault that horizontally offsets the Cascades and dictates the straight upper course of the Willamette River southeast of Eugene. South of the Eugene area, until it meets the Klamaths near Roseburg, the Coast Range extends eastward to the Cascades just as it must have done farther north before faulting opened the Willamette Valley. This arrangement probably reflects the differences in thickness of the earth's crust north and south of Eugene.



Map showing distribution of basalt lava flows and sediment-filled basins in the Willamette Valley. The pattern of faults shown outlining the basins is partly hypothetical.

The kinds of lavas erupted in the Cascades suggest that the buried northern tip of the Klamaths must extend about as far as Eugene. North of Eugene the Cascades stand on the same rocks we see in the Coast Range, on the stagnant slab of seafloor that stopped moving about 35 million years ago. The earth's crust under the Klamaths and indeed most of southern Oregon must be at least 20 miles thick, while that under the old seafloor slab is much thinner. Therefore the linkage of the descending slab of Pacific Ocean floor to the crust under southern Oregon must be much tighter and extend much farther inland than that to the thinner seafloor crust beneath northwestern Oregon. This may well explain why the shear between the sinking slab and the continent is distributed all the way across southern Oregon but is confined to the narrow zone of the Willamette Valley in the northern part of the state.

Almost all the gravelly sediments that fill the basins in the Willamette Valley washed into them during Pliocene time, between 11 and 3 million years ago. That was a period of widespread gravel deposition not only in the Willamette Valley but elsewhere in Oregon as well as in the great valley of California, the mountain valleys of the Rockies and the length and breadth of the high plains. Had the geologic periods been named in the American west, instead of in western Europe, the Pliocene might well have been called the "Gravel period." Ever since the end of Pliocene time, our modern streams have been busily carrying all that gravel to the ocean but their job is hardly begun.

If we look at our modern world, which can't be all that different from the world of 10 million years ago, we find that widespread deposition of gravel happens only in very arid regions. Deserts have a very high rate of soil erosion because of their scanty plant cover and a very low volume of stream flow to carry the eroded debris away. So gravels eroded from desert hillsides tend to wash into the nearest valley and stay there. Evidently western Oregon was a desert during Pliocene time, incredible as that might seem today, and the basins in the Willamette Valley filled with gravel as quickly as fault movements opened them. In fact, they filled to overflowing, covering the bounding faults with gravel making them hard to recognize and the geologic picture hard to interpret today.

Even though those faults are largely buried under the Pliocene gravels and are therefore to some extent conjectural, there is nothing speculative about the earthquakes they occasionally cause. There aren't many earthquakes in the Willamette Valley, no doubt because the rate of movement is very slow, but there are a few and they do fit into the general geologic pattern. The Portland earthquake of 1962, for example, was caused by horizontal movement on a northwest-trending fault on which the south side moved northwest. This movement precisely fits the pattern we suggest and almost certainly indicates that the Coast Range is still going north and the Willamette Valley still widening.

If this movement continues for millions of years into the future, as it may well do, it will almost certainly eventually convert the Willamette Valley into the narrow inland seaway that it never has been.

[illegible] ırried right off thr ap and most of it is now in the south jetty .on which is one o. e best places in Oregon to see nice, fresh f blueschist. The jetty at Coos Bay is another good blueschist but that came from another quarry.

and there the sediments blanketing the marine terrace in- ›posits of black sand that contain as much as 10 per cent ә along with small amounts of platinum and gold. Both the ә and platinum come from patches of old oceanic crust in the ıs, from dense, black igneous rocks that usually contain .nerals. Gold never comes from such rocks but there are some :olored igneous rocks in the Klamaths which have deposits of ociated with them. Streams bring all these minerals from rious sources to the coast where the waves sort them, because all heavy, into deposits of black sand. Several small mines rked the black sands in this area during times when chromite ›hort supply and several have attempted to work them for n and gold. But reserves are small so future prospects are

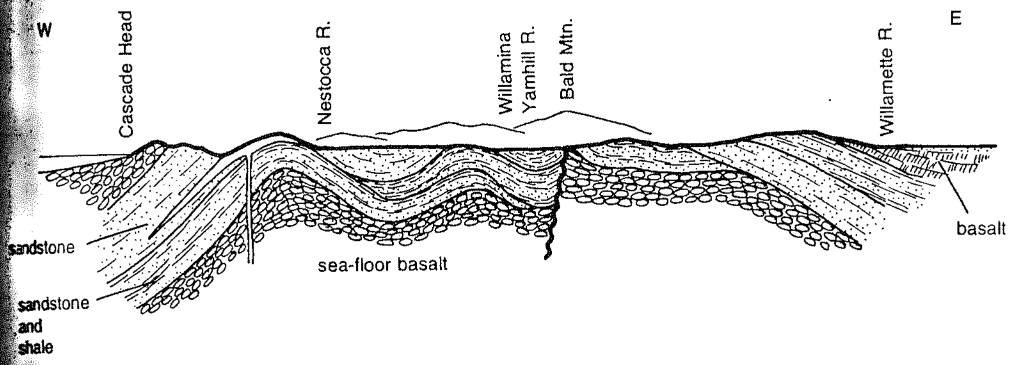
where in the tangle of hills about 20 miles east of Port Orford ormous meteorite found by Dr. John Evans, an early Oregon , back in July, 1856 and never seen since. There is no doubt xists because Dr. Evans sent a specimen to the Smithsonian ı which still has it. He estimated that the entire mass must ıore than 10 tons which, if true, would place it among the ten netoerites ever found. Hundreds of people have looked for the t Orford meteorite and there are dozens of theories about might be, but most students of the problem seem to think robably lies somewhere in the headwaters of the Elk River, on the west slope of Iron Mountain. The meteorite, if found, :e an interesting museum specimen but will not bring untold its discoverer as so many searchers have imagined. We know ə specimen in Washington that it is composed mostly of an iron and nickel and has crystals of a green mineral called scattered through it.

oregon 18

lincoln city — portland

The route between Lincoln City and Portland crosses both the Coast Range and the Willamette Valley, passing some very interesting rocks which are hard to see. Thick soils and all that greenery keep western Oregon's rocks remarkably well hidden.

Lincoln City is on an old beach now raised above the waves, either by uplift of the land or a drop in sea level, to make a smooth and nearly level terrace overlooking the modern beach; an excellent townsite. The route follows this terrace to Neotsu where highway 18 turns inland, crossing about 3 miles of mudstones laid down on the seafloor during Eocene time, about 50 million years ago. The road follows the Salmon River inland from Otis, passing through Eocene seafloor basalts for about 6 miles and then back into Eocene mudstones all the way through Grande Ronde to Willamina.

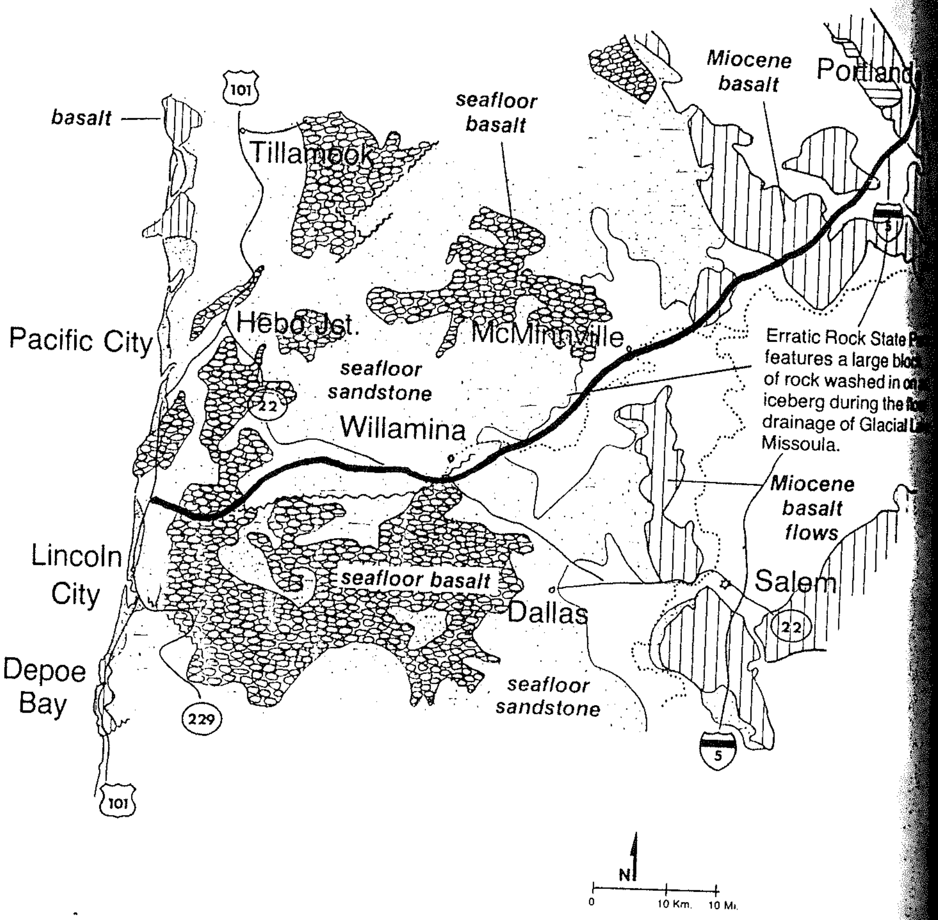


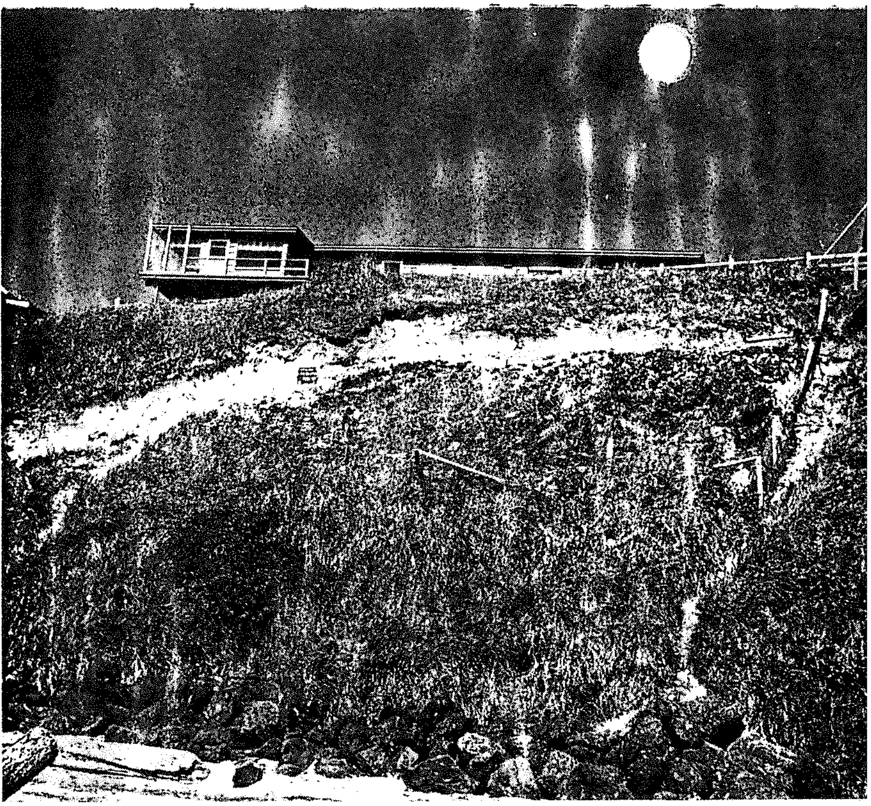
Section through Coast Range just north of Lincoln City.

From Willamina the highway follows the broad floodplain of the Yamhill River through McMinnville to Newberg on the Willamette River. Just east of Newberg the road leaves the floodplain to cut

18
LINCOLN CITY — PORTLAND
(70 miles or 113 kilometers)

22
SALEM — HEBO JCT.
(55 miles or 89 kilometers)





A landslide in the wave-eroded edge of an old coastal terrace threatens homes in Lincoln City.

across a tract of low hills eroded on basalt lava flows which it follows into the outskirts of Portland. These basalt flows are the westernmost end of the Columbia Plateau; they poured all the way from northeastern Oregon down the Columbia River and onto the north ends of the Coast Range and Willamette Valley. Those eruptions happened during Miocene time, about 20 million years ago, so they are much younger than the rocks in the Coast Range.

The line of hills which runs just west of Portland through Sylvan, Oswego and West Linn is a chain of small volcanoes which were active during the last several million years. There are literally dozens of small volcanoes around Portland, grouped in clusters all around the town.

Fourth Edition

Geology of Oregon

Elizabeth L. Orr
William N. Orr
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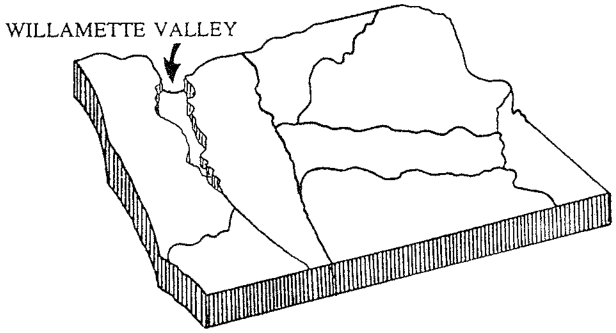
Willamette Valley

Physiography

The Willamette Valley and Puget Sound physiographic province is a lowlands stretching from Cottage Grove, Oregon, to Georgia Strait in Washington. The smallest physiographic division in Oregon, the valley is a level, elongate alluvial plain which narrows at either end for 30 miles before it pinches out. Enclosed on the west by the Coast Range, on the east by the Cascade Mountains, and bordered on the north by the Columbia River, the main valley is 130 miles long and from 20 to 40 miles wide. From 400 feet at the southern end of the valley near Eugene, the elevation drops to sea level at Portland, an average of 3 feet per mile. The overall gradient is to the north and not from the margins toward the middle. The southern end of the valley is narrower but flatter than the northern hilly Salem and Portland areas. Salem is bordered by the Eola Hills to the west, the Ankeny Hills to the south, and the Waldo Hills to the east. The 1,000 feet high Tualatin Mountains are adjacent to Portland on the west, the Chehalem Mountains cross to the southwest, while to the east and southeast smaller volcanic buttes and peaks dot the landscape. Near the center of the valley, the 45th parallel, halfway between the equator and the North Pole, passes close to Salem.

With a watershed of 11,200 square miles, the Willamette River is the major waterway in the valley. Originating at the junction of the Coast and Middle forks near Eugene, the river runs north-northeast to its confluence with the Columbia. Flowing into the Willamette, sediment laden waters of the Coast and Middle forks from the south, the McKenzie, Calapooia, North and South Santiam, Pudding, Molalla, and Clackamas rivers from the Cascade Mountains, and the Long Tom, Marys, Luckiamute, Yamhill, and Tualatin rivers from the Coast Range drain the surrounding areas.

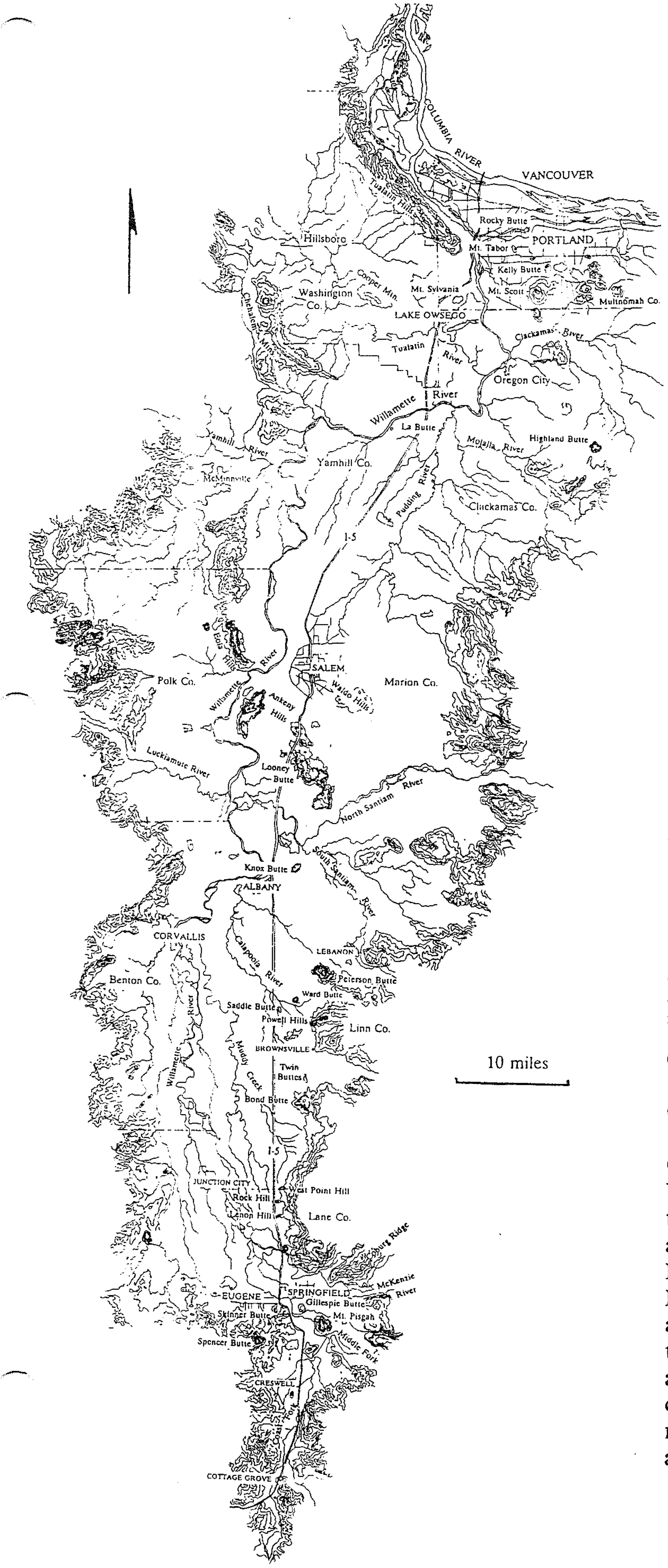
Although comparatively small, the Willamette Valley is the economic and cultural heart of Oregon. As the only natural lowland of any size, its moderate climate supports 70% of Oregon's population as well as intense and varied agriculture.



Geologic Overview

Physiologically the Willamette-Puget Sound lowland is similar to the Great Valley of California, but geologically the two are significantly different. The California valley was at one time an inland sea behind the Coast Range, whereas the Oregon province was part of a broad continental shelf of the ocean extending from the Cascades westward beyond the present coast. Structurally the Willamette Valley was more of a coastal marine environment than a true isolated basin or a valley cut by a river. Although subsurface geology of the Willamette Valley is closely related to that of the Coast Range, the later history of the valley is primarily one of glacial events. Thick layers of Late Pleistocene and Holocene alluvium cover all but a few areas of preTertiary rock from Eugene to Portland.

Older foundation rocks here are volcanics that erupted as part of a submarine oceanic island archipelago. Once the archipelago was attached or accreted to the western margin of North America, the volcanic rocks subsided, and a forearc basin formed on top. This basin was to become the focus of marine deposits from the Eocene through Pliocene. Fossils and sediments accumulating in the basin during the Oligocene,



Miocene, and Pliocene reflect shallowing as the ocean shoreline retreated northwestward. These marine sediments were covered in turn by Columbia River lavas that poured through the gorge from eastern Oregon during the middle and late Miocene to invade as far south as Salem.

Uplift and tilting of the Coast Range block and Western Cascades brought about the trough-like configuration of the Willamette Valley and the formation of a number of closed basins on the continental shelf. During the Pliocene and Pleistocene in the northern part of the province, a large lake received silts, muds, and gravels from the Willamette and Columbia rivers. The eruption of the Boring lavas from over 100 small volcanoes near Oregon City as well as east and west of Portland covered these earlier lake sediments, and today the vents project as small buttes.

The dominant signature on Willamette Valley geology resulted from a number of large-scale Pleistocene floods that scoured eastern Washington and the Columbia River gorge leaving deposits throughout the province. Enormous glacial lakes formed in Montana when the Clark Fork River was dammed by ice and debris. Once the ice blockage was breached, rushing flood waters carrying icebergs cascaded across Idaho, southeastern Washington, and down the Columbia gorge. Water backed up into the Willamette Valley creating temporary lakes and strewing a field of boulders in its wake. An unknown number of floods took place during a 2,500 year interval until the climate warmed, and glaciers retreated northward.

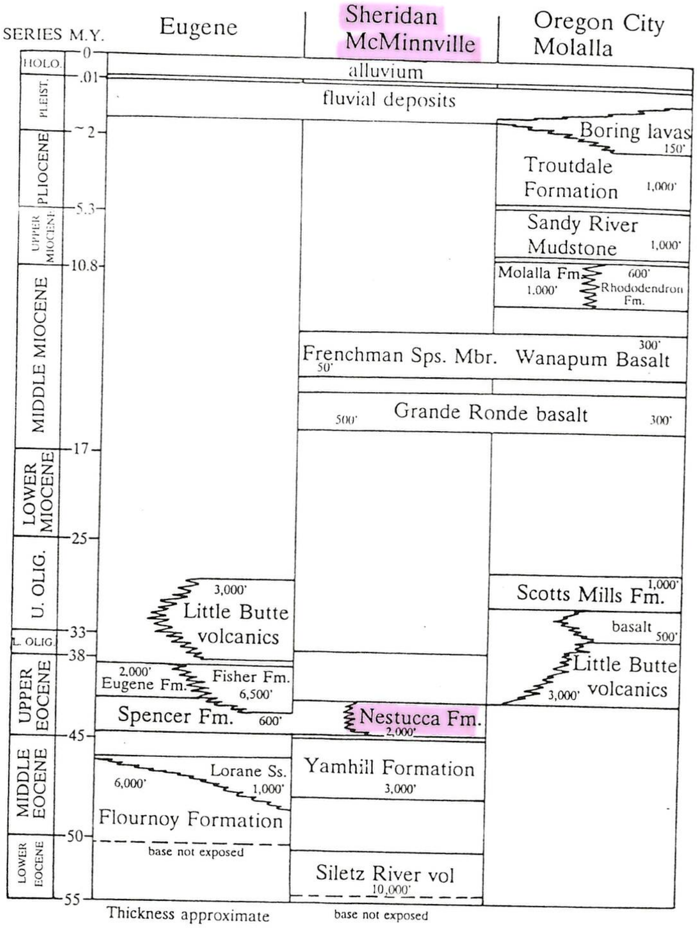
Because of its position close to the offshore subduction zone between Pacific Northwest plates, Oregon experiences a continual number of seismic events, and in the future the state could be the site of catastrophic earthquakes although details of time and place are uncertain. The coastal regions and Willamette Valley would be particularly vulnerable should a strong quake occur.

Geology

Geologically part of the eastern margin of the Coast Range block, foundation rocks of the Willamette Valley have played something of a passive role against the backdrop of moving tectonic plates. In Eocene time an undersea chain of volcanoes atop the Kula and Farallon plates collided with the westward moving North American plate where they were accreted. With a thickness of more than 2 miles, the volcanic rocks of the island chain form the basement of the Coast Range and Willamette Valley. After docking or making initial contact with North America, the island archipelago was rotated clockwise beginning in the early Eocene. With accretion, the old subduction zone east of the volcanic block was abandoned and a new one activated offshore to the west where it is today.

The slow subsidence of the block created a broad forearc trough along the western margin of North America. From Eocene through Pliocene time the basin was the recipient of deposits that blanketed the earlier volcanic platform. Rivers draining the Klamath Mountains and later the Idaho batholith provided abundant sediments that accumulated in the newly formed basin. During the early Eocene the eastern edge of the subsiding coastal block that was to become the Willamette Valley collected sandstones and siltstones of the Flournoy Formation near Lorane, Philomath, Falls City, the low hills around Camp Adair, and in the southern valley. Where Eocene rocks are exposed in the area north of Corvallis, rolling hills contrast sharply with the flat valley floor elsewhere that is covered with Pleistocene fill.

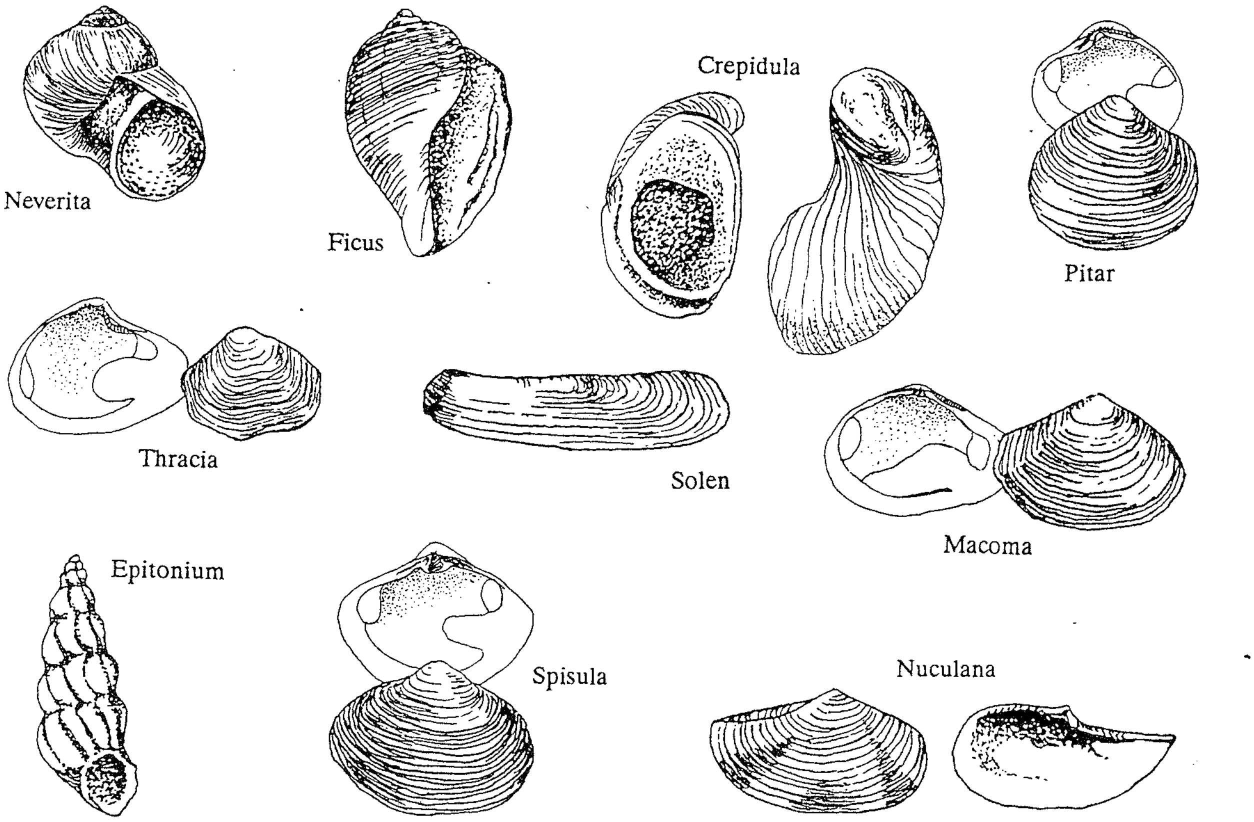
In the northern part of the valley these deposits were followed by middle Eocene Yamhill muds, sands, and silts, mixed with ash and lavas from the ancestral Cascades that were carried into the shallow seaway. Within the Yamhill, shoals of limestones around offshore banks formed the Rickreall and Buell limestones containing broken mollusc shells, foraminifera, and calcareous algae intermixed with volcanic debris. In the northern valley 2,000 feet of Nestucca Formation deposited in a deep water setting extended westward from McMinnville, while near-shore sands, silts, and muds of the shallow marine Spencer Formation produced deltas along the margin. Found along the western side of the valley from Eugene north to Gales Creek in Washington County, Spencer sands are covered by nonmarine tuffs and conglomerates of the late Eocene Fisher Formation. Fossil plants from the Fisher Formation southwest of Cottage Grove indicate a warm, moist tropical climate where broad leaf plants as the Aralia grew close to the shoreline. Beneath Eugene almost a mile of upper Eocene silts and sands of the Eugene Formation extend northward toward the Salem hills. Marine molluscs, crabs, and sharks in this formation suggest warm, semitropical seas. Sediments of the Spencer, Fisher, and Eugene formations were derived from the rapidly growing volcanics of the Western Cascades.



Willamette Valley stratigraphy (after COSUNA, 1983)

Oligocene

The Oligocene ocean in the Willamette Valley reached only as far south as Salem. The high-water mark on the western shoreline is recorded by marine sediments in the vicinity of Silverton and Scotts Mills in Marion and Clackamas counties. In the Scotts Mills Formation a transgressive, advancing seaway followed by a regressive, retreating ocean chronicles storm conditions, shallow water, and coastal swamps that gave rise to thin layers of low-grade coal. Coal beds at Wilhoit Springs and Butte Creek were deposited along the margins of the sea as it retreated. Prior to the arrival of the Columbia River lavas in the middle Miocene, the Scotts Mills sediments were tilted eastward and severely eroded.



Invertebrate fossils of the late Eocene Eugene Formation

In the Nehalem Valley fine-grained shallow marine sediments of the Scappoose Formation are contemporaneous with the Scotts Mills Formation. Over 1,500 feet of Scappoose sandstones, mudstones, and conglomerates were deposited in an estuary or delta environment covering a dissected landscape.

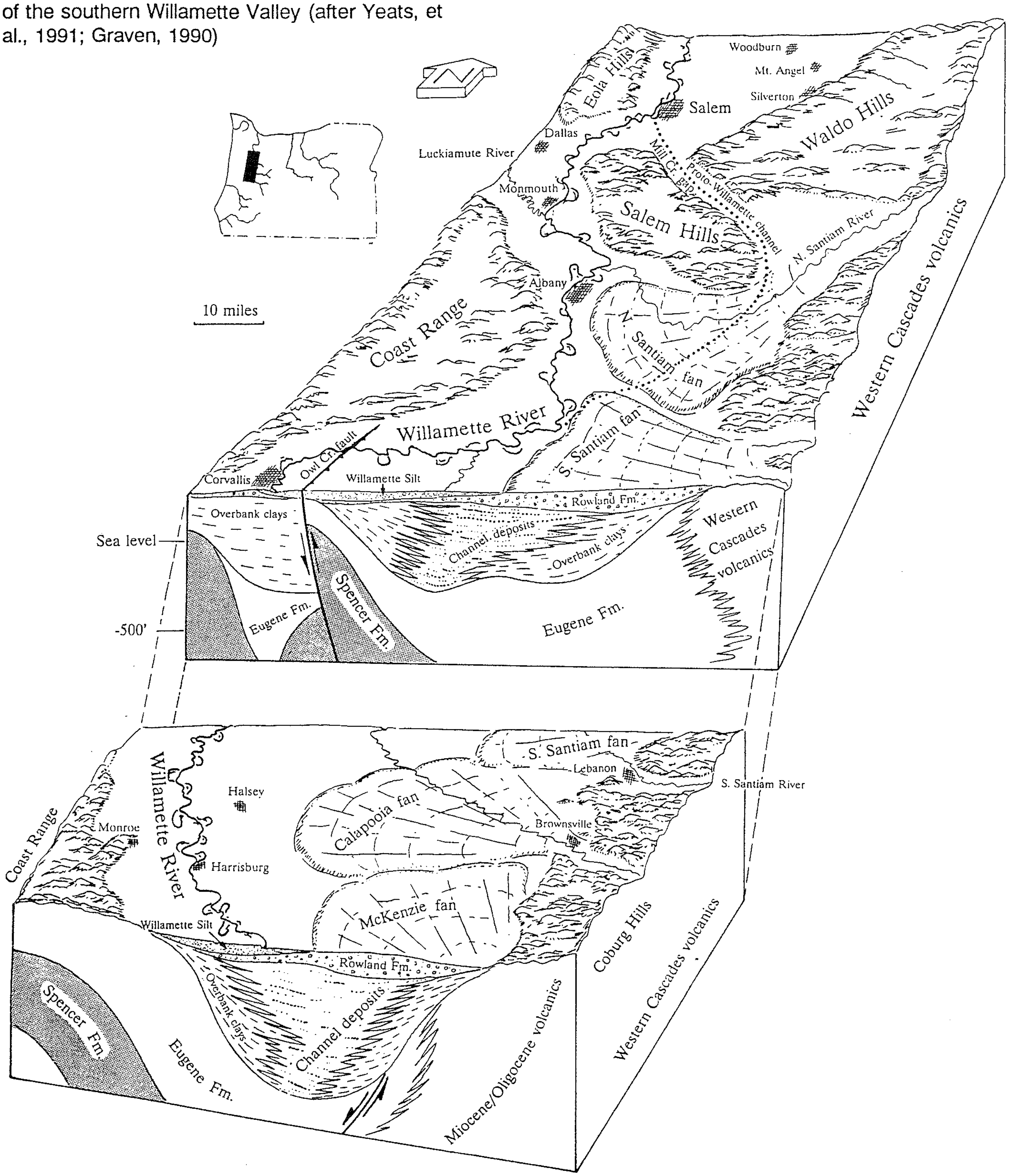
Miocene

With slow uplift of the Coast Range, the sea withdrew from the region of the Willamette Valley. The deep shelf and slope environment became shallower as the basin filled. Little is known about the configuration and environment of the Willamette Valley following the regression of the late Oligocene seaway. A broad semitropical coastal plain, where lakes ponded in slight depressions, extended from the ancestral Cascades out to the present shoreline. Black, silty clays lying between weathered Pleistocene and late Eocene Spencer sandstones near Monroe reveal ancient lakebed sediments that contain fossil pollen from coniferous as well as broadleaf plants once living around the lacustrine basin. Much of the pollen from this lake is from plants now extinct in the Pacific northwest.

In middle and late Miocene time, voluminous sheets of basaltic lava from fissures and vents in northeastern Oregon poured through the Columbia gorge and into the Willamette Valley where they reached as far south as Salem. The fluid Columbia River lavas covered the region of the Portland Hills, most of the Tualatin Valley, as well as the slopes of the Chehalem, Eola, and Amity hills. The dark, finely crystalline, collumnar-jointed basalt ranges up to 1,000 feet in thickness. Near Portland the layers of lava produced a monotonous, flat landscape with only the tops of several higher hills projecting above the flows. After cooling and crystallizing, the lavas rapidly decomposed in western Oregon's wet climate so that almost all of the original volcanic landscape has been thoroughly dissected. Dark red soils around Dundee, the Eola Hills, and Silverton Hills are easily recognized as decomposed Columbia River basalts.

Interfingering with the Columbia River basalts in northern Marion and Clackamas counties, 1,000 feet of clastic sediments, mudflows, and volcanic tuffs of the Molalla Formation represent the first terrestrial sediments deposited after the withdrawal of the Oligo-

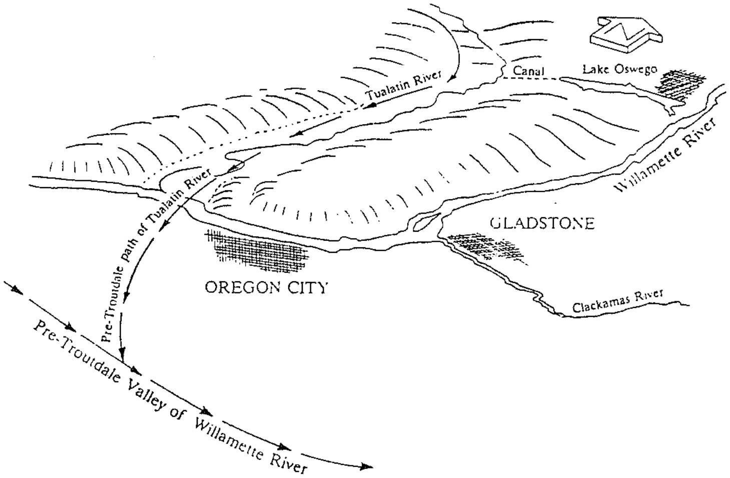
Pleistocene fluvial and flood deposits and structure of the southern Willamette Valley (after Yeats, et al., 1991; Graven, 1990)



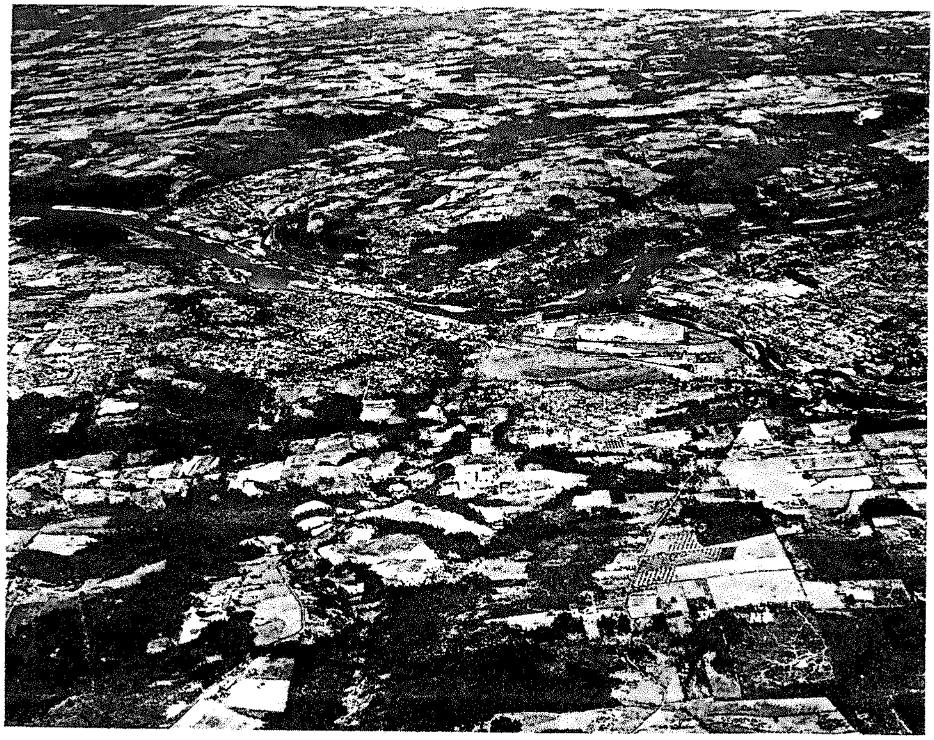
cene seaway. Mudflows here originated when heavy rains on the slopes of ancient volcanoes caused loose ash to flow for miles down valleys. Abundant fossil flora in these sediments suggest a hilly topography covered with Liquidambar, (sweet gum), Platanus, (sycamore), and Carya, (hickory) adjacent to swamps dominated by cypress. Ginkgo and Metasequoia commonly occured in the warm, rainy climate.

Around 1,000 feet of silt in the Portland and Tualatin basins, designated as the Helvetia Formation, sits directly above the Columbia River basalts. Pebbles of basalt quartzite, granite, along with abundant quartz and mica, suggest these sediments were deposited by streams of the surrounding mountains ranges as well as the ancestral Columbia River.

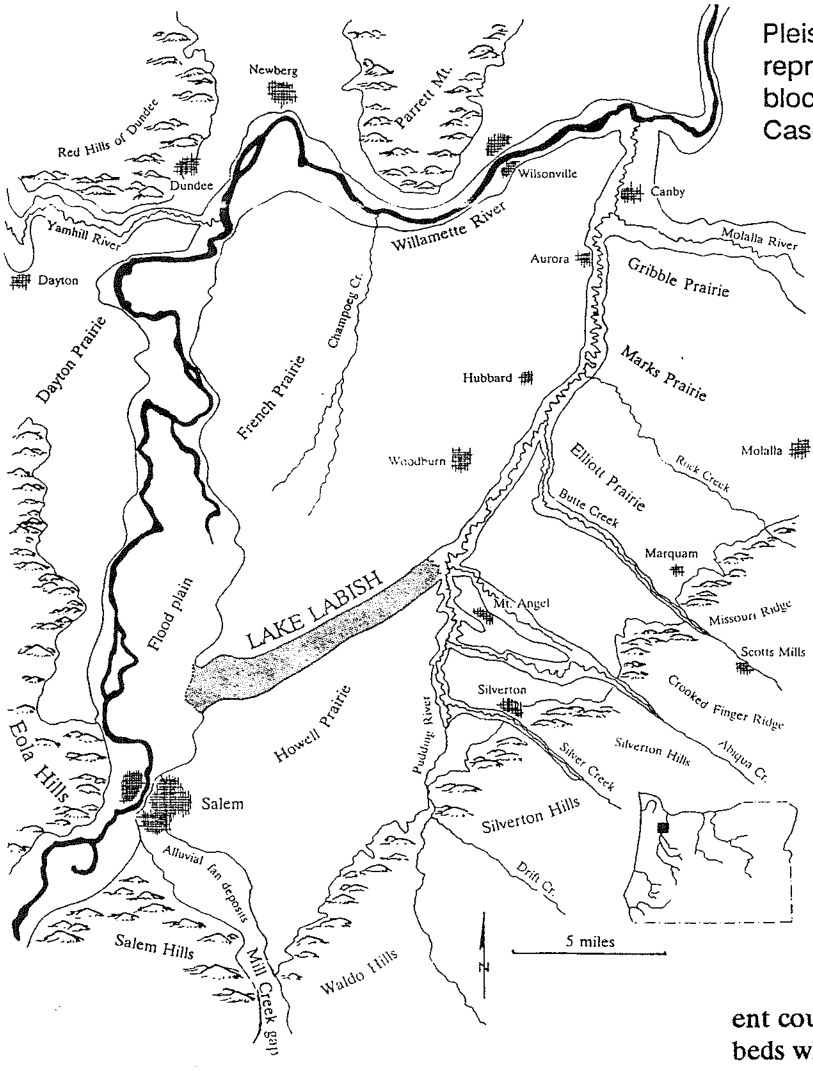
With margins around Portland and Tualatin in the north and west and Sandy on the east, a bowl-shaped structure gently sloped from 700 feet at Sandy to 250 feet at Portland and Vancouver. Flowing in a channel south of its present course, the Columbia River aided by the northerly flowing Willamette River emptied into the basin to form a lake and deposit silts and muds in a delta over 1,300 feet thick. More than 1,500 feet of the Sandy River Mudstone of sandstones, siltstones, and conglomerates filling the Portland basin underlie the city today. Later Pliocene Troutdale gravels from the Columbia River drainage washed into the lake, covering the mudstone to depths of 700 feet. Dissection and erosion by rivers and Ice Age floods removed portions of the Troutdale Formation from the Portland Hills and surrounding areas.



Pathways of the pre-Troutdale Willamette and Tualatin rivers in the northern Willamette Valley. Extrusion of the Boring lavas moved the Willamette River channel northward to Oregon City (after Baldwin, 1957).



Geomorphology of Lake Oswego (photo courtesy of Delano Photographics)



Pleistocene Lake Labish northeast of Salem may represent an older channel of the Willamette blocked by sediments from the Western Cascades (after Glenn, 1962).

Pliocene

During the Pliocene epoch, continued subduction of the Juan de Fuca plate and growth of the offshore accretionary wedge brought about the renewed uplift and tilting of the Coast Range and gentle folding of northern Willamette Valley rocks. The end of the wide coastal plain marked the beginning of the Willamette Valley as a separate physiographic feature once the sea had withdrawn to its present position. At this time major folds of the coastal mountain range formed, and outer continental shelf environments were raised over a mile from 1,000 to 2,000 feet below sea level to elevations of 3,000 feet above.

About 5 million years ago in the northern valley Boring Lavas erupted from over 100 small vents, cones, and larger shield volcanoes as Mt. Defiance, Larch Mt., Mt. Sylvania, and Highland Butte. Boring Lavas can be readily distinguished from the older Miocene Columbia River basalts by their fracture pattern. The fine-grained, light-weight Boring lavas break into large blocks and are seldom found in the small columns so common to the Columbia River Basalt.

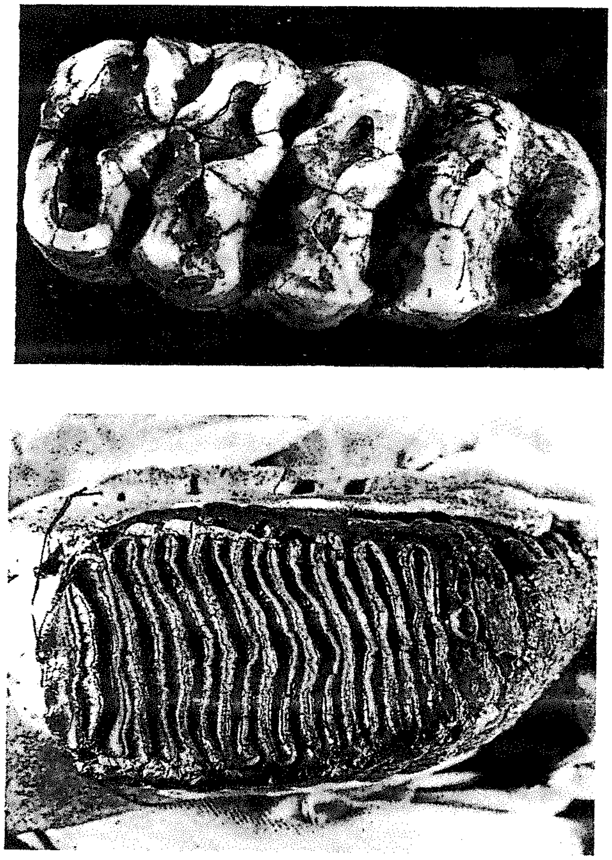
Basalt.

The Pliocene lavas covered the gravels in the old lake bed, and today they make up many of the buttes near Gresham and Boring as well as capping a number of hills in the vicinity of Oregon City. Rocky Butte, Mt. Scott, Mt. Tabor, Kelly Butte, and Mt. Sylvania contain cinders and lavas of these flows, the most westerly of which is along the slopes of the Tualatin Valley near Beaverton and Metzger. La Butte southwest of Wilsonville in Marion County may be the most southern eruption of these lavas. The landscape in the valley and around Portland shows clear evidence of these late eruptions. Flows from Highland Butte southeast of Oregon City pushed the Willamette River ten miles to the northwest near its present course, whereas in Portland lavas filled old streambeds where Burnside Street and Canyon Road are now located. Rocky Butte, a volcanic vent that erupted approximately 1.2 million years ago, and Mt. Tabor, with a small cinder cone projecting from its north side, are presently in downtown Portland. Across the river in Washington, Bobs Mountain northeast of Portland and Battle Ground crater north of Vancouver still have intact cones.

Pleistocene Rivers

Just prior to deposition of the Willamette Formation, up to 150 feet of coarse gravel and sand of the Rowland Formation spread over a broad area in the southern Willamette Valley. Divided into two members, the Rowland represents glacial outwash from the Cascades that was flushed into the valley by the North and South Santiam, Calapooia, and McKenzie rivers. This massive outwash unit thins toward the northwest and forms a complex series of coalescing alluvial fans that have bulldozed the Willamette channel off to the western margin of the valley between Eugene and Corvallis.

The valley beneath the Rowland glacial-alluvial fan sequence is filled with almost 300 feet of proto-

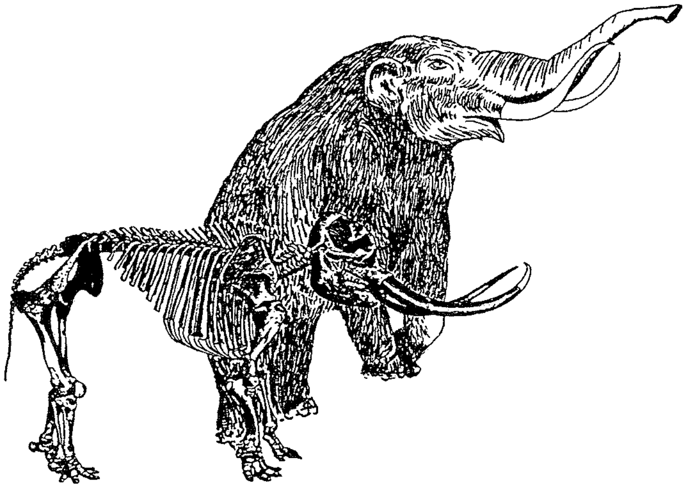


Crown views of elephant teeth clearly distinguish the low cusps of the browsing mastodon (top) from those of the grazing mammoth (bottom). (Fossils courtesy of the Thomas Condon collection, Univ. of Oregon)

Willamette River sands and gravels. Bordered on both sides by bluish clay overbank deposits, these coarse pebbles trace the path of the ancient river as it began filling the rugged erosional surface on top of the Columbia River basalts and older Tertiary units in the valley. Prior to the emplacement of the alluvial fans, the Willamette River may have followed a more easterly pathway in the valley. There is evidence that the old channel between the southern and northern valleys ran through a narrow gap at Mill Creek between Salem and the Waldo Hills.

With uplift and intensive erosion of the land during glacial periods when sea level was lowered, rejuvenated streams began to cut deeply into flood plains. Terrace gravels, recording the many changes in stream levels, can be seen along the Sandy and Clackamas rivers and in eastern Portland where the streets rise in elevation toward Gresham. At that time the ancient Willamette River ran southeast of Oregon City. Here it was joined by the ancestral Tualatin River flowing along the western margin of the Portland Hills. Both rivers wandered over a wide floodplain resulting from thick alluvial deposits which first filled the Portland and Tualatin basins, then backed up the stream valleys, and finally, in places, covered the divides between the streams. As sea level continued to drop, the Tualatin flowed through the channel at Lake Oswego while the Willamette established its present pathway in the Columbia River basalts at Oregon City where cutting action of the river produced the falls. In the final stage, flood waters flushed out the sands of the previously abandoned channel, diverting the Tualatin back into its original southward pathway to merge again with the Willamette. Today water from the Tualatin River is channelled into Lake Oswego by means of a low dam and ditch.

The rich dark soils of what may be a former channel of the Willamette River, now called Lake Labish, can be seen in a straight strip extending for almost 10 miles northeast of Salem in Marion County. The former course of the river was cut off during the Pleistocene when a natural dam of sand from Silver, Abiqua, and Butte creeks blocked the channel. The resulting shallow lake slowly filled with silt and organic



About the size of a modern Indian elephant, mastodon roamed in herds throughout the Willamette Valley during the Pleistocene.

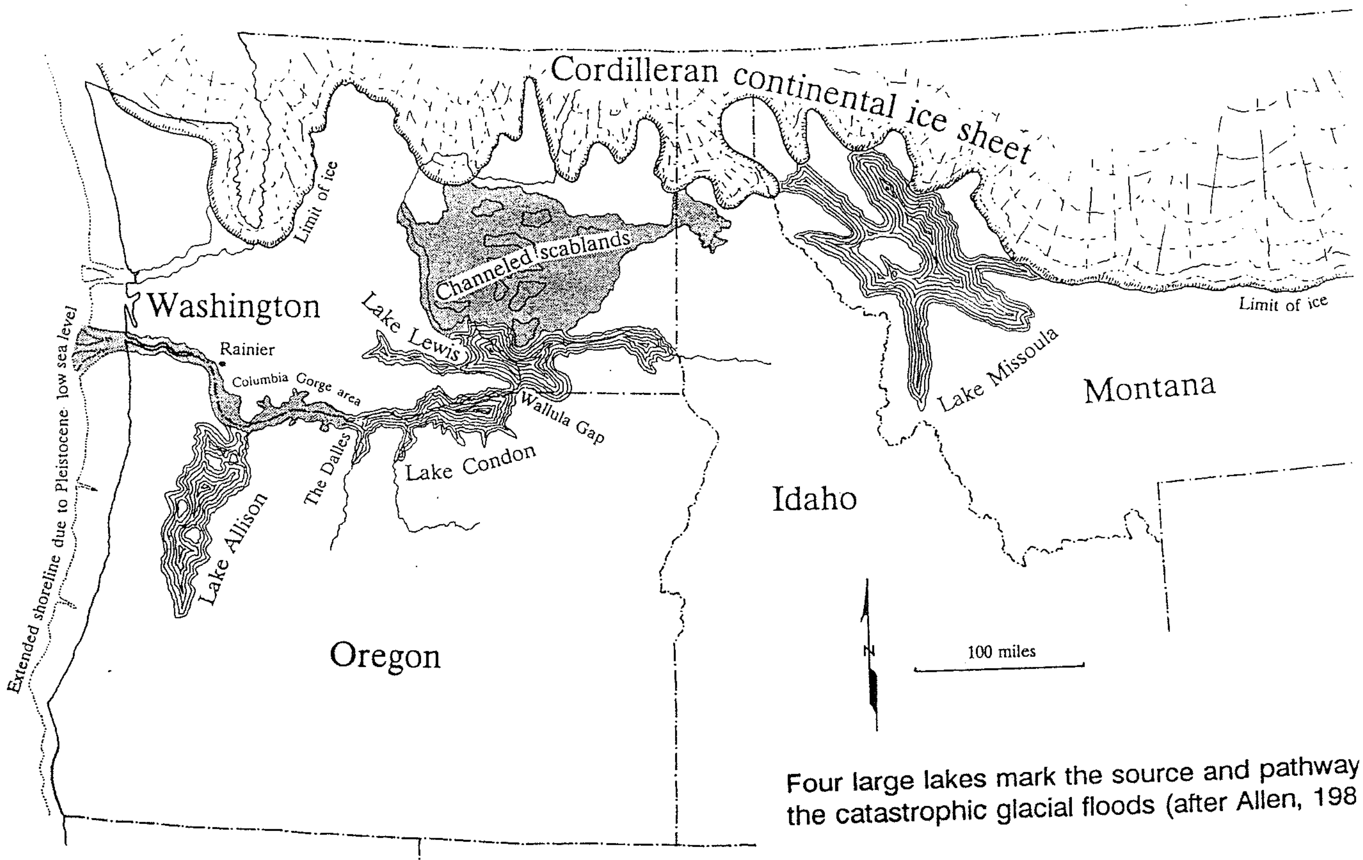
debris to become a marsh. Thick peat deposits in the old lake reflect a long period as a swamp and bog. In this organic layer, bones of Ice Age mammals such as mammoths, mastodon, giant sloth, and bison are frequently found. Unlike the Pleistocene LaBrea tar pits of Los Angeles, the animals were probably not mired in the peat, but carcasses were washed in and covered allowing the remains to be preserved in the oxygen-poor bog away from the attentions of scavengers. Today the fertile soils of Lake Labish support a thriving onion industry.

Pleistocene

Covering the Boring lavas and Troutdale gravels, a gritty, structureless, yellowish-brown sediment called the Portland Hills Silt was deposited within the last 700,000 years. Commonly 25 to 100 feet thick, the layer mantles much of the Portland area from the Tualatin and Chehalem mountains on the west all the way to the Gresham Hills and Ross Mountain on the east. Microscopically the silt is remarkably uniform, and the identified minerals include many which must have been derived from terrains as far north as Canada. This unique formation has long been something of a geologic puzzle and has been designated as both a wind-blown and water-laid deposit. The physical characteristics of the silt are similar to the palouse strata in southwest Washington indicating that the sediments are wind blown in origin. The Yellow River in China derives its name from comparable Pleistocene loess deposits that blanket vast areas in the northern part of the country. Ground up rock flour, produced by the crushing and milling action of glacial ice, was transported by water to be deposited along flood plains o the Columbia River. Strong Pleistocene winds, collecting the fine dust, carried it aloft in enormous clouds to cover the Portland Hills. Four different layers of sil are separated by three soil horizons. Interglacial, warm intervals are represented by the silt deposits, wherea soil horizons reflect times of glacial advance.

Ice Age Floods

Beginning about 2 million years in the pas the Ice Ages mark the advance and retreat of continen tal glaciers, an event that triggered one of the mos catastrophic episodes in Oregon's geologic histor When first proposed in the 1920s by J. Harlen Bret the theory of an enormous flood washing acros Washington and through the Columbia River gorg was not readily accepted. Careful work by Bret however, built up a body of evidence that could not b ignored. Between 15,500 and 13,000 years ago, th Columbia River drainage experienced a series o spectacular floods from ruptured ice dams along i



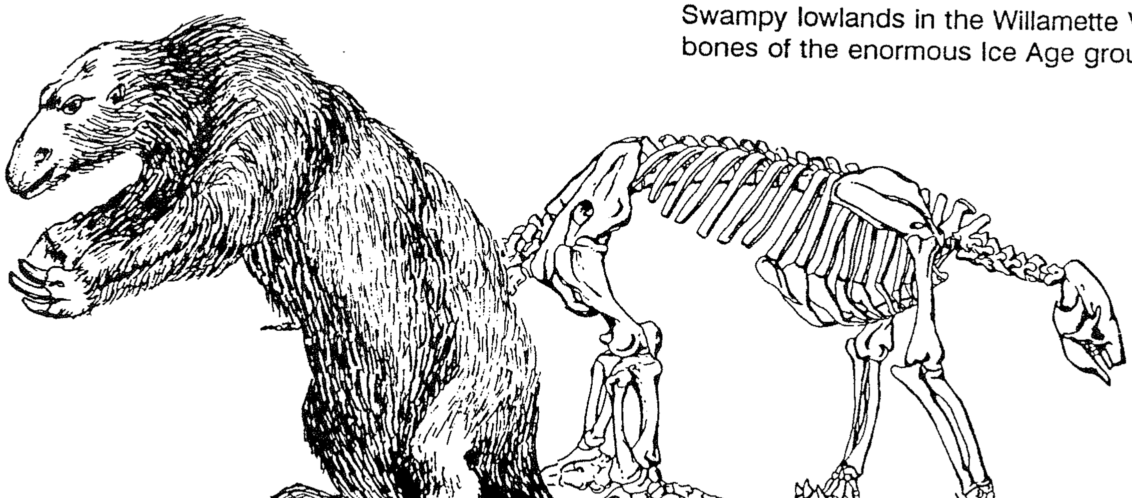
Four large lakes mark the source and pathway the catastrophic glacial floods (after Allen, 198

Skulls and skeletal elements of Ice Age bison up to 8 feet high at the shoulder are common in Willamette Valley swamp deposits (specimen from the Thomas Condon Collection, Univ. of Oregon).

canyon and tributary streams high in the upper watershed. The amount of water in a single flood, estimated at up to 400 cubic miles, is more than the annual flow of all the rivers in the world. The natural reservoir of Lake Missoula filled and emptied repeatedly at regular intervals suggesting that natural processes were regulating the timing of the floods. Once the lake had filled to a certain level, it may have floated the ice lobe or glacial plug that jammed the neck of the valley which, in turn, released enough water to allow the flooding process to begin.

Prior to each flood, an ice lobe from northern Idaho stretched southwest to dam up the Clark Fork River that flows northward to join the Columbia across the Canadian border. Old shorelines visible today high above the city of Missoula, Montana, are evidence that the ice dam backed up a vast lake covering a large area of western Montana. As the ice dam was breached, water, ice, and sedimentary debris poured out at a rate exceeding 9 cubic miles per hour for 40 hours. Flushing through the Idaho panhandle and scouring the area now known as the channeled scablands of southeast Washington, the lake drained in about 10 days.

After crossing eastern Washington, the water collected briefly at the narrows of Wallula Gap on the Oregon border where blockage produced the 1,000 foot deep Lake Lewis. Ponding up a second time at The Dalles to create Lake Condon, the rushing water stripped off gravels and picked up debris, steepening the walls of the Columbia gorge. Near Rainier the river channel was again constricted causing flood waters to back up all the way into the Willamette Valley. At Crown Point flood waters spilled south into the Sandy River drainage and across the lowland north of Vancouver taking over the Lacamas Creek channel. Most of the water exited through the gorge to the ocean, but as much as a third spread over the Portland region to depths of 400 feet. Only the tops of Rocky Butte, Mt. Tabor, Kelly Butte, and Mt. Scott would have been visible above the floodwaters. Surging up the ancestral Tualatin River, the waters covered the present day site of Lake Oswego to depths over 200 feet, while Beaverton, Hillsboro, and Forest Grove would have been under 100 feet of water.

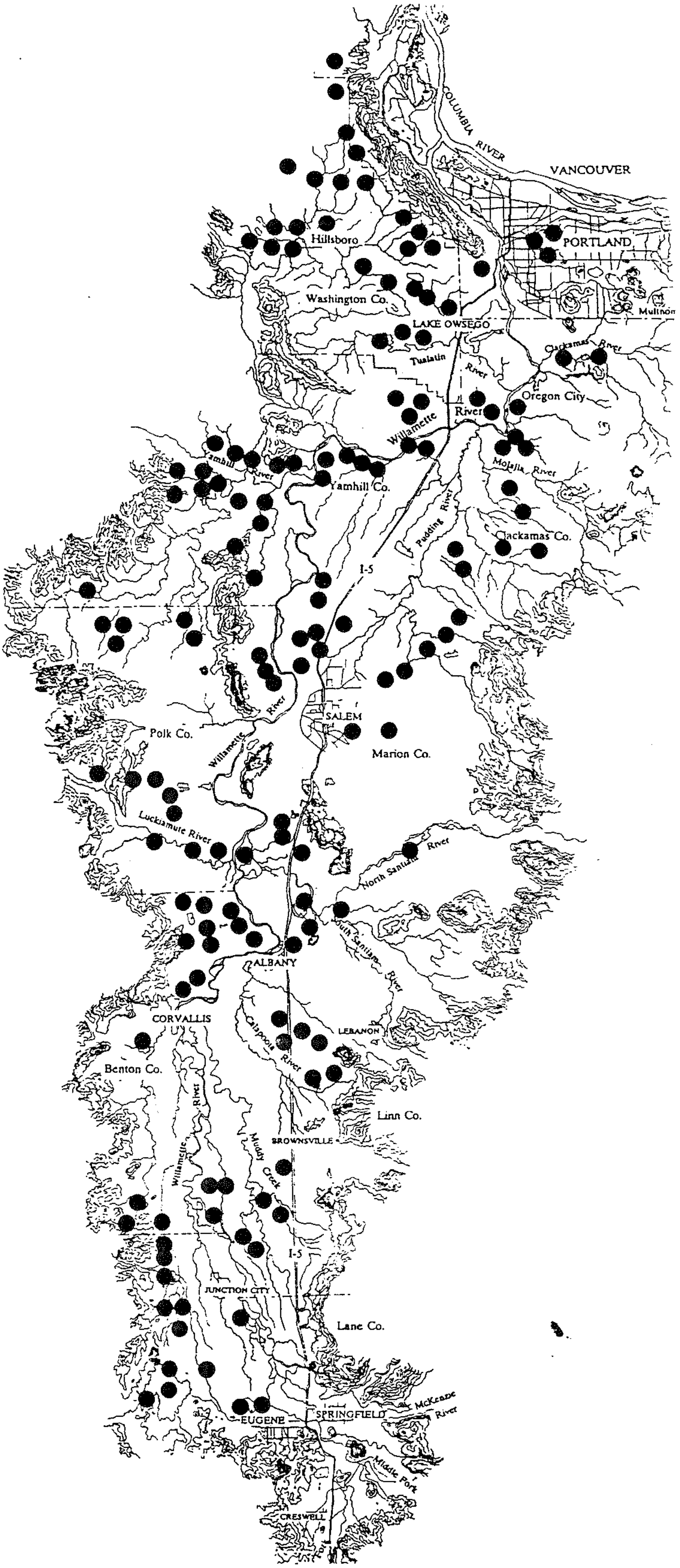


Swampy lowlands in the Willamette Valley yield the bones of the enormous Ice Age ground sloth.

Along with floating icebergs, the rushing waters carried enormous amounts of gravel, sand, silt, and clay in suspension as well as rolling and tumbling along the bottom. In the valley this mass of flood borne sediment was segregated by the narrows at Lake Oswego leaving much of the coarse material in the vicinity of Portland and the Tualatin Valley. A huge sand and gravel bar dammed the Tualatin River for a period to form a small lake 5 miles west of Oswego. Sometime after the flood receeded, the river cut through the bar, and the lake drained, but the basin which had been scoured and deepened by the flooding remains. Sweeping through Lake Oswego, large volumes of the finer sands and silts along with ice rafted boulders that had been collected upstream washed southward into the lower Willamette Valley where they were deposited over the valley floor and lower slopes of the surrounding hills. Sands predominate at Canby and Aurora, and silts, tens of feet thick, were spread as far south as Harrisburg.

The muddy waters filled the central valley temporarily creating Lake Allison. Extending from the Lake Oswego and Oregon City gaps southward almost to Eugene, the surface of this large body of water was over 350 feet above present sea level. The lake formed when the valley was dammed at its north end by ice jams or overwhelmed by the amount of water coming south. Repeated surging as new water came through the gap at Oregon City and ebbing as it drained out kept the lake level in a constant state of fluctuation. The tops of lake silt deposits are commonly 180 to 200 feet in elevation throughout the Tualatin, Yamhill, and Willamette valleys. After a brief interval the water drained back out to the Columbia and the ocean.

The multiple floods had a lasting impact on the channel of the Columbia River and the Willamette Valley. Because the flow of flood water into the Willamette Valley was opposite to the normal northward drainage, the river was disrupted for periods up to two weeks until the waters receeded. Distinct banded layers of Willamette Silt brought into the valley indicate the flood waters must have invaded many times. As flood waters entered the valley they were quickly stripped of coarse sand and gravel when ponding took place. Silt and clay particles, however, remainded suspended in the turbid waters and covered the valley with a layer up to 100 feet deep exposed today along the banks of the Willamette and its tributaries. Surface deposits of these silts are best developed in the southern Willamette Valley where they are subdivided into four members of the Willamette Formation on the basis of subtle mineral and textural differences. Within the Willamette Silts, the Irish Bend Member has been identified as the primary



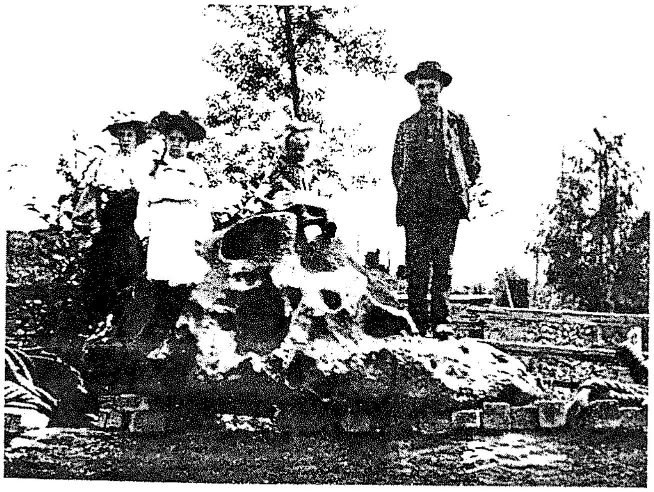
Glacial erratics carried into the Willamette Valley atop icebergs during large Pleistocene floods are scattered from Eugene to Portland (after Allison, 1935).

sediment of a large-scale flood. Extending over 300 square miles of the southern valley, the Irish Bend silt reaches a maximum thickness of nearly 50 feet just south of Corvallis.

With the separate silt layers in the Willamette Valley suggesting multiple periods of flooding, the precise number of floods is in doubt. Figures proposed are "many floods", "35 floods", or "7 to 8 floods". Whether the floods occurred in "two cycles", "annually", "every 175 years", "over an extended period of time", or were "short-lived" is still conjectural. These floods continued over the 2,500 year interval until the ice sheets permanently retreated northward with a warming climate.

Erratics

Flood waters spilling into the Willamette Valley carried large blocks of ice borne on the torrent. Atop and within the icebergs, rocks and sediment were transported all the way from Montana. Once the ice melted, the stones were dropped as glacial erratics in a wide pattern across the valley. Although more than 300 occurrences of these erratics have been recorded, thousands more lay unrecognized. More than 40 boulders over 3 feet in diameter have been located, and many smaller stones as well as chips and pebbles of foreign material have been noted in farm fields, roadcuts, and along old river terraces.



The Willamette meteorite from near West Linn may have been carried into the valley by an iceberg during flooding (photo courtesy of Oregon Historical Society).

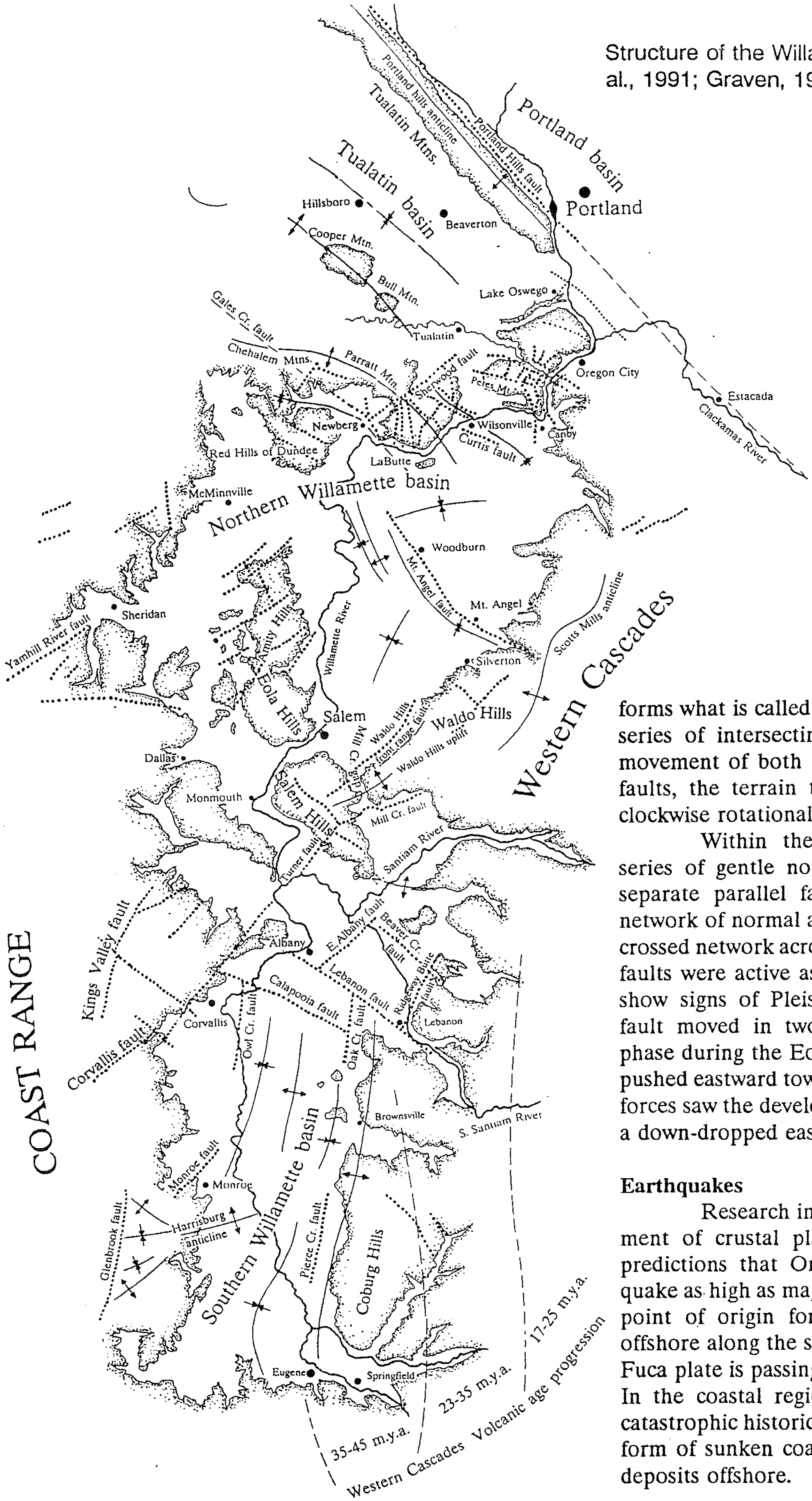
Varying in composition and size, the erratics are granite, granodiorite, quartzite, gneiss, slate, and a few of basalt. With the exception of basalt, these rocks are common to central Montana and not the Willamette Valley. Because of the exotic composition of the erratic material, the path along which they were rafted into the valley can be traced down the Columbia River channel. Erratics were deposited through Wallula Gap to The Dalles where they are found up to 1,000 feet above sea level. In the Willamette Valley erratic fragments are imbedded in the top of the Willamette Silt.

The largest known erratic lies in the valley between McMinnville and Sheridan in Yamhill County. Composed of the metamorphic rock argillite, the boulder originally weighed about 160 tons, but over 70 tons have been removed by tourists. Perhaps the most famous erratic is the Willamette meteorite which may have fallen in Montana only to be transported by floodwaters to where it came to rest near West Linn in Clackamas County. The meteorite was subsequently purchased for $20,000 in 1905 by Mrs. William E. Dodge who donated it to the American Museum of Natural History in New York.

Structure

Uplift, tilting, and folding in the Coast Range and Willamette Valley are attributed to the continued subduction of the Juan de Fuca plate. Gentle folding accompanied by faulting with as much as 1,000 feet of vertical displacement produced deep valleys. Columbia River basalts, that had filled the bowl-shaped Tualatin, Wilsonville, and Newberg valleys in the middle Miocene, were depressed to 1,300 feet below sea level by steady eastward tilting of the Coast Range block. Within the Willamette Valley, broad northwest trending anticlinal folds are interspersed with parallel, subdued synclines. The dominant folds are the Portland Hills, Cooper Mountain, and Bull Mountain, as well as Parrett and Chehalem mountains. Separating the anticlinal hills, wide valleys of Tualatin, Newberg, and Wilsonville are gentle synclines or downfolds.

The Portland Hills anticline that formed during the late Miocene and Pliocene is steepened on the east side by a large fault that stretches for over 60 miles northwest and southeast of Portland. This fault system extends southeastward to join the Clackamas River lineament, an alignment of surface fractures on a grand scale that traverses Oregon all the way to Steens Mountain as part of the Brothers Fault zone. Running parallel to this immense feature, the Mt. Angel fault trends northwestward under Woodburn to project into the Gales Creek fault zone of the Coast Range. Northeast of Salem, the butte at Mt. Angel



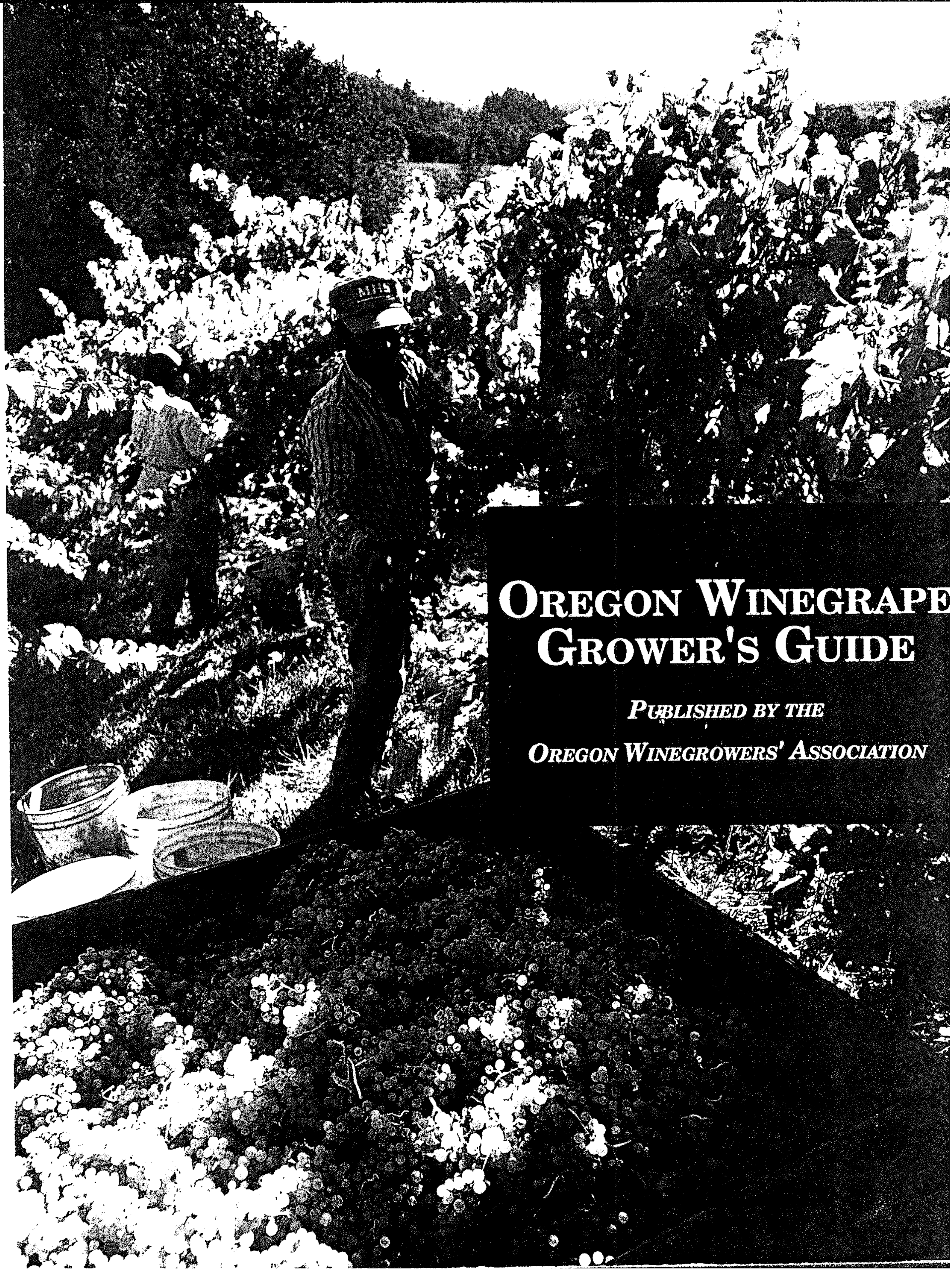
Structure of the Willamette Valley (after Yeats, et al., 1991; Graven, 1990; Werner, 1990).

forms what is called a fault "pop-up" caught between a series of intersecting fault blocks. With continuous movement of both the Portland Hills and Mt. Angel faults, the terrain trapped between them displays a clockwise rotational movement.

Within the southern Willamette Valley, a series of gentle north-south folds in the subsurface separate parallel faults. Eastward from Corvallis a network of normal and thrust faults extends in a criss-crossed network across to the Western Cascades. These faults were active as far back as Oligocene, but some show signs of Pleistocene movement. The Corvallis fault moved in two phases. In an earlier thrusting phase during the Eocene, the western upper plate was pushed eastward toward the valley while later tensional forces saw the development of a normal fault here with a down-dropped eastern block.

Earthquakes

Research into the relationship between movement of crustal plates and earthquakes has led to predictions that Oregon could experience an earthquake as high as magnitude 8 on the Richter scale. The point of origin for such massive quakes would be offshore along the subduction zone where the Juan de Fuca plate is passing under the North American plate. In the coastal region of Oregon good evidence for catastrophic historic earthquake activity is found in the form of sunken coastal bogs and distinctive turbidite deposits offshore.



OREGON WINEGRAPE GROWER'S GUIDE

PUBLISHED BY THE

OREGON WINEGROWERS' ASSOCIATION

CHAPTER 3

Soils and Fertilization

by Ken Brown

SOILS

Basics

The Oregon winegrape industry is located primarily on hill soils adjoining the Willamette Valley, and there is a thriving industry in southwest Oregon. Some grapes are grown along the Columbia River east of the Cascade Mountains, and there may be other areas of the state where winegrapes could be grown. There are distinct differences in soils between and within vineyards around the state. This discussion will attempt to cover the major soil conditions.

Red hill soils in western Oregon are the backbone of the industry at this time. Two of the most common red hill soils are Nekia and Jory. The Nekia soil is 20 to 40 inches deep over broken basalt bedrock. Jory is more than 40 inches deep over either basalt or sandstone. Other common red hill soils are Bellpine and Bateman. All of the red hill soils are old and leached. These and other soils like them are the most sought after soils for winegrape production when other site considerations are desirable.

Most Coast Range foothill soils develop in marine sediments, though there are a few of volcanic origin. These soils vary in depth and internal drainage. The better drained, deeper Coast Range foothill soils include Bellpine, Bateman, Steiwer, Willakenzie, and Dixonville. All of these are between 20 and 40 inches deep except where top soil has eroded away. These soils have favorable nutrient content and water holding capacity per foot of soil but tend to have limited depth. The base material is a soft siltstone or sandstone. The actual depth of these soils, observed by digging test holes, is important to know.

Many of the soils in western Oregon have restricted internal drainage. Some of them contain a dense clay layer that restricts the downward movement of water. If the soil is saturated when the grapes are ready to grow in the spring, yields will be low. Soils such as Bashaw, Panther, Waldo, Hazelair and Wapato are specific soils with poor internal drainage.

Lower infiltration rates during winter rains make erosion a greater hazard on many of the sedimentary Coast Range soils compared to redhill soils, but erosion management is important on all hill soils in western Oregon.

Alluvial soils consist of older valley floor soils and the more recently developed river bottom soils. Restricted internal drainage keeps many of the old valley floor soils from being considered for winegrapes. Moreover, there is an increased hazard of spring and fall frost on most valley floor sites compared to hill sites.

Where the drainage is adequate and the area is relatively frost-free, valley floor soils can and are being used for winegrapes. The well-drained Willamette soil and the closely associated Woodburn soil, with slightly restricted internal drainage, are examples. These soils are deep, productive soils, and growth control may be a problem. The early winegrape pioneers avoided these soils, but now a few vineyards located on these types of soils are testing their suitability.

River bottom soils are more recent alluvial soils that range from silty Chehalis and Cloquato soils to sandy Newberg soils.

Cascade foothill soils are a mixture of soils. Most are moderately deep, well drained soils that developed from volcanic rocks. In southern Oregon, many of the soils used for winegrapes are alluvial soils along the Umpqua and Rogue Rivers and their tributaries. These soils are comparable to the alluvial soils in the Willamette Valley, ranging from medium-textured to the lighter textured soils.

Granitic and volcanic soils are another important group of southern Oregon soils for winegrape production. These hill and terrace soils range from 20 inches or less, to 60 plus inches deep, and tend to be loam or clay loam texture. Loam soils associated with the Siskiyou Mountains and derived from granite are good vineyard soils if they are deep enough to supply

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About the author: Ken Brown is an extension Agent presently stationed at the OSU, North Willamette Research and Extension Center (NWREC), Aurora. He evolved into a specialized winegrape Agent position as the Oregon winegrape industry was evolving. Information and expertise in soils and fertilization, along with other cultural practices and pest management, were adjusted to meet the needs of the winegrape industry.

sufficient moisture without irrigation. Examples include Central Point, Holland and Brockman series.

Clay soils in southern Oregon are hard to manage and have not been utilized much for winegrapes. However, successful vineyards have been established on clay soils in Bear Creek Valley. These soils are generally classified as Coker, Carney and Medford series.

In the Applegate Valley, Manita and Ruch soils have been used successfully, while Abegg and Takilma-Foehlin-Kerby complex are used in the Illinois Valley. Some soils, i.e. Kerby and Brockman, are of serpentine origin and therefore may require the addition of potassium and lime prior to planting.

In the Umpqua Valley the best terrace soils for vineyards are Bateman, Jory and Rosehaven. The most fertile soils on the valley floor are Roseburg, Chehalis, Malabon, Evans and Newberg. Valley floor soils are more productive, but excessive vine growth may require techniques to control the growth (see Chapter on Scott Henry Canopy System).

In the Hood River Valley, vineyards are situated on Oak Grove soils, while in The Dalles, vineyards are on terraces having Cherryhill and Chenoweth soils. Further east, in the Boardman area, vineyards are on Winchester sandy loam or Warden silt loam. The low rainfall makes irrigation for winegrapes mandatory.

Soil pH

Upland native soils are generally slightly to strongly acid in the higher rainfall areas of western Oregon and neutral to moderately alkaline in the more arid areas of the state. The normal process is for rain to leach the basic elements such as potassium, calcium, magnesium, and sodium from the top soil. These are replaced with hydrogen, resulting in acidification. In the native situation, the leaching is partially countered by basic ions being brought to the surface by plants and returned to the soil through decomposition.

In western Oregon, the red hill soils are naturally strongly acid (pH 5.1 - 5.5) due to weathering and leaching. Soils on terraces and flood plains are naturally less acid, but many have become highly acidic due to farming practices. Farming reduces the amount of plant material deposited on the surface, and most fertilizers also accelerate acidification. To counteract these effects, some farmers have applied lime to bring the pH up to 5.5 or higher. Soils east of the Cascades tend to be less acid or even alkaline except where irrigation and fertilization have acidified the soil.

Soil Productivity

Many Willamette Valley soils have been given a productivity rating of zero to one hundred based on the production of numerous crops. Table 3-1 gives ratings for a few soils that might be of interest to grape growers. Irrigation and other adjustments, including lime, fertilizer and drainage, result in the maximum irrigated and dryland ratings.

These productivity ratings weren't designed for winegrapes, but they are useful because of the importance of growth control to produce a specific quality of wine. A less productive soil gives the grower a tool to control vine growth. Notice the range of productivity from Pilchuck, with its need for irrigation, to Willamette with the highest possible rating.

The ratings listed in Table 3-1 may be useful for other areas of the state. People with a knowledge of soils in a local area should be able to relate to the Willamette Valley soils listed. For instance, the deep, productive loam soils in the Umpqua and Rogue River bottoms are comparable to the Willamette or Woodburn soils.

Native productivity is probably the most useful number. Most winegrape soils are well drained, and fertilizer and lime amendments aren't as important as with many other crops. The medium and low native productivity soils can limit growth in the early part of the growing season when moisture is generally not limiting.

The benefits from growing grapes on productive soils should not be overlooked. There is limited experience with vineyards on Woodburn and comparable soils. The production is higher and, with current high demand for certain varieties, selling the grapes from these soils has not been a problem. Higher production could more than compensate for lower prices for the grapes. Cultural techniques like trellising, hedging, and leaf removal may allow the manager to handle excess growth on productive soils and still produce premium wine.

Soil Moisture

Available water holding capacity (AWHC) is a very important soil feature, particularly for the non-irrigated vineyards. AWHC is the water held in the soil that can be used by the vine. Starting in May or June, moisture consumption by vines exceeds the normal precipitation. This typically continues through August and much of September. Moisture stored in the soil is what keeps the vine functioning in non-irrigated vineyards through the summer months until the start of significant fall rain.

Table 3-1 shows the available moisture in some typical soils. The available moisture is a combination of moisture per foot of soil and the effective rooting depth. Notice the range of available moisture from 4.8 inches in Bellpine to 13 inches in a Willamette soil. If soil moisture is readily available, vines can consume nine or more inches from the soil reservoir during the growing season.

The amount of moisture in the soil that is necessary or desirable is hard to quantify. Most vineyards in western Oregon are purposely grown on soils that have limited AWHC to restrict growth and produce a specific quality in the wine.

Winegrapes have a remarkable ability to function with moisture deficiency, but there is a limit. Severe deficiency limits yield below an acceptable level and can also reduce fruit quality. Severe deficiency also limits the vines' ability to produce an acceptable crop the following year, due to poor shoot growth and poor flower initiation in the developing bud. The threshold between an acceptable and unacceptable moisture deficiency will change with the price of grapes. If there isn't a premium paid for grapes grown in moisture

Table 3-1. Productivity and Available Moisture for Certain Willamette Valley Soils

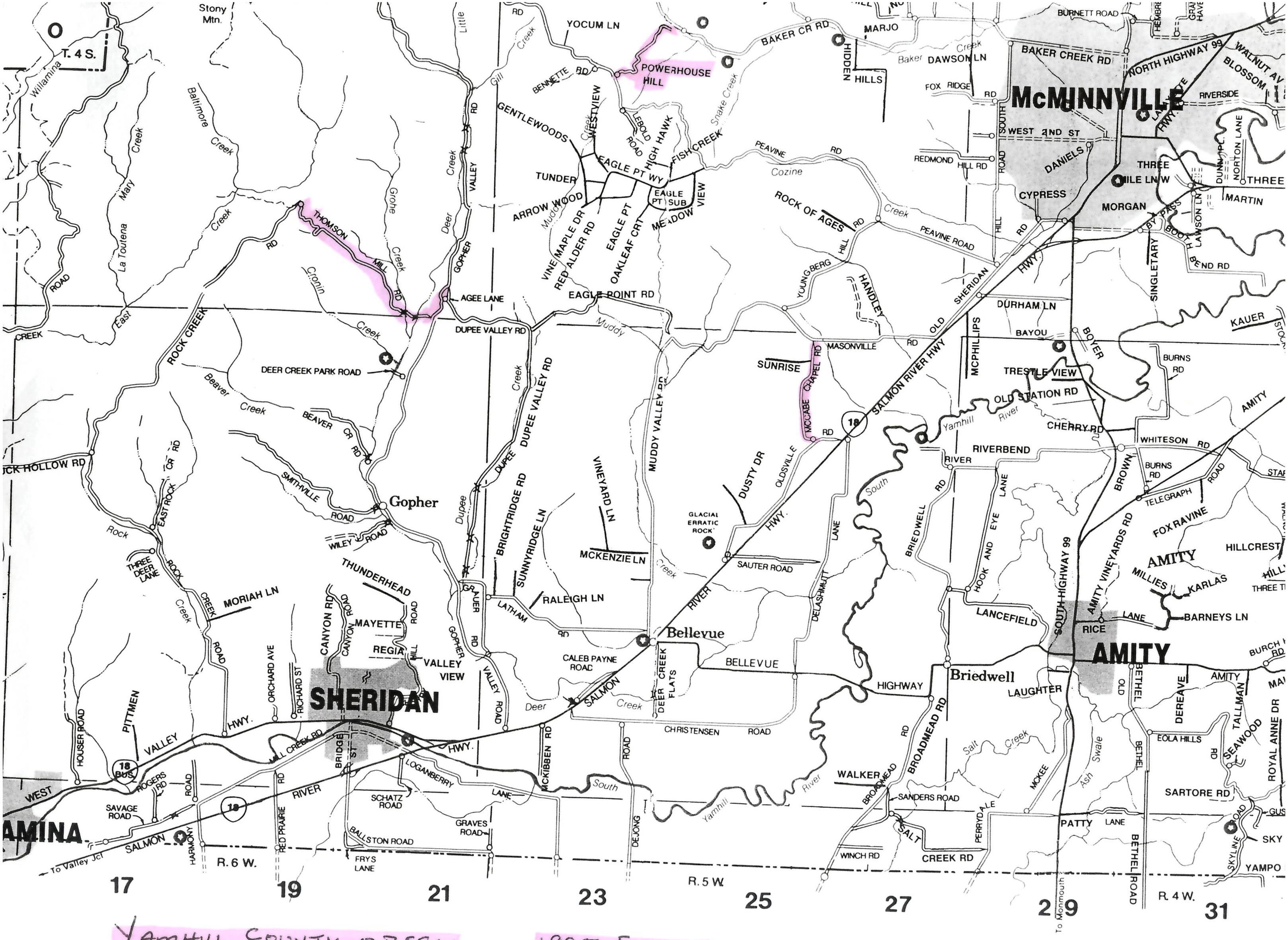
	Productivity* (Maximum)**			**Soil Depth and Moisture**	
	Native	Irrigated	Dryland	Typical Soil Depth (Inches)	Average Total Available Moisture (Inches)
RED HILL					
NEKIA silty clay loam	27	74	48	36	5.8
JORY clay loam	45	80	60	63	10.0
SEDIMENTARY					
BELLPINE silty clay loam	30	74	50	32	4.8
WILLAKENZIE silty clay loam	47	86	62	36	6.3
ALLUVIAL					
PILCHUCK fine sandy loam	10	70	30	60	4.5
WILLAMETTE silt loam	75	100	80	60	13.0
WOODBURN silt loam	65	95	78	60†	12.0
MIXED ORIGIN					
STEIWER silt loam	52	86	62	40	5.8
LAURELWOOD silt loam	64	95	75	60	9.8

** 0 - 100*

*** Maximum productivity includes use of tile, lime and fertilizer.*

† Rooting depth depends on perched water table in winter.

SOURCES:
Soil Conservation Service, Soil Surveys of Marion, Polk and Yamhill Counties, US Department of Agriculture.
Agricultural productivity Ratings for Soils of the Willamette Valley, EC 1105, OSU Extension Service, 1982.



YAMHILL COUNTY, OREGON
ROAD INDEX MAP

1995 EDITION

Sheridan, OR

Click a month to see the details for that month. The details for each day of the selected month are shown below.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. High	46°F	51°F	55°F	61°F	68°F	75°F	82°F	82°F	77°F	65°F	52°F	45°F
Avg. Low	32°F	34°F	36°F	37°F	42°F	46°F	48°F	48°F	46°F	41°F	37°F	33°F
Mean	40°F	43°F	46°F	50°F	55°F	61°F	66°F	66°F	62°F	53°F	45°F	40°F
Avg. Precip.	8.10 in	6.00 in	5.60 in	2.70 in	1.90 in	1.20 in	0.50 in	0.70 in	1.60 in	3.30 in	7.70 in	9.10 in

SHERIDAN, OR PRECIPITATION AVG. (ANNUAL) = 48.4" ✓

Willamina, OR (97396)

Click a month to see the details for that month. The details for each day of the selected month are shown below.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. High	45°F	50°F	54°F	59°F	66°F	72°F	79°F	81°F	75°F	64°F	52°F	45°F
Avg. Low	31°F	33°F	34°F	36°F	40°F	46°F	48°F	48°F	45°F	40°F	35°F	32°F
Mean	39°F	42°F	45°F	48°F	53°F	60°F	64°F	65°F	61°F	52°F	44°F	39°F
Avg. Precip.	N/A	9.00 in	8.10 in	3.70 in	2.40 in	1.30 in	0.50 in	0.90 in	1.70 in	4.60 in	N/A	N/A
Record High	64°F (1971)	70°F (1992)	78°F (1994)	85°F (1998)	98°F (1983)	101°F (1992)	104°F (1998)	104°F (1977)	105°F (1988)	92°F (1988)	72°F (1962)	63°F (1980)
Record Low	6°F (1979)	7°F (1989)	19°F (1971)	25°F (1968)	26°F (1964)	32°F (1976)	35°F (1970)	35°F (1973)	25°F (1961)	24°F (1970)	10°F (1985)	2°F (1972)

PER OCS DATA AVGS

JAN PRECIP $\bar{x} = 8.39$

NOV PRECIP $\bar{x} = 7.58$

DEC PRECIP $\bar{x} = 9.41$

Station number: 359372 Station name: WILLAMINA 2 S

Element : DAILY PRECIPITATION Quantity : MONTHLY SUM Units : INCHES
a = 1 day missing, b = 2 days missing, c = 3 days, ..etc..,
z = 26 or more days missing, A = Accumulations present
Long-term means based on columns; thus, the monthly row may not
sum (or average) to the long-term annual value.

Maximum allowable number of missing days : 5
99.99 = missing month 999.99 = incomplete year

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1925	12.88	10.95	2.75	3.49	1.68	2.37	0.00	0.67	1.15	0.12	7.72	7.54	51.32
1929	7.36	1.63	4.07	6.47	1.28	2.11	0.00	0.05	0.54	1.46	0.78	14.78	40.53
1930	5.25	9.19	2.71	3.64	3.05	1.02	0.00	0.00	1.44	2.13	5.55	5.54	39.52
1935	6.95	5.25	11.20	4.29	0.72	0.44	0.36	0.29	0.88	3.05	2.90	7.41	43.74
1936	13.58	6.09	3.57	1.09	4.09	2.05	0.73	0.00	1.22	0.16	0.36	7.59	40.53
1937	6.03	9.07	4.28	8.56	1.73	2.81	0.00	1.11	0.79	3.90	12.10	15.88	66.26
1938	5.74	9.07	8.88	1.62	0.76	0.27	0.14	0.04	0.82	3.80	5.76	4.77	41.67
1939	7.18	7.11	3.58	0.83	1.02	1.01	0.44	0.67	0.19	2.38	1.36	13.80	39.57
1940	7.20	14.58	6.38	3.23	2.70	0.12	0.27	0.01	1.87	5.09	5.74	8.31	55.50
1941	7.76	2.73	1.91	2.73	4.05	1.06	0.00	0.70	2.74	2.40	6.71	13.09	45.88
1942	5.22	5.84	2.57	1.93	2.55	1.11	0.89	0.16	0.00	1.84	16.61	12.82	51.54
1943	7.51	5.77	7.17	3.69	1.31	1.85	0.31	1.53	0.10	7.91	3.25	4.34	44.74
1944	5.32	3.22	3.28	4.61	1.00	1.41	0.39	0.32	1.29	2.15	5.87	3.42	32.28
1945	6.35	9.65	9.03	4.61	3.53	0.14	0.31	0.17	3.37	1.61	15.49	9.85	64.11
1946	10.20	8.46	6.49	2.53	1.75	1.34	0.45	0.00	1.33	5.77	10.15	6.81	55.28
1947	6.14	4.78	3.33	2.70	0.14	5.75	0.73	0.77	1.42	10.62	5.14	5.93	47.45
1948	9.50	8.19	5.49	5.88	4.22	0.42	0.83	0.62	2.86	3.39	9.63	11.18	62.21
1949	2.30	13.16	4.36	1.10	3.44	0.73	0.16	0.43	1.05	3.01	7.05	8.27	45.06
1950	99.99	99.99	99.99	99.99	99.99	99.99	0.46	0.61	1.61	9.53	12.16	8.76	999.99
1950	14.98	7.70	7.28	2.09	0.72	1.42	99.99	99.99	99.99	99.99	99.99	99.99	999.99
1951	12.82	7.29	7.22	1.46	2.16	0.02	0.23	0.58	1.18	8.17	7.83	12.00	60.96
1952	8.76	5.69	5.56	2.10	0.53	1.13	0.00	0.32	0.41	0.51	2.32	10.16	37.49
1953	14.66	5.29	7.07	3.41	3.06	0.78	0.07	1.18	1.19	3.19	8.62	10.19	58.71
1954	15.10	8.50	3.41	4.24	1.25	2.74	0.30	2.94	0.84	4.06	6.54	7.93	57.85
1955	5.06	3.64	7.38	5.32	0.89	0.97	0.81	0.00	2.94	5.38	9.58	16.46	58.43
1956	15.81	8.22	7.34	0.71	0.98	0.86	0.03	0.33	1.41	7.12	2.00	5.24	50.05
1957	3.61	8.57	6.83	3.13	2.63	0.66	0.14	0.28	0.42	2.51	4.86	9.63	43.27
1958	9.09	9.93	4.38	5.45	1.03	2.06	0.00	0.02	0.87	3.19	9.12	7.17	52.31
1959	13.27	4.04	5.89	1.42	1.79	1.89	0.52	0.06	3.84	1.91	4.08	3.92	42.63
1960	6.61	8.62	7.81	4.13	3.99	0.42	0.00	0.75	0.69	4.01	12.56	4.32	53.91
1961	6.64	12.27	10.82	2.55	2.50	0.30	0.38	0.33	0.82	4.26	6.06	7.96	54.89
1962	2.98	5.35	7.34	4.75	2.23	0.72	0.05	0.72	1.77	6.26	12.63	4.15	48.95

1963	2.41	6.41	8.18	5.33	3.57	0.92	0.93	1.18	2.01	3.64	9.38	5.40	49.36
1964	13.70	2.24	6.62	1.95	0.90	0.99	0.66	0.51	0.66	1.39	8.00	18.74	56.36
1965	11.76	4.81	0.98	2.94	1.95	0.73	0.14	0.84	0.07	2.24	10.50	11.30	48.26
1966	10.63	3.88	9.52	1.52	1.15	1.09	0.34	0.25	1.51	2.71	5.83	14.23	52.66
1967	11.80	3.01	9.75	3.62	0.88	0.39	0.00	0.00	0.81	7.15	4.28	7.99	49.68
1968	8.40	9.94	6.44	1.74	2.85	2.56	0.12	3.54	1.65	7.03	9.46	16.77	70.50
1969	12.64	6.89	2.37	2.90	1.79	1.44	0.02	0.07	2.39	4.53	4.89	13.79	53.72
1970	16.05	5.89	3.62	3.62	0.84	0.41	0.02	0.03	1.58	4.98	8.43	15.00	60.47
1971	12.20	5.50	9.97	4.14	2.13	1.42	0.08	0.21	3.62	3.73	8.91	14.05	65.96
1972	10.38	6.16	7.80	5.86	1.45	0.94	0.03	0.12	3.15	1.03	5.09	11.36	53.37
1973	6.76	2.28	4.26	2.09	0.70	1.13	0.00	0.55	3.79	3.24	19.49	13.53	57.82
1974	14.84	9.65	9.29	3.22	2.33	1.07	0.84	0.02	0.17	0.72	7.56	11.54	61.25
1975	8.84	8.42	7.67	2.99	2.24	0.86	0.87	1.38	0.03	7.98	6.52	9.21	57.01
1976	7.18	9.07	5.95	2.59	0.95	0.70	0.72	1.21	0.81	1.49	1.77	1.92	34.36
1977	1.26	3.21	8.16	0.62	3.64	0.73	1.01	1.65	3.42	3.07	9.32	11.21	47.30
1978	8.89	6.34	1.92	5.21	3.76	1.01	1.02	2.40	4.15	0.94	3.49	4.44	43.57
1979	3.55	9.78	3.14	3.44	3.01	0.69	0.62	0.82	2.08	7.26	4.93	10.29	49.61
1980	11.39	6.63	5.47	5.10	0.64	1.60	0.43	0.08	0.89	1.47	7.98	11.91	53.59
1981	2.84	4.75	4.48	4.11	3.13	3.98	0.14	0.08	2.60	6.56	7.40	14.64	54.71
1982	7.98	9.13	5.86	7.53	0.20	1.60	0.66	0.34	1.93	5.42	6.55	14.22	61.42
1983	9.68	13.09	11.98	2.72	2.78	1.50	1.40	0.88	0.43	1.05	13.43	8.80	67.74
1984	4.31	7.53	5.09	4.18	3.89	2.38	0.11	0.07	1.50	5.94	16.09	5.44	56.53
1985	0.38	4.20	4.92	2.03	0.75	4.21	0.28	0.45	2.37	4.07	5.28	4.07	33.01
1986	8.96	7.71	4.56	3.04	1.37	0.55	1.27	0.02	3.02	3.05	7.27	6.38	47.20
1987	8.07	7.69	8.83	1.53	2.05	0.19	2.39	2.16	0.31	0.12	3.18	13.69	50.21
1989	99.99	99.99	99.99	99.99	99.99	1.17	0.47	0.63	0.72	3.16	99.99	4.25	999.99
1990	13.41	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	3.92	4.90	3.74	999.99
1991	3.66	4.79	5.65	99.99	2.63	2.04	0.18	0.37	0.06	99.99	7.80	4.05	999.99
1992	5.93	6.07	1.22	5.74	0.00	0.60	0.28	0.42	1.63	3.28	6.96	8.64	40.77
1993	5.01	1.01	4.31	5.46	4.21	1.52	1.23	0.10	0.02	1.66	1.35	9.27	35.15
1994	5.51	99.99	3.92	2.67	0.93	2.18	0.01	0.00	1.36	5.28	10.86	9.94	999.99
1995	10.25	4.77	7.70	5.03	1.09	1.95	.07	.88	2.21	3.42	11.60	9.33	58.30
1996	10.99	14.32	3.25	7.85	4.05	.72	.53	.19	2.91	5.42	12.10	22.00	84.33
1997	8.88	2.82	7.75a	3.39a	2.89	2.13	0.24	0.93	2.88	6.65	7.11	4.73	50.40
1998	10.84	8.11	5.96	2.61	4.72	0.78	0.01	0.00	0.87	3.25	12.86	11.96	61.97
1999	10.62	17.61	6.15	1.28	3.46	0.87	0.11	0.21	0.32	2.65	13.18	7.87	64.33
2000	6.39	6.28	2.95	0.00z	2.72	1.38	0.15	0.00	0.59	2.41	3.67	5.05	31.59a
2001	2.22	3.10	2.47	1.98	1.80	1.35	0.20	0.58	0.00z	2.88	0.00z	0.00z	16.58c

WILLAMINA, OR PRECIPITATION AVG. (ANNUAL) = 51.57"

Monthly Means and Extremes

Otis, Oregon Period: 1961-1990

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean Temperature (F)													
Maximum	47.0	51.1	53.9	56.7	61.3	65.6	69.3	70.8	69.1	61.4	52.3	46.9	58.8
Minimum	36.0	37.5	38.1	39.4	43.1	47.5	49.5	50.3	48.4	44.5	40.3	36.5	42.5
Mean	41.5	44.3	46.0	48.0	52.2	56.6	59.4	60.5	58.7	53.0	46.3	41.7	50.6
Extreme Temperature (F)													
Maximum	65	72	78	83	88	95	96	98	92	82	76	64	98
Minimum	14	11	23	28	30	35	35	39	34	27	15	4	4
Precipitation (inches)													
Monthly mean	14.88	11.11	11.11	6.77	4.84	3.69	1.68	1.92	3.91	7.69	14.25	15.55	96.49
Extreme 24 hour	7.44	4.33	4.00	2.43	2.56	3.28	3.05	2.93	2.60	3.16	4.95	4.60	5.73
Snowfall (inches)													
Monthly mean	1.71	.08	.56	.02	.00	.00	.00	.00	.00	.00	.14	1.09	3.81
Average number of days													
Temperature													
Maximum 90 or more	.0	.0	.0	.0	.0	.1	.3	.3	.1	.0	.0	.0	.9
Maximum 32 or less	.3	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.8	1.0
Minimum 32 or less	10.5	6.3	5.3	3.0	.3	.0	.0	.0	.0	.5	4.4	9.2	40.5
Minimum 0 or less	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Precipitation													
.01 inches or more	21.5	18.6	19.4	17.4	15.3	11.1	6.7	7.3	10.3	14.5	20.5	22.5	184.1
.10 inches or more	17.5	15.6	16.7	13.0	10.4	6.4	3.4	4.1	6.5	10.8	16.8	18.1	138.5
.50 inches or more	9.8	7.8	8.2	4.8	3.0	2.7	1.0	1.2	2.9	5.3	9.9	10.3	66.3
1.00 inches or more	4.8	3.8	3.2	1.5	1.0	.8	.3	.3	1.0	2.5	5.1	5.5	29.5
Degree Days													
Heating days @ 65F	729	583	588	510	398	257	178	145	192	371	561	724	5251
Growing days @ 50F	5	10	14	31	94	198	291	326	262	116	22	6	1365

Oregon Climate Service

Station number: 353705 Station name: HASKINS DAM

Element : DAILY PRECIPITATION Quantity : MONTHLY SUM Units : INCHES
a = 1 day missing, b = 2 days missing, c = 3 days, ..etc..,
z = 26 or more days missing, A = Accumulations present
Long-term means based on columns; thus, the monthly row may not
sum (or average) to the long-term annual value.

Maximum allowable number of missing days : 5
99.99 = missing month 999.99 = incomplete year

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1932	11.70	7.59	11.11	6.55	2.16	0.53	0.59	0.18	0.09	3.87	18.67	18.60	81.64
1933	15.11	6.96	10.21	1.11	7.02	2.78	0.00	0.43	4.72	5.79	2.76	33.50	90.39
1934	11.65	2.66	6.91	3.01	2.12	0.38	0.06	0.14	1.79	12.72	22.51	16.12	80.07
1935	9.71	7.43	13.45	3.27	0.84	0.27	0.46	0.24	1.82	3.52	4.83	12.69	58.53
1936	23.44	12.81	6.07	1.60	5.77	1.90	0.23	0.00	0.65	0.30	0.35	13.08	66.20
1937	7.59	12.41	6.64	11.77	2.76	4.51	0.02	1.39	0.95	6.41	17.31	20.56	92.32
1938	99.99	99.99	99.99	3.62	0.73	0.00	0.33	0.00	1.03	6.03	8.85	7.98	999.99
1939	11.10	13.01	3.88	0.64	1.14	0.87	0.34	0.93	0.31	4.16	2.48	19.29	58.15
1940	8.39	22.06	9.12	4.63	3.09	0.00	0.12	0.11	1.96	6.55	7.39	9.01	72.43
1941	13.32	3.80	2.79	3.12	5.68	1.33	0.00	2.75	4.30	3.08	9.27	18.64	68.08
1942	6.84	7.70	3.70	3.50	4.05	1.62	1.18	0.13	0.08	4.78	23.34	18.37	75.29
1943	8.23	9.86	11.99	4.77	2.41	1.70	0.48	1.68	0.00	9.52	5.76	7.99	64.39
1944	8.33	6.68	5.10	5.60	2.39	1.57	0.52	0.21	2.67	2.70	9.21	4.29	49.27
1945	10.40	13.06	16.03	4.72	5.05	0.08	0.35	0.00	4.41	1.81	21.79	15.11	92.81
1946	14.98	13.79	8.94	4.25	0.93	2.04	0.95	0.10	1.00	7.57	15.41	13.43	83.39
1947	10.51	7.70	8.17	3.42	0.28	5.30	0.89	0.04	0.34	16.99	5.88	8.47	67.99
1948	11.86	15.45	8.28	7.62	7.84	0.44	0.70	0.65	3.60	4.39	15.70	18.28	94.81
1949	1.71	24.74	5.18	1.70	5.02	0.69	0.30	0.18	1.22	4.34	12.01	12.05	69.14
1950	18.07	12.33	13.86	3.61	1.55	99.99	99.99	99.99	99.99	99.99	99.99	99.99	999.99
1950	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	1.57	99.99	14.76	99.99	999.99
1951	18.88	10.69	7.89	2.23	2.53	0.09	0.23	0.51	3.68	11.71	15.63	16.87	90.94
1952	11.53	8.05	7.73	2.37	0.42	2.12	0.00	0.35	0.38	1.02	3.67	15.99	53.63
1953	27.38	7.45	9.86	5.28	4.88	1.39	0.00	3.24	2.20	3.63	12.42	14.59	92.32
1954	21.35	15.44	5.61	6.23	1.79	3.30	0.48	1.65	1.86	5.39	11.50	13.21	87.81
1955	8.34	7.81	12.22	8.27	0.82	1.17	1.50	0.00	3.29	11.87	17.05	21.82	94.16
1956	21.14	9.27	15.74	0.49	0.84	1.08	0.10	0.84	99.99	99.99	3.28	8.70	999.99
1957	4.78	10.63	12.22	4.42	3.91	1.28	0.38	0.38	0.59	4.32	7.58	22.00	72.49
1958	16.15	15.04	5.23	8.11	0.95	1.94	0.17	0.05	1.13	4.55	13.01	11.02	77.35
1959	17.44	7.95	9.47	3.05	1.71	2.36	0.55	0.08	6.23	4.46	6.13	6.97	66.40
1960	8.29	13.46	11.51	8.35	5.46	0.43	0.00	1.01	0.46	4.87	18.44	5.76	78.04
1961	11.64	19.73	16.53	3.52	3.32	0.20	0.81	0.68	1.06	8.33	10.33	10.88	87.03
1962	2.95	7.25	8.26	6.11	2.20	0.42	0.00	1.08	3.33	8.52	20.10	4.62	64.84

1963	3.21	6.36	9.33	5.59	4.14	99.99	1.10	0.80	1.87	99.99	13.69	6.77	999.99
1964	21.79	2.52	8.98	2.43	1.07	1.48	0.65	0.57	1.08	1.70	13.90	99.99	999.99
1965	17.01	5.52	0.98	3.26	2.88	0.69	0.29	0.66	0.02	3.10	14.74	13.54	62.69
1966	15.39	5.90	13.79	1.18	1.60	0.90	0.45	0.51	1.21	5.39	8.44	19.82	74.58
1967	19.05	4.02	99.99	3.21	0.86	0.63	0.00	0.00	1.35	11.07	6.05	11.48	999.99
1968	10.47	15.65	10.55	2.33	3.27	2.91	0.05	4.88	2.21	8.87	12.43	18.29	91.91
1969	13.19	7.96	3.12	4.09	1.91	0.95	0.02	0.01	2.98	5.70	5.74	17.45	63.12
1970	99.99	9.09	5.11	4.83	0.97	0.50	0.09	0.02	1.31	8.51	11.18	24.66	999.99
1971	15.86	7.75	99.99	5.62	3.01	2.12	0.06	0.63	5.44	4.90	13.98	19.25	999.99
1972	17.55	9.06	10.74	7.59	1.69	0.93	0.20	0.10	4.66	0.99	11.31	16.34	81.16
1973	99.99	4.03	6.53	2.54	1.95	1.79	0.02	0.94	6.36	5.08	26.79	21.69	999.99
1974	19.95	14.55	15.16	5.15	3.09	1.46	1.65	0.25	0.08	1.66	11.17	14.76	88.93
1975	99.99	99.99	9.93	3.04	3.62	0.92	0.95	2.51	0.07	11.06	15.88	13.33	999.99
1976	11.97	8.21	9.52	2.77	2.22	0.76	0.69	1.55	0.73	2.66	2.20	3.24	46.52
1977	1.60	6.39	13.39	0.52	4.98	1.36	0.57	3.23	5.16	4.84	13.67	22.05	77.76
1978	13.28	10.86	4.12	7.40	5.42	1.23	0.40	2.56	4.57	1.08	4.56	99.99	999.99
1979	3.42	14.17	4.89	3.37	4.16	1.25	0.67	1.33	3.12	8.03	5.85	13.17	63.43
1980	12.91	10.36	6.40	6.75	1.12	1.48	0.34	0.09	2.01	1.99	12.46	15.04	70.95
1981	3.22	9.95	6.03	4.94	2.86	4.20	0.16	0.01	4.51	8.40	10.08	21.58	75.94
1982	13.04	14.01	7.15	9.89	0.37	2.04	0.33	0.43	2.62	8.12	10.19	18.48	86.67
1983	13.23	19.28	16.42	3.41	2.79	1.97	2.34	1.57	0.74	1.73	23.64	10.37	97.49
1984	4.89	11.30	7.69	6.46	5.41	2.96	0.00	0.01	1.85	8.98	20.94	7.69	78.18
1985	0.39	5.60	7.44	2.76	1.04	3.68	0.51	0.46	2.57	6.60	6.00	4.47	41.52
1986	14.66	10.83	5.88	3.93	3.46	0.58	1.26	0.01	4.52	4.60	12.36	8.10	70.19
1987	12.39	10.24	13.13	2.22	3.04	0.32	1.37	0.30	0.19	0.37	5.44	18.20	67.21
1988	14.57	2.76	8.23	4.29	4.13	2.93	0.26	0.08	1.08	0.73	18.69	7.32	65.07
1989	8.50	6.99	11.53	2.03	1.92	1.28	0.50	0.91	1.03	4.10	5.30	5.33	49.42
1990	21.86	13.07	4.34	3.15	3.15	2.10	0.28	1.03	0.48	5.72	8.33	6.19	69.70
1991	6.69	8.26	8.21	13.19	2.52	1.67	0.24	0.76	0.10	2.88	9.28	6.50	60.30
1992	11.78	7.37	1.35	8.00	0.04	0.83	0.46	0.26	2.70	3.79	10.76	11.97	59.31
1993	9.22	2.20	7.59	10.21	4.29	3.03	0.62	0.17	0.01	1.55	2.06	15.19	56.14
1994	9.24	11.62	6.26	4.08	2.19	1.99	0.00	0.19	2.04	8.49	14.02	19.22	79.34
1995	18.35	8.08	11.69	6.94	1.53	1.82	.79	.90	2.28	5.44	17.34	18.30	93.46
1996	16.26	21.84	3.83	15.70	5.05	.92	.77	.19	3.38	7.47	11.47	28.52	115.40
1997	13.08	4.51	14.28	5.42	3.64	2.05	0.23	1.63	6.80	14.23	13.28	6.36	85.51
1998	21.04	12.97	8.85	2.76	4.44	0.53	0.13	0.10	1.23	5.11	22.28	21.49	100.93
1999	18.82	30.55	9.97	3.15	3.36	1.05	0.23	0.96	0.31	4.83	18.97	15.44	107.64
2000	13.33	9.58	5.72	2.07	4.15	3.08	0.05	0.07	1.08	3.56	4.61	8.70	56.00
2001	3.73	3.73	4.42	2.90	3.47	2.16	0.20	1.56	0.70	4.84	18.20	0.00z	45.91a

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Monthly Averages and Records

Dundee, OR (97115)
Click a month to see the details for that month. The details for each day of the selected month are shown below.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. High	46°F	51°F	56°F	61°F	68°F	75°F	82°F	82°F	76°F	64°F	52°F	45°F
Avg. Low	33°F	35°F	36°F	38°F	42°F	47°F	49°F	49°F	46°F	41°F	37°F	33°F
Mean	40°F	44°F	47°F	50°F	56°F	61°F	66°F	66°F	62°F	53°F	45°F	40°F
Avg. Precip.	7.20 in	5.20 in	4.90 in	2.60 in	1.90 in	1.00 in	0.50 in	0.70 in	1.60 in	3.20 in	6.70 in	7.80 in
Record High	69°F (1931)	72°F (1968)	87°F (1930)	89°F (1931)	100°F (1983)	103°F (1992)	108°F (1938)	106°F (1972)	105°F (1988)	95°F (1988)	75°F (1930)	69°F (1950)
Record Low	-7°F (1950)	2°F (1950)	15°F (1956)	24°F (1931)	24°F (1954)	31°F (1976)	34°F (1971)	30°F (1955)	28°F (1970)	23°F (1972)	9°F (1955)	-5°F (1972)

Daily Averages and Records

Dundee, OR (97115)
March
Sunrise and Sunset Times are in local time for 2002

	8	9	10	11	12	13	14	15	16	17	18	19
Sunrise	6:37 AM	6:36 AM	6:34 AM	6:32 AM	6:30 AM	6:28 AM	6:26 AM	6:24 AM	6:22 AM	6:21 AM	6:19 AM	6:17 AM
Sunset	6:09 PM	6:10 PM	6:11 PM	6:13 PM	6:14 PM	6:15 PM	6:17 PM	6:18 PM	6:19 PM	6:21 PM	6:22 PM	6:23 PM
Avg. High	55°F	55°F	55°F	55°F	56°F	56°F	56°F	56°F	56°F	56°F	57°F	57°F
Avg. Low	36°F	36°F	36°F	36°F	36°F	36°F	36°F	36°F	36°F	36°F	36°F	37°F
Mean	46°F	46°F	46°F	46°F	46°F	47°F	47°F	47°F	47°F	47°F	47°F	47°F
Record High	70°F (1965)	70°F (1981)	72°F (1965)	72°F (1965)	76°F (1930)	74°F (1979)	73°F (1947)	76°F (1947)	78°F (1947)	77°F (1947)	72°F (1978)	75°F (1928)
	20°F	26°F	25°F	26°F	23°F	24°F	26°F	23°F	24°F	24°F	26°F	26°F

Go Shopping

Monthly Means and Extremes
McMinville, Oregon Period: 1961-1990

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean Temperature (F)													
Maximum	46.6	51.2	56.3	61.6	68.8	75.4	81.9	82.7	76.6	65.3	52.8	46.0	63.7
Minimum	33.8	35.7	36.8	38.6	42.5	47.1	49.4	49.8	46.5	41.6	37.9	33.9	41.2
Mean	40.2	43.4	46.5	50.1	55.7	61.2	65.6	66.3	61.6	53.5	45.3	40.0	52.4
Extreme Temperature (F)													
Maximum	62	72	75	85	100	98	105	106	105	95	71	64	106
Minimum	7	8	18	25	26	31	34	31	28	23	15	-5	-5
Precipitation (inches)													
Monthly mean	6.53	5.07	4.81	2.55	1.84	1.00	.48	.72	1.57	2.95	6.23	7.66	41.86 ←
Extreme 24 hour	2.70	2.90	1.76	1.76	1.76	1.07	1.05	1.69	1.80	1.55	2.37	2.82	2.90
Snowfall (inches)													
Monthly mean	2.01	.63	.18	.01	.00	.00	.00	.00	.00	.00	.04	2.31	4.98
Average number of days													
Temperature													
Maximum 90 or more	.0	.0	.0	.0	.3	2.1	5.9	6.7	2.8	.1	.0	.0	18.3
Maximum 32 or less	.9	.1	.0	.0	.0	.0	.0	.0	.0	.0	.2	.9	2.3
Minimum 32 or less	13.1	9.4	8.3	5.3	.8	.1	.0	.0	.5	2.5	6.4	12.2	59.5
Minimum 0 or less	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.1
Precipitation													
.01 inches or more	17.1	15.1	16.1	12.3	9.2	5.3	2.4	3.6	6.6	10.6	16.5	17.7	134.7
.10 inches or more	12.2	10.9	11.2	6.9	5.5	2.8	1.2	1.9	4.0	6.9	12.1	13.3	90.3
.50 inches or more	4.8	3.6	3.4	1.3	.9	.6	.3	.4	1.1	1.9	4.4	5.9	28.9
1.00 inches or more	1.5	1.0	.7	.2	.1	.1	.0	.1	.1	.4	1.4	1.9	7.5
Degree Days													
Heating days @ 65F	768	608	573	447	297	144	54	48	137	359	591	776	4818
Growing days @ 50F	3	9	21	68	188	337	485	504	347	138	18	3	2120

2121

Oregon Climate Service