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The morphology and genesis of soils of the Willamette series and of some Willamette-associated soils and their relationships to geomorphic surfaces were studied in an area near McCoy, Polk County, Oregon. Influences of regional extent, such as climate and parent material, were related to the soils and landforms. The soils were mapped by methods proscribed in the Soil Survey Manual, and the geomorphic surfaces were recognized and delimited using descriptions previously published. Interpretations of the soil and geomorphic relationships were extended to other portions of the northern Willamette Valley, particularly the Yamhill River Valley.

Of four geomorphic surfaces mapped in the study area, three were previously recognized, and a new one, the Bethel surface, was proposed. It was described and compared to the Quad surface in the Willamette Valley, and is presumably of similar age. The other geomorphic surfaces in the area were mapped as Calapooyia, Senecal, and Ingram units. Stratigraphic investigations identified the nature of the materials under the surfaces.

Chemical and physical analyses were made of samples from horizons of representative soil profiles. The laboratory data were used to compare and contrast soils of the different surfaces. The Willamette "group" of soils, which occur on three of the surfaces, were found to be similar. They are members of fine-silty, mixed, mesic families of Pachic Ultic Haploxerolls, Ultic Argixerolls, Pachic Ultic Argixerolls, and Aquultic Argixerolls, a topo-chrono-litho (perhaps bio-) sequence. Soils of the subgroups Argiaquic Xeric Argialbolls, Typic Ochraqualfs, and Typic Albaqualfs are limited to two geomorphic surfaces, and one soil, a member of Fluventic Haplaquolls, is on only one surface, the youngest mapped in the study area. Lithologic discontinuities, correlated with stratigraphic evidence, were observed in and recorded for each soil profile described.

Each of the soils that was recognized and analyzed is comprised of more than one deposit. The upper limit of the older material in the sola is marked by brown and reddish brown clay films on ped faces, probably the result of clay illuviation prior to the deposition of the next major stratum. Modification of the strata by additions of organic matter, eluviation of bases, reduction of iron and manganese under wet conditions, local erosion and deposition of alluvium, and

possibly alteration under different kinds of vegetation produced different morphologies of the soils, depending on the topographic locations and nature of the strata. Soils on the hilltops, the Bethel surface, have thinner mollic epipedons than do other Willamette "group" soils on the main valley terrace, the Senecal surface. The clayey strata under the Calapooyia and Ingram surfaces, although deposited at different times, affected the soils on those surfaces similarly by restricting the downward movement of water. Reducing conditions in all of the soils sometime during the rainy season was considered. Cool, moist winters and warm, dry summers affected the kinds and rates of chemical reactions in the soils. The observations made in the study area are applicable to similar areas in other parts of the Willamette Valley. During the progress of the Polk County soil survey, careful examination of the soils associated with the Bethel surface is important.

Willamette and Associated Soils on Late Pleistocene Geomorphic Surfaces Polk County, Oregon

by

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INTRODUCTION

"Soils of the Willamette series occupy the gently rolling, naturally drained, brown-colored lands in the old Valley filling or Valley floor of the Willamette River and include about one-third million acres," according to Powers, Ruzek, and Stephensen (76) in 1928. They further summarized,

> Four types . . . have been mapped . . . namely, loam, silt loam, clay loam, and silty clay loam. The average texture of the surface is silt loam with about 5 percent organic matter. The weight per cubic foot . . . is 80 pounds and its field water capacity nearly two acre-inches for the first acre-foot of soil.

They then described the physical and chemical characteristics of, fertilizer experiments on, and the values of crop rotation and supplemental irrigation for the soils of the Willamette series. In 1928, soils of the Willamette series included most of what are now soils of the Woodburn series.

In the official series description, soils of the Willamette series are described as being ". . . on level to gently sloping broad valley terraces 2 to 15 feet higher than the valley floor plain. . . ."[1] The occurrence of Woodburn soils is similarly described. The settings of

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[1] Description of the Willamette Series, National Cooperative Soil Survey, U.S.A.

these soils are not limiting but rather define where the soils usually occur.

The present study was initiated to observe in detail the relationships of Willamette and associated soils and geomorphic surfaces near McCoy in Polk County, Oregon (Figure 1). Observations were made of the effects that landforms had on the soil characteristics. Physical and chemical data were used to characterize the soils in the area and to determine if these soils are restricted to specific surfaces. The data were also used to characterize the Willamette and similar soils in the area.

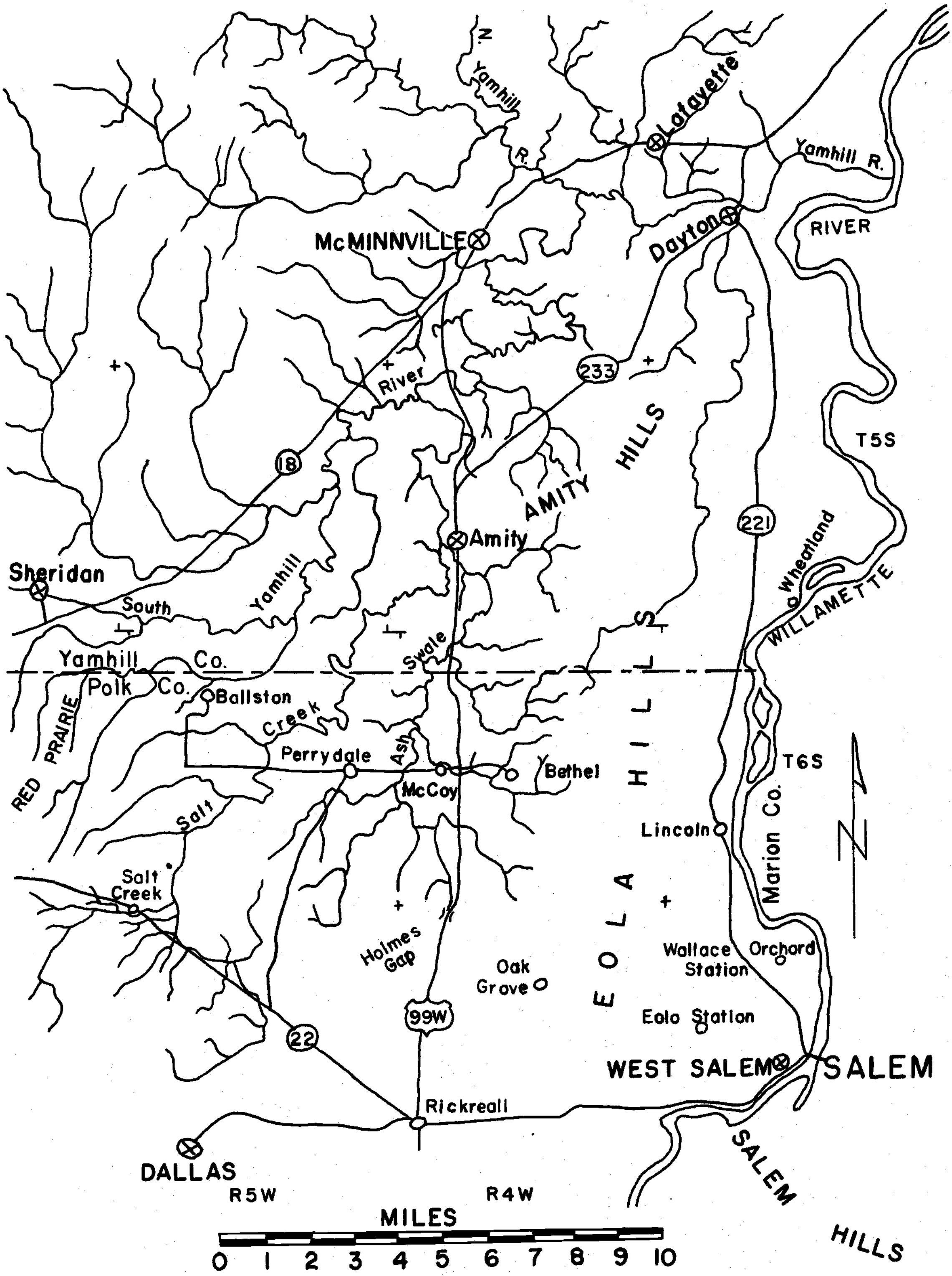

Figure 1. Major portions of the South Yamhill River watershed. McCoy, in Polk County, is in the Ash Swale drainage area.

LITERATURE REVIEW

Soils

Soils of the order Mollisols are widespread in the United States. The seven suborders are comprised of soils of diverse characteristics, ranging from the cold Borolls to the warm Ustolls and from the wet Aquolls to the dry Xerolls. Several recent studies have been completed on Udolls in Illinois (34) and Iowa (7), on Albolls and Xerolls in Oregon (70), on Borolls in North Dakota (79), and on Borolls and Ustolls in South Dakota (103). Rendolls comprise the seventh suborder.

Soils of the Willamette series are Xerolls. Other soils of the main terraces in the Willamette Valley are also seasonally dry, either with or without a mollic epipedon; in the latter case they are Xeralfs or Aqualfs. Willamette soils are on low, rounded hills and on valley terraces.

General field observations in Polk County in 1967 revealed that the silty soils on low, smooth, convex hills have morphologic characteristics similar to Willamette and Woodburn soils on the main valley terrace. Data for some Willamette, Woodburn, Amity, Concord, and Dayton soils and their occurrence on the main valley terrace of the southern Willamette Valley have been presented by Parsons, Simonson, and Balster (70). Wert studied drainfield performances of the same soils (102). These soils were considered by Pomerening and Knox (74) to comprise a drainage catena, but it was later shown that the Dayton soils are not members of the catena, although they do represent one of the poorly drained associated soils (68). Concord soils differ little from Dayton, except that they have a thicker A and a thinner IIB horizon. The Amity series is, however, the somewhat poorly drained member of the Willamette catena (74), in which Woodburn is moderately well drained and Willamette is well drained.

Balster and Parsons (16) have shown that specific soils of the Willamette Valley are representative of named geomorphic surfaces. Similar observations have been made in New Mexico (40, 42, 43, 84), Oregon (15), North Carolina (29), and Iowa (83). Some soils in the Willamette Valley occur on more than one geomorphic surface. The map of the Soil Survey of Polk County, Oregon (95), shows Willamette silt loam on low, smooth convex hills near McCoy, as well as on the nearly level valley terraces around the town (Figure 2). The general locations of the Dayton, Amity, and Willamette soils are accurate within the bounds of the original map scale. Typical Carlton and Melbourne clay loam mapping units were not found in the study area although they were delimited in the earlier survey (95) as shown in Figure 2. Woodburn and Concord soils have been recognized and defined since the 1927 soil survey (95). Wapato soils are on the stream

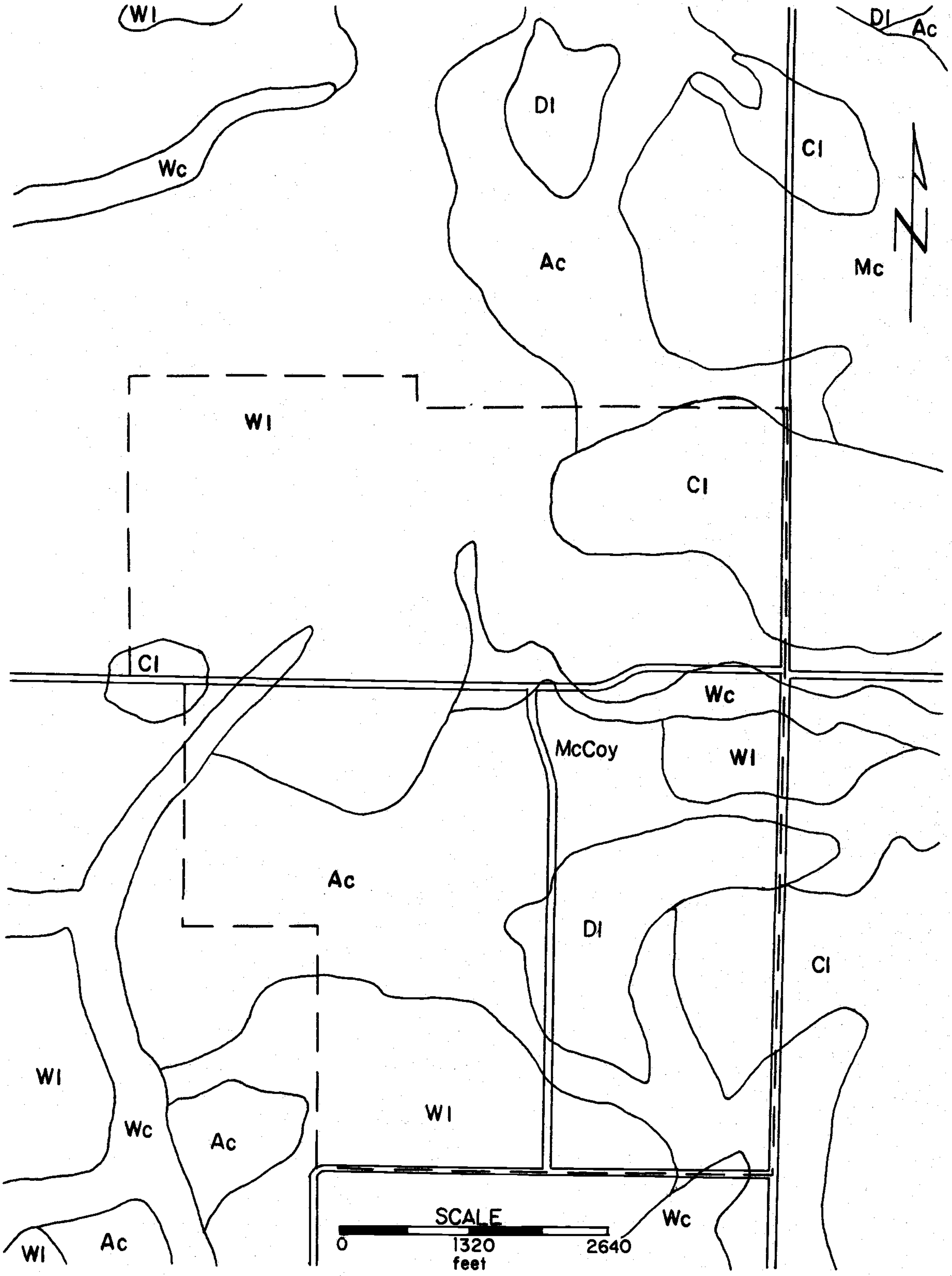

Figure 2. Early soil survey of the McCoy area (95). Ac = Amity; Cl = Carlton; Dl = Dayton; Mc = Melbourne; Wc = Wapato; Wl = Willamette soils. Dashed line is study area boundary.

terraces of the drainageways.

Geomorphology

Several investigations of soil-geomorphology relationships have revealed that different geomorphic surfaces are often surmounted by soils that differ according to the recognized surface (14, 24, 28, 30, 41, 87, 67, 69). Daniels, et al., (28) noted of the Atlantic Coastal Plain:

> . . . soil properties also change in response to changes in sediment properties. Thus, not all the changes in soils across the scarp can be related only to age or to change in sediments. Some change in soil properties should be expected at every major change in stratigraphy and geomorphology on the coastal Plain because soils are products of their environment and they reflect the history of their landscape.

Balster and Parsons (16) observed that in the Willamette Valley, "In many places, soil and geomorphic boundaries coincide. However, association with a landform alone does not constitute a series criterion." They mapped and described geomorphic surfaces in the Willamette Valley. The surfaces are Horseshoe, Ingram, and Luckiamute, the flood plains of the rivers and streams; Winkle, a terrace, rarely flooded; Senecal, Calapooyia, and Quad, components of the main valley terrace; Dolph, eroded remnants of an old valley terrace; and Eola, the oldest and highest stable surface. Some of these surfaces, pertinent to the study area, are more completely described in Appendix A.

In discussing the composition, rating, and conservation of Willamette Valley soils, Powers, Jones, and Ruzek (75) listed the soil series according to whether they were located along recent stream bottoms, on the main valley floor, or as hill lands. Willamette, Amity, Dayton, and Concord soils are shown as valley floor soils and Carlton soils as members of the hill group.

Regional Geology

The Willamette Valley is situated between the gently folded and faulted marine and nonmarine sedimentary and igneous rocks of the Coast Range and the volcanic peaks and flows of the Cascade Mountains (Figure 3). On the west side of the Valley, the South Yamhill River drains northwestern Polk County and southern Yamhill County from within 15 miles of the Pacific Ocean to the Willamette River north of Salem. In the upper reaches, the Yamhill River bed generally cuts into the surface of the Eocene sediments which dip toward the Cascades. The major formations in the Yamhill basin are the Yamhill and the Nestucca which underlie tuffaceous Oligocene marine siltstones and sandstones. The lower reaches of the river are in Pleistocene and Recent fluviatile materials. The Eola and Salem Hills (Figure 1) have Columbia River Basalt capping the Oligocene sediments. Weathered clay, silt, and gravel of Pliocene age, on the

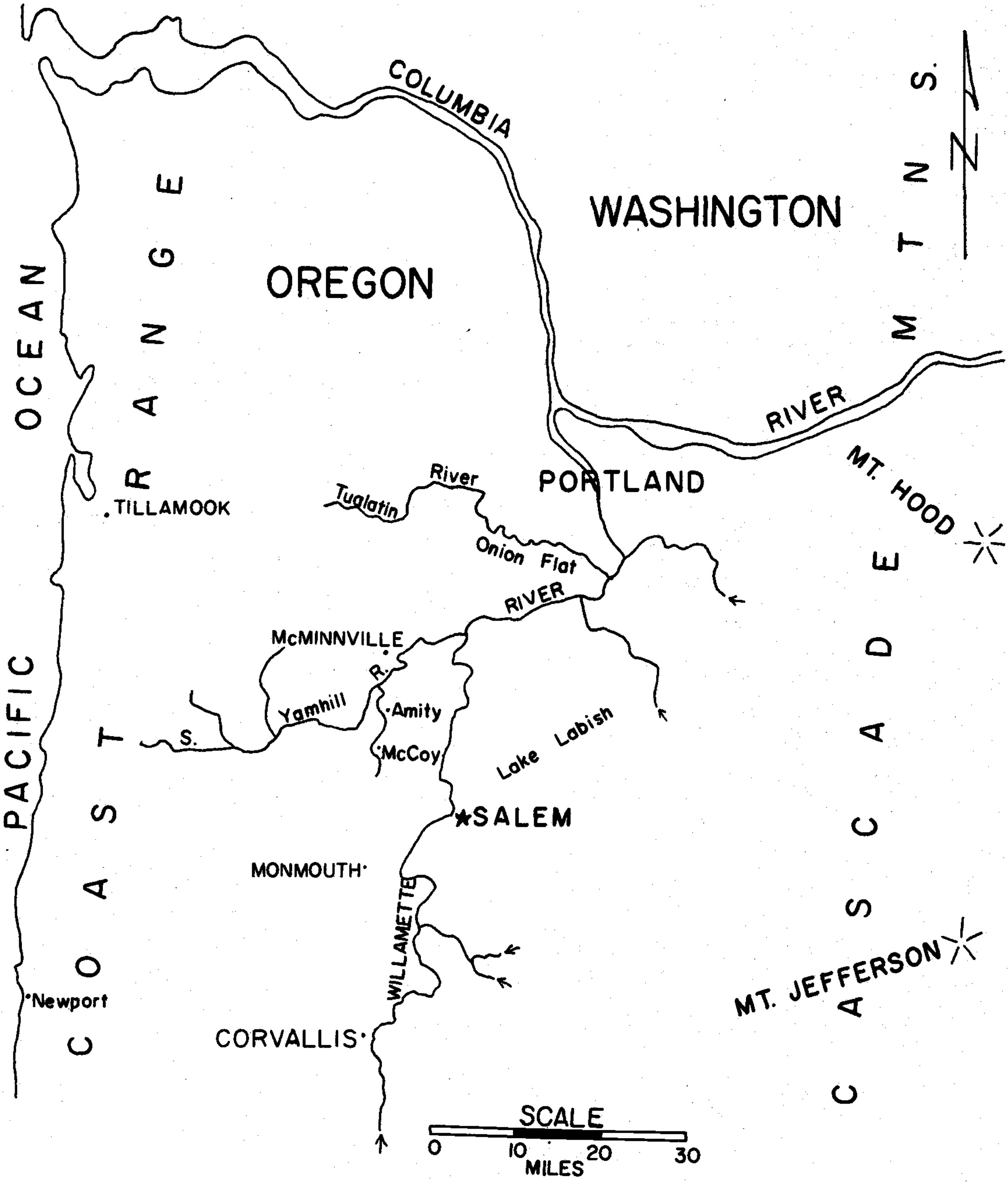

Figure 3. Location of McCoy and Ash Swale within the lower Willamette drainage in northwestern Oregon (56).

Columbia River Basalt along the east edge of the Eola Hills, and red weathered gravels (middle Pleistocene) resting on a relatively undeformed erosion surface on Red Prairie are considered as decomposed sediments by Baldwin, et al., (12). The "red hill soils" have formed in this material, as well as in alluvium and colluvium from basaltic rocks (69). Red Prairie is representative of the Dolph surface, which is considered to be middle Pleistocene in age (16).

During the late Pliocene and early Pleistocene there was much uplift and subsequent incision by streams and rivers. Pleistocene glaciation lowered sea level, and, hence, regional base level. The lowered base level promoted downcutting by precipitation runoff and melt waters from Cascade glaciers. In addition there was regional uplift of the West Coast during the late Pliocene and the Pleistocene that facilitated downcutting and emphasized differences in relief. "During the rise in sea level following Illinoian glaciation the Willamette Valley was inundated and partially filled with silts" (11). This fresh water lake that formed had a surface elevation of about 350 feet above present sea level and extended southward almost to Eugene. It was in existence during the last interglacial stage (11). Condon (25) envisioned this body of water as a sound, not unlike Puget Sound today. The silts were recognized by Allison (2) as Willamette Silts. They have been redefined for the southern Willamette Valley as the Irish Bend Member of the Willamette Formation by Balster and Parsons (17). Ages for the

Willamette Silts range from late (2) to perhaps middle Pleistocene (17).

Two other members of the Willamette Formation are recognized as being subsequent deposits on the Irish Bend Member.

> The Malpass Member is typically a massive gray clay with iron-manganese oxide concretions (35) that ranges from a few inches to as much as 3 feet thick. . . .
>
> The Greenback Member . . . is the uppermost unit of the . . . Formation. . . . Where the Malpass Member is absent, the Greenback may be directly on the Irish Bend Member. . . .
>
> [It is a] light gray, silty material . . . of silt-size quartz and feldspars with a significant content of coarse and sand-size iron-manganese oxide concretions near the base of the unit (17).

The Greenback and Malpass Members have been studied only in relation to the Senecal and Calapooyia surfaces and are not coextensive with the Irish Bend Member.

Near the end of the Wisconsin, great quantities of melt water and ice surged down the Columbia River and backed up into the Willamette Valley (11). Bretz, et al., (22) suggested that there was more than one flood, but that the last was most distinct, with the water surface at about 400 feet above present sea level. "The flood left many chips of erratics and a thin silt that covered the entire valley below 400 feet" (11, p. 52).

After the Wisconsin stage of glaciation, eustatic rise and fluctuation in sea level (26, 27) assisted filling of the valleys by alluvium (11). Flood plains and alluvial fans created at that time are geomorphic surfaces that have since been incised to form the youngest surfaces in the valley (66). Since about 5, 250 years ago (78), the present flood plains and low terraces were formed by downcutting and subsequent alluviation. This is apparently a result of headward erosion of the Willamette River and its tributaries as indicated by the deeper incisions of the younger into the older surfaces downstream (16). The most recent geomorphic surface is the channel of the rivers and streams in the valley. It is of postsettlement age (16).

The Yamhill River Valley is a tributary valley of the northern Willamette Valley and has geomorphic features common to both the northern and southern Valleys (16). The aggradation of the Willamette River flood plain has caused much meandering and aggrading with very little incision of the lower reaches of the Yamhill River and its tributaries (Figure 1).

History of the Vegetation

A record of the post-Pleistocene vegetation is preserved in the peat beds of Onion Flat, an old channel of the Tualatin River southwest of Portland and in Lake Labish of the Little Pudding River northeast of Salem (Figure 3). Pollen in the sediments show the forest succession of adjacent lands from postglacial to near present times. Hansen (48, 49) believes that the initial postglacial forests of the Willamette Valley, the eastern slopes of the Coast Range, and the western slopes of the Cascades were composed primarily of lodgepole pine (*Pinus contorta*), Sitka spruce (*Picea sitchensis*), and lowland white fir (*Abies grandis*). He assumes that the lodgepole was near the retreating fronts of the Cascade glaciers where edaphic and climatic conditions were unfavorable for Douglas-fir (*Pseudotsuga menziesii*) and western hemlock (*Tsuga heterophylla*), which were present only in small quantities. The spruce and white fir grew in the more favorable positions in the valley.

Hansen (48) also observed that the pollen in the peat beds is probably more representative of the Coast Range vegetation than of the Cascades because, he felt, most of the deposits in the Tualatin and Little Pudding Rivers originated on the west side of the valley. Pollen analyses indicate that, after a long period of moist conditions, the climate became warmer and drier and Douglas-fir began to invade the valley. White oak followed the fir, and, as the xeric period reached its maximum, the oak (*Quercus Garryana*) became dominant among the tree species. More recently, a cooler and moister climate encouraged an equilibrium between Douglas-fir and the oak.

The climatic and vegetative changes in Oregon were not much different from other areas in North America during the same time. A pollen study in Aroostock and Kennebec Counties in Maine showed a maximum level for oak with subsequent decline to the present as the climate changed (31). Oaks (*Quercus alba* or *Q. velutina*)(61), however, were not dominant. Hemlock (Tsuga canadensis) and beech (Fagus grandifolia) pollen counts were more numerous.

Ruhe and Scholtes (88) related soil landscapes in Iowa with climatic and vegetative changes and noted that there was a cool, moist arboreal climate following glaciation until about 5, 000 years B. P. (before present) when a warmer, subhumid to humid prairie environment became dominant. From about 11, 000 B. P., the change was from coniferous to deciduous forest to grassland. The Thermal Maximum extended from about 6, 000 to 4, 000 B. P. Another maximum occurred before 1, 000 A. D.

Using pollen zones from studies in Maine, northern Europe, and Switzerland, Deevey and Flint (32) proposed a Hypsithermal Interval for the period where temperatures were from 2 to 3° C. above the present. This period extended from about 9, 000 to about 2, 500 years B. P. They noted a series of hot, dry summers just about 600 B. C. in northwest Europe.

Schwarzbach (90) reported that temperatures in the temperate latitudes of the Northern Hemisphere were 8 to 12° C. (14 to 22° F.) lower during the Ice Age than at present. He also noted that after the Wisconsin there were slight temperature fluctuations, especially during the Climatic Optimum of 5, 000 to 3, 000 B. C. when temperatures were 2 to 3° C. (4 to 5°F.) greater than now. Climatic differences were not attributable so much to an increase in precipitation during glacial periods, compared to interglacial periods, as to a decrease in temperature.

Habeck (47) studied Willamette Valley land surveyor records from the 1850's. He also noted that there were reports of frequent fires in the valley from at least 1647 to about 1848. In general, the Douglas-fir was on the hills; and the oak groves, oak openings, and grasslands were on progressively lower topographic positions. The oak forests consisted primarily of Garry oak (Q. Garryana), Douglas-fir, red alder (Alnus rubra), and laurel (Umbellularia californica). The oak openings were mostly oak with occasional Douglas-fir and an understory of grasses, forbs, and shrubs of which hazel (Corylus californica) and fern (Pteridium aquilinum) were most reliably recorded.

In 1919, Nelson (60) compiled a list of grasses near Salem. Of 106 species, only 51 were native to Oregon; the rest were introduced to the Willamette Valley. He grouped the grasses into three sites according to the conditions in which he found them growing. The sites are not different from the present locations of the grasses (71) and are likely similar to the grass habitats before the 1850's. Some of the native grasses as grouped by Nelson are as follows:

Hydrophytes

Alopecurus aequalis--little meadow-foxtail

Deschampsia caespitosa--tufted hair-grass

Glyceria pauciflora--few-flowered manna-grass

Leersia oryzoides--rice cut-grass

Poa palustris--fowl meadow bluegrass

Xerophytes

Agrostis Hallii--Hall's bent-grass

Agropyron trachycaulum--slender wheat-grass

Bromus carinatus--california brome-grass

Danthonia californica var. americana--western wild oat-grass

Elymus glaucus--western rye-grass

Silvicole

Bromus vulgaris--narrow-flowered brome-grass

Deschampsia elongata--slender hair-grass

Festuca occidentalis--western fescue

Festuca subulata--nodding fescue

Poa Howellii--Howell's bluegrass

The names used by Nelson were herein revised according to Peck (71).

The hydrophytes were found in or adjacent to the waterways. The xerophytes were on the open prairies or in similar sites. The silvicole were in open woods in both dry and moist conditions.

Habeck (47) presented a map of a six mile wide strip across the Willamette Valley south of Rickreall from the Salem Hills to the Coast Range west of Monmouth (T8S, R1W to R8W). A comparison of this vegetative survey with the geomorphic map (15) showed bottomland vegetation was mostly on the younger Ingram, Winkle, Luckiamute, and Horseshoe surfaces. Prairie vegetation, grass, was mostly on Calapooyia, Senecal, and Quad surfaces with some on Dolph and Ingram. Oak forests were on the steep Looney unit, while Douglas-fir was on the higher Looney or on the Eola surface. Oak openings were on Eola, Looney, Calapooyia, and well-drained parts of Senecal surfaces.

Joel Palmer (64) made brief observations in the Willamette Valley in 1846 and later resided near Dayton. He reported that a belt near the Willamette River below the mouth of the Yamhill was thinly covered with yellow pines and observed that along the South Yamhill River "near the water courses is fine prairie land, occasionally interspersed with fine groves" (64, p. 172). He said the rolling hills were well covered with grass and there were oak groves. In the Coast Range the Yamhill River banks were "well supplied with large fir trees, as are its several tributaries" and there were "firs, more or less, [along] its whole length" (64, p. 171). Palmer also reported that the first "plateau" between the North and South Yamhill Rivers was covered with grass. He observed that a "considerable portion of the valley of the Yam-hill is not only claimed, but settled, and finely improved" (64, p. 172).

It is likely, therefore, that the area near McCoy and Perrydale was in grass with oak groves or openings from at least the mid-1600's to the mid-1800's with grass on the flats, aquatic plants in the bottoms, and oaks on the better drained sites. There have been, of course, changes in vegetation since settlement and cultivation.

DESCRIPTION AND NATURE OF THE AREA

General

The study area, drained by Ash Swale, a tributary of the South Yamhill River, is centered around the town of McCoy. McCoy is situated on the Southern Pacific Railroad about 1/4 mile west of U. S. Highway 99W on the east-west Bethel-Perrydale road (Figure 4). The study area is in Sections 17, 18, 19, and 20, TWP6S, R2W, WBL&M. It is bounded on the east by U. S. Highway 99W, on the south by the Stephensen farm road, and on the west and north by field borders and the Wilson landing strip road. The area is slightly in excess of one square mile.

In their description of the Eola-Amity Hills Area, Price and Johnson (77) considered the Ash Swale basin a part of the "west valley plain." They described it as "an undulating surface owing to local outcrops of relatively resistant shale and siltstone, which form small scattered knolls and hills" (77). Ash Swale drains the west side of the Eola Hills north of Holmes Gap (Figure 1).

Elevations range from about 155 feet above sea level adjacent to the incision of the waterway to over 220 feet at the crest of the hill in the northwest corner of the area. There are four major hills or knolls in the area. The two over which U.S. 99W travels are

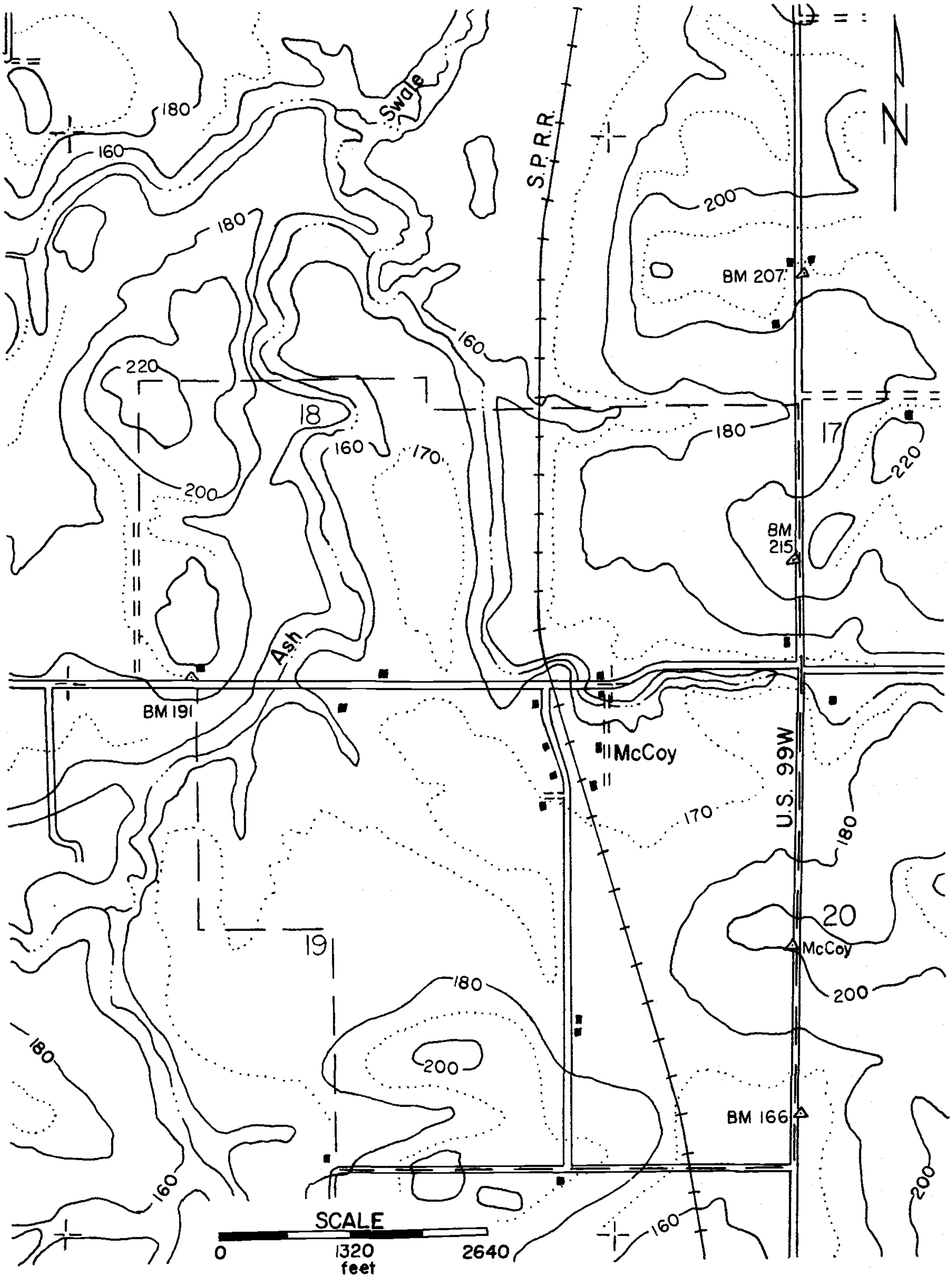

Figure 4. Topographic map of the McCoy study area (101). Contour interval is 20 feet; dotted contour at 10 foot interval. Ash Swale is an ephemeral stream. Dashed line is study area boundary.

extensions of larger hill masses to the east. The others are the knoll south of McCoy and a double-crested hill in the northwest corner. The main valley terrace is, in general, between 160 and 180 feet above mean sea level. The poorly drained incised swales are below 160 feet.

Geology

Baldwin et al. (12) delineated only two units within the study area on the geologic map of the Sheridan and McMinnville Quadrangles. The units are tuffaceous sedimentary rocks (Tts) of Oligocene age and Willamette Silts (Qws) of Wisconsin time. The areas of each are shown in Figure 5. Much of what is mapped as Willamette Silts is now considered to be the Willamette Formation, which is comprised of either two or three members: Irish Bend, Greenback, and Malpass Members (17).

Geomorphic Surfaces

Balster and Parsons (16) mapped four major geomorphic surfaces within the area. These are shown in Figure 6. The Ingram surface is the higher of two flood plains of the Willamette River and its major tributaries. This unit is between 555 ± 100 to 3,290 ± 120 years old (15, 16). The Senecal surface is the low, nearly level and rounded portion of the valley terrace. It is a combination of areas of deeply incised drainageways graded to Ingram and of areas of "very slight

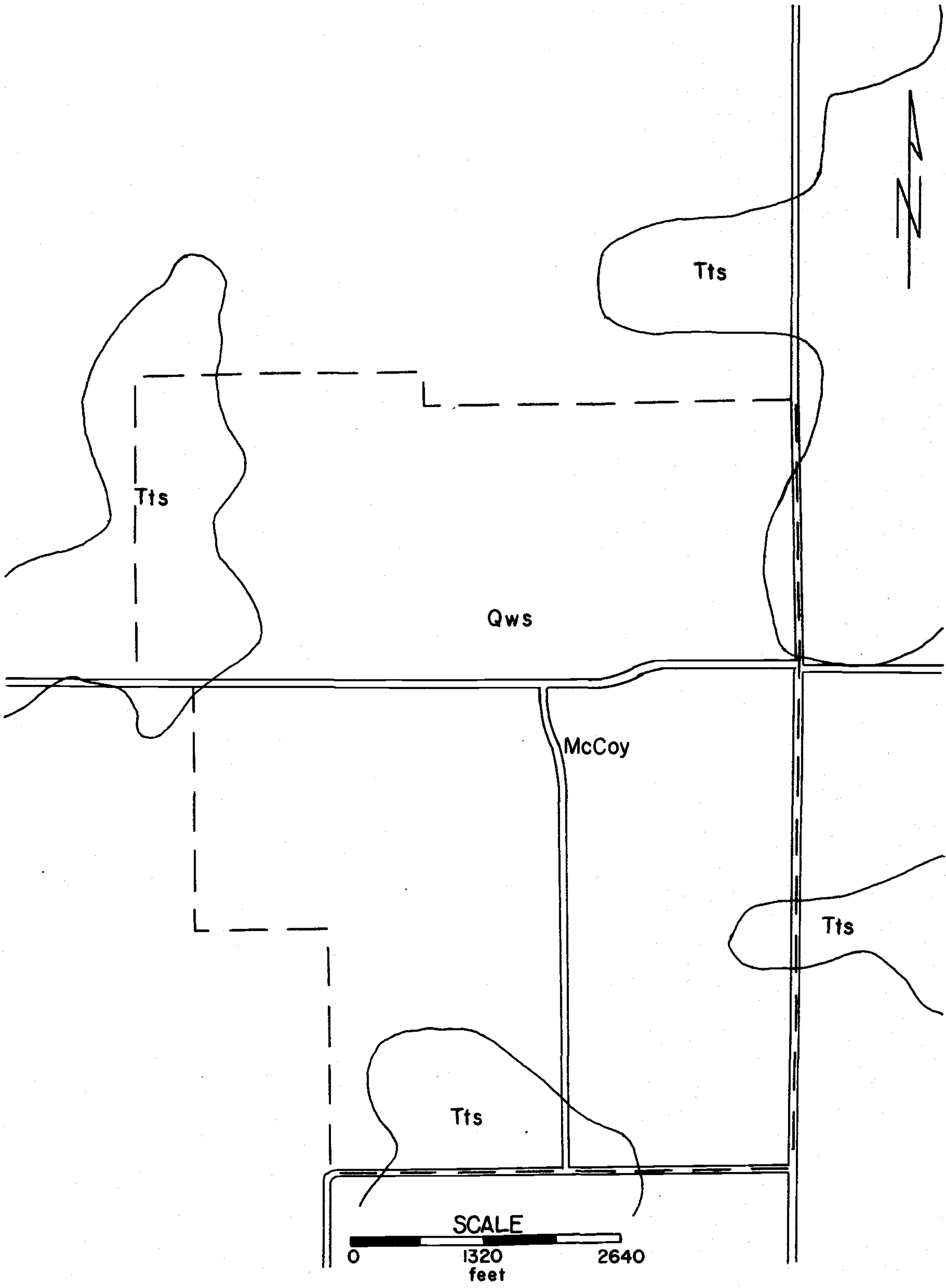

Figure 5. Geology of the McCoy area (12). Tts = Tuffaceous marine sedimentary rock (Oligocene); Qws = Willamette Silts.

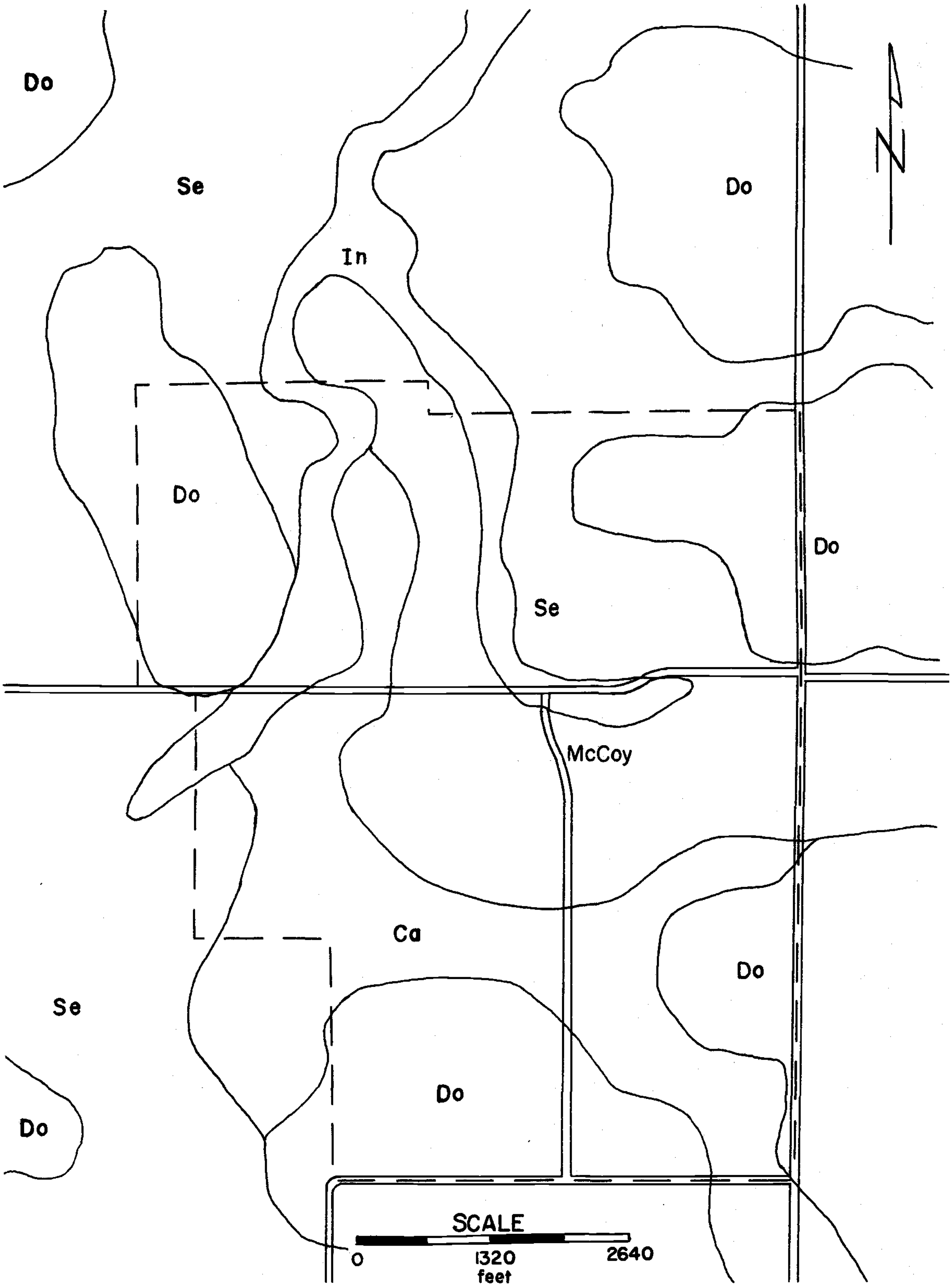

Figure 6. Geomorphic surfaces in the McCoy area. Enlarged from the geomorphic map of the Willamette Valley (16). Ca = Calapooyia; Do = Dolph; In = Ingram; Se = Senecal surfaces.

relief and organization of drainages with little incision" (16). Winkle, an intermediate surface between Senecal and Ingram, began to be formed between 5,250 ± 270 (78) and 12,240 ± 330 years ago (45). It has not been recognized in the area. Because it is topographically higher, the minimum age of Senecal must be greater than that of the next younger Winkle surface and is beyond the reach of radiocarbon dating, ". . . late Pleistocene age is reasonable" (16).

The nearly flat areas of the valley terrace are representative of the Calapooyia surface. Its major characteristic is an "absence of appreciable local relief. . . . [the] maximum difference in elevation usually does not exceed 2 or 3 feet" (16). Since the surface extends beyond any of the strata of the Irish Bend Member and yet includes soils of the Dayton and Concord series, in which is the Malpass Member, "it must be concluded that the . . . surface is . . . younger than the Willamette Silts" (16). Glenn gives a possible maximum age of 34,410 ± 3,450 years.

The oldest surface of the study area is represented by the hills and their rounded slopes. This, according to Balster and Parsons (16), is the Dolph surface and is characterized by

> extensive flats . . . [that] have been dissected to form a rolling topography . . . the small valleys and their side-slopes that have been formed by dissection of the flats are also included. . . . The age of the Dolph surface should be considered to be middle Pleistocene (16).

Climate

The Willamette Valley is in a humid, microthermal province with a summer period of moisture deficiency (93). The average annual temperature in the McCoy area is about 52 degrees F (11°C). Average temperatures in January are 37° F (3°C) and for July 66° F (19°C). The mean annual precipitation is approximately 45 inches (114 cm). Average snowfall is about 6 inches (15 cm).

There are no weather recording stations in the Ash Swale-Salt Creek drainage basin; four nearby stations were selected as representative. The above data for the McCoy area are approximations based on data from three stations in Polk County and McMinnville in Yamhill County (Figure 1). Average temperature and precipitation data for these stations are given in Table 1.

Crops and Present Vegetation

The native grasses of the South Yamhill River basin have been replaced by introduced grass species and crops. For the most part, the oak groves and oak openings are gone. A few old oak sentinels remain on the crests of the hills and on the valley terraces. Square-bordered, thickly populated oak groves are less than 100 years old and have an understory of wild roses.

The principal crops are winter wheat, barley, and oats with common and perennial rye grass, hairy vetch, and crimson clover grown for seed (97). There are a few cherry and prune orchards. Apples are grown in home gardens. Some farms have small herds of sheep and cattle that graze on pastures. Most hay is cut from clover and timothy or alfalfa.

Table 1. Average Temperature and Precipitation Data (53).

	Dallas		Eola Station		McMinnville		Wallace Orchard	
Month	Temp. F	Ppt. In.	Temp. F	Ppt. In.	Temp. F	Ppt. In.	Temp. F	Ppt. In.
Jan.	36.7	7.7	37.2	6.0	37.3	6.3	38.2	6.2
Feb.	41.0	7.4	39.6	5.8	42.2	5.9	41.7	4.8
March	44.5	5.3	45.7	4.9	46.0	4.7	46.1	3.7
April	49.8	2.7	49.5	2.8	51.3	2.1	49.8	2.7
May	55.4	2.1	54.4	1.9	57.1	1.8	54.7	1.9
June	59.9	1.3	59.6	1.3	61.2	1.2	60.4	1.3
July	65.1	0.3	64.5	0.4	66.4	0.4	65.6	0.4
August	64.2	0.5	64.9	0.4	65.6	0.3	65.2	0.5
Sept.	61.3	1.3	59.7	1.6	61.9	1.5	59.9	2.0
Oct.	52.9	4.0	51.6	3.2	53.5	3.7	52.6	2.8
Nov.	44.0	7.5	43.1	4.8	44.5	6.8	44.4	6.1
Dec.	40.5	8.7	39.6	6.3	41.3	7.9	39.2	6.0
Annual	51.3	48.8	50.8	39.4[a]	52.4	42.6	51.5	38.4[a]

Elevations:

Dallas, 325 feet; Eola Station, 500 feet; McMinnville, 150 feet; Wallace Orchard Station, 173 feet.

[a] The Eola and Wallace Orchard Stations are in the rain shadow of the Eola Hills.

FIELD PROCEDURES

The soils in the area were mapped by field investigation and photo interpretation (9). Typical profiles were described and sampled for laboratory analysis. Short, close-interval transects were made to study the transitions between soils, thicknesses of strata, and contacts between geomorphic surfaces. Comparisons were made between soils and surfaces in the study area and in nearby (Monmouth), as well as distant (Corvallis), areas of the Willamette Valley in order to verify the accuracy of interpretations of the data obtained.

The geomorphic surfaces were mapped by field observations and use of topographic and planimetric maps. The nomenclature used conforms generally to the names and definitions of the surfaces defined for the Willamette Valley by Balster and Parsons (17). Following Ruhe's (85, p. 5) definition of geomorphic surface in regard to mapability, the detail was increased and the four surfaces in Figure 6 were delineated.

The hill in the southeast corner of the area was chosen to study the stratigraphy and soils of an older landscape. Deep auger holes were bored at intervals of about 175 feet along two parallel lines about 500 feet apart. Differential elevations were run, and depths to the different strata, soil materials, and the underlying sandstone or to 21 feet, were recorded.

LABORATORY PROCEDURES

Particle-size distributions[2] were determined by a pipette method. Bulk density determinations were made on paraffin-coated clods (20).

Soil pH values were obtained from a saturated paste with a Beckman Zeromatic pH meter (80). Organic matter percentage, cation exchange capacity, and exchangeable bases were determined by the methods used at the Oregon State University Soil Testing Laboratory (1). Exchangeable acidity was obtained by following the procedure first published by Peech _et al_. (72). Base saturation and calcium-magnesium ratios were calculated from the data obtained from the analyses above (80).

In addition, grain mounts were made of selected soil horizons (23, 83).

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[2] Descriptions of the laboratory procedures are in Appendix C.

RESULTS AND DISCUSSION

Stratigraphy

Two transects of deep auger holes across the southeastern hill of the study area revealed the strata and rock shown in Figure 7. The reddish brown, brown, gray, and blue clays are on the Oligocene sandstones that form the core of the hill. In these sections, the clays are a total of one and one-half to six and one-half feet thick. They may be remnants of soils similar to the "red hill soils" of western Oregon (14, 69). The brown to blue colors of some of the clays are indicative of increasing iron reduction produced by poor aeration. The "clays" include textures of clay, clay loam, silty clay, and silty clay loam. They contain up to 10 percent medium to coarse sand and fine rounded pebbles, as well as some dark mineral grains, mostly in the lower levels of the strata. Some of the pebbles are quartz and quartzite. There are reddish brown clay films in the clay and in rock fractures below. Sandstone fragments and clay are mixed at the lower boundary. The clay resembles the paleosolic Diamond Hill Member of the Rowland Formation (17) in the southern Willamette Valley.

The brown silts lie unconformably on the clays and have a clear lower boundary. The silts are coarsely stratified pale brown to brown, micaceous silt loam to silty clay in layers from six inches to three or

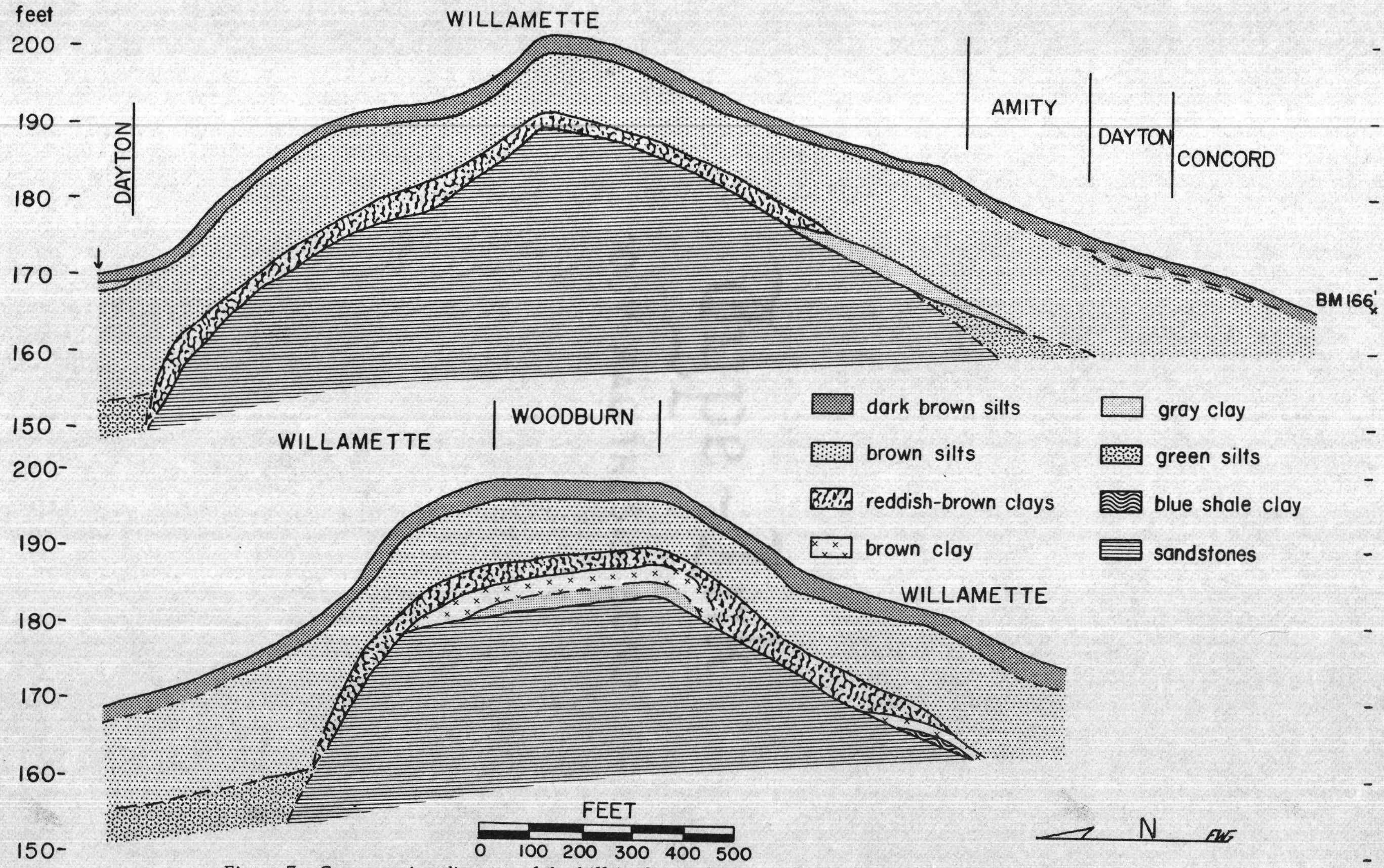

Figure 7. Cross-section diagram of the hill in the southeast quadrant of the study area showing the major strata. Arrow shows point of connection with cross-section in Figure 8.

more feet thick. The silts are from seven and one-half to thirteen and one-half feet thick over the clays and at least twenty-one feet thick, extending into the green silts, under the valley terrace (Calapooyia and Senecal surfaces). The green color of the silts below the water table is a a product of reducing conditions; otherwise, the silts are the same as the brown silts. The silts could be erosion products of the mica-rich Tyee Formation in the Coast Ranges as suggested by Balster and Parsons (17). The upper boundary is clearly defined in either of two ways: by the gray clay above (Figure 8) where present on the valley terrace, or by a pedogenetic zone of illuviated brown and reddish brown clay films on ped faces and in pores. The clay films are most easily observed in the field in Willamette soils, less so in Woodburn, and are rather obscure in Amity soils. The increasingly poor drainage conditions reduce color contrasts and, perhaps, aid in degradation. The films are evident in the IIIC horizons of Concord and Dayton soils after drying. Also, in digging or probing, the brown silts seem to be more dense than the dark brown silts above. This impression, however, is not corroborated by bulk density data in Appendix D.

These bedded brown silts strongly resemble the Irish Bend Member of the Willamette Formation (17), which is described as "faintly bedded, micaceous, silty sediments . . . [with] well-defined upper and lower boundaries." Balster and Parsons (17) also comment

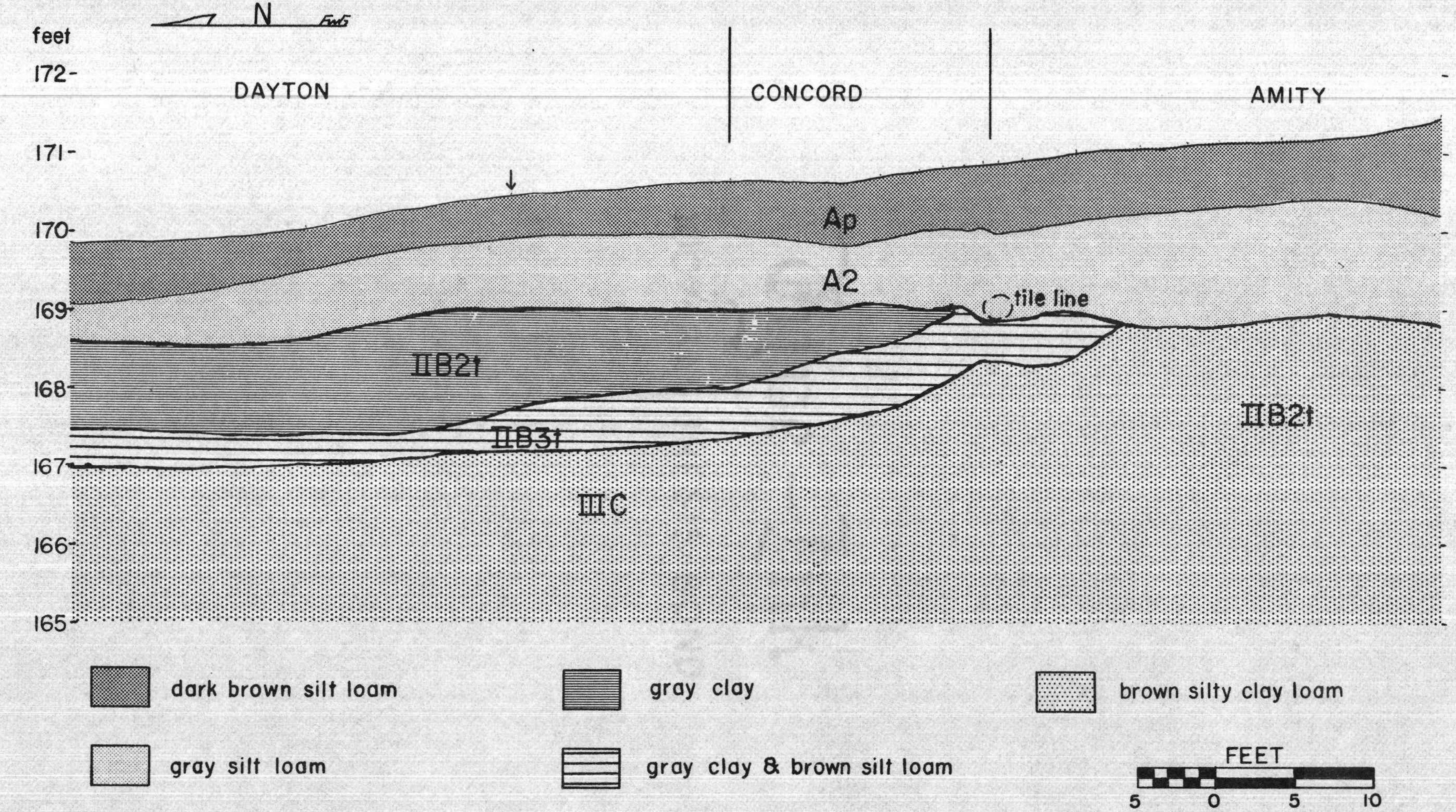

Figure 8. Cross-section diagram of strata at the juncture of valley terrace and rounded hill. Arrow shows positions of this site in relation to hill in Figure 7.

that "the pale gray silts that mantle many of the higher geomorphic surfaces" should be excluded from the Irish Bend Member. It is not because "the pale gray silts physically lie above," whereas the "zero edge of the Irish Bend Member lies beneath," the upper members of this formation (17) but that the "pale gray" silts seem to be equivalent to the Greenback Member, and they mantle the higher surfaces as dark brown silts. The faintly bedded brown silts (Figure 7) have characteristics different from the "pale gray silts" (17).

The Malpass Member is the "massive, gray clay . . . that ranges from a few inches to as much as three feet thick" (17). This deposit is not present in all parts of the valley terrace but is restricted to old swales and flats, those formed before Malpass deposition. In Figure 7, this member is the upper deposit (68) of gray clay in the top cross-section and is also shown in Figure 8. The two figures join where indicated by the arrow.

The gray clay is dense, cracks on drying into large polyhedral peds similar to coarse prisms, has slickensides, contains iron-manganese segregations, and has few to common fine yellowish brown mottles. This layer is the IIB2t horizon in the Dayton soil profile (62, 68). The origin of the Malpass material has not been determined, but it may be clay similar to that in soils of higher surfaces (67) or weathered shales and siltstones.

The dark brown silts mantle the hills and lie unconformably on the brown silts. In addition to the differences in color, texture, and apparent density, a major criterion for the recognition of the boundary between the two silts is the occurrence of the aforementioned illuviated brown and reddish brown clay films. From the hill shown in Figures 7 and 8, the dark brown "silts" merge downslope into the dark brown and gray silt loams of the Greenback Member that lie on the gray clay of the Malpass Member. The transition between surfaces is gradual, the dark brown color becoming progressively more gray with decreasing elevation and increasingly poor drainage. The gray silty material, where it overlies Malpass, is obviously Greenback. Without the intervening Malpass, the surficial silts on both the terrace and the hill are dark brown and lie directly on silts similar to the Irish Bend Member (68). The dark brown silts of the hill are, except for color, quite similar to the Greenback over Malpass and cannot be distinguished from the Greenback on Irish Bend. Differences, such as color and acidity between the surficial silts are probably due to pedogenetic processes rather than origin or time of deposition.

On the basis of the foregoing descriptions, it seems quite likely that the upper strata of the hills and valley terraces should be recognized as the Greenback, Malpass, and Irish Bend Members of the Willamette Formation with the Malpass restricted to the valley terrace. Whether or not the reddish brown, brown, and gray clays are the Diamond Hill Member of the Rowland Formation has not been determined conclusively in this area. The clays have many of the characteristics described by Balster and Parsons (17) for the Diamond Hill Member and are below strata like those of the Willamette Formation. The clays are not on Linn Gravel as at the type location and contain few rounded pebbles. This is to be expected since there are few possible sources for gravel west of the Eola Hills in the northern Willamette Valley. There are sandstone fragments, presumably from the hill core, mixed in the clays and these could be equivalent to the gravel of other areas. Stratigraphic sequences similar to Figure 7 have been observed in several other hills in Polk County, all below elevations of about 250 feet above present sea level.

Between elevations of approximately 250 and 400 feet, there is an uphill-thinning deposit of grayish brown to dark brown silts over a variety of materials such as weathered gravel, reddish brown clays, and saprolitic sandstone or shale. There seem to be no brown silts, corresponding to Irish Bend, above 250 feet in Polk County. The dark brown silts are usually less than three feet thick. Allison (2) included them with Willamette Silts. Balster and Parsons (17) have excluded these from and considered them to be older, not younger, than the Irish Bend Member in assigning them exclusively to the Dolph surface. They also remark:

> The pale gray silts on the Dolph surface are characterized by lack of bedding features and a higher percentage of sand. . . . Contorted 'slump structures' may usually be

> observed on a freshly exposed surface . . . but . . . never . . . in the Irish Bend Member. . . . The erratic rocks (Allison, 1935) of the valley tend to be more commonly associated with the pale gray silts. . . .

Previously, Balster and Parsons (16) had noted that "near McCoy, thick massive or contorted silts with numerous erratics" obscure older landforms and materials. One such location is a road cut below the Bethel cemetery about one and one-half miles east and three-quarters mile south of McCoy. In the northwest corner of the cemetery, at 240 feet above sea level, a deep, hand-augered hole revealed 21 inches of dark brown silt over brown silts down to sandstone at 12 1/2 feet. There are no brown or reddish brown clays at this point. The brown silts in the road-cut are sufficiently bedded that the contortions are apparent on close examination. Ruhe (85) notes that contorted bedding indicates some kind of solifluction, a process that requires declivity, or a large mass bearing unequally on fluid sediments. In the Willamette Valley, contortions in the silts that may be caused by declivity are on hillsides while there is no evidence of contorted bedding in the silts of the nearly level terraces.[3] Erratics in bedded silts on a Dolph surface north of Dayton caused distortions in the silts (4). The continuous strata curve below and above the erratic pebbles and cobbles embedded in the materials.

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[3] R. B. Parsons, personal communication.

At Bethel and around McCoy, the pale gray silts of Allison and the contorted Dolph silts of Balster and Parsons are not the same. Instead, they appear to be the Greenback and Irish Bend Members of the Willamette Formation, respectively, mantling an older surface, which either was bed rock or was a reddish brown soil on the rock.

Therefore, it seems that the strata under the major geomorphic surfaces in the Ash Swale portion of the South Yamhill River Valley are little different from those of the valley terrace of the southern Willamette Valley, particularly near Corvallis. The youngest of these strata is the Greenback Member, usually associated with Dayton soils.

Geomorphology

A geomorphic surface is "a portion of the land surface that is specifically defined in space and time. It . . . may include many landforms . . . [and] must be a mappable feature, . . . delineable on . . . maps" (85).

Methods of determining the relative ages of geomorphic surfaces involve the concepts that topographically higher levels are older than lower levels and that stratigraphically higher deposits are usually younger than deeper deposits. By the use of these concepts, it was determined that the Eola surface is relatively older than the Dolph surface and that the Dolph is older than the Calapooyia surface (16). The materials underlying the Dolph and Eola surfaces of the Willamette

Valley are older than the materials under the Calapooyia surface. Relative methods were used because the most accessible absolute method, radiocarbon dating (55), has been limited to less than 50,000 years and usually is not available for greater than 40,000 years. Thus, depending on the laboratory and the sample, a date of greater than 37,000 years is radioactively "dead" and may be from a sample that is 100,000 years old.

Glenn (45) obtained several radiocarbon dates in his study of "Willamette Silts." The sample from the base of the silts on scoured conglomerate of the Troutdale Formation (89) is dated at greater than 37,000 years. This date indicates that the conglomerate is older and the silts are younger than some point in time previous to about 37,000 years B.P. (before present). Another sample from within extensively oxidized and weathered gravel of an old flood plain south of Salem (44) is 34,410 ± 3,450 years old. This is about the time of the end of early Wisconsin (Bull Lake) glaciation (81). Glenn asserts that "gravels in the floodplain of the Willamette River near the southwest end of the Labish Channel are similar to the exposed Mill Creek floodplain gravels and are correlated with them" (45). Then, citing Piper's (73) report of waterbearing gravels beneath the silts, he concludes that the Mill Creek "gravels underlie Willamette Silt," (45) and that the date is a maximum age for the Willamette Silt. Unfortunately, the gravels are under a depositional geomorphic surface that is intermediate in age between Senecal and Ingram (16); also, the gravels were not traced directly beneath the Irish Bend Member under the nearby Senecal surface. Because of these inconsistencies, Balster and Parsons could only conclude that the intermediate (Winkle) surface is less than about 34,410 years old (16), a time after which sedimentation under the what is now the surface may have begun. Samples from the base of the Labish Channel peat are 11,000 ± 230 years old (45), and similar deposits in western Washington are between 10,200 ± 500 and 13,650 ± 550 years old (82). A date within the Onion Flat section is 12,240 ± 330 years B.P. (45). A relatively warm, dry climate during this time favored initiation of growth of materials that subsequently formed the peats (50). The dates encompass the Twocreekan interstade in Wisconsin (37), are after the Vashon stade of Puget Sound (26), and are within middle Pinedale time in the Rocky Mountains (81). It can be concluded that about 13,000 years is the minimum time since the beginning of downcutting into the sediments beneath the Senecal and Calapooyia surfaces.

A chronology of development of geomorphic surfaces is suggested for the Willamette Valley. Beginning in the Sangamon, more than 70,000 (50) and as many as 100,000 years B.P. (27), the red soils of the Eola surface developed under conditions favoring an oxidized, relict soil (86, 92). Soil development continued during the downcutting of the landscape during the early Wisconsin, Bull Lake stades (81), when the Dolph surfaces began to be formed. Some red soils on Dolph and the Diamond Hill Member (17) are representative of these times. Lowering of sea level 55,000 to 50,000 years B.P. (36) and before 47,000 years ago (33, 46), would have aided the downcutting.

From late Bull Lake and through middle Pinedale time, there were floods on the Columbia River from Lake Missoula (21, 65) and probably from other lakes (39, 57, 58, 59, 81) that brought sediments into the Willamette Valley. These are the Willamette Silts (2). The Willamette Valley filled to a maximum of about 250 feet above present sea level with the stratified Irish Bend Member of the Willamette Formation (17) by flood deposits alternating with little downcutting during drainage of the basin. Glenn (45) considers that there were many floods bringing water and sediments into the basin as proposed by Bretz, et al., (22) and Allison (4, 5). Then, "After weathering of the Willamette Silt and after dissection of the silt surface, a climactic Columbia River flood larger than any previous floods entered the Willamette Valley" (45, p. 193).

Sometime between incision of the Willamette Silts--Irish Bend Member--and deposition of the materials containing many erratics, or in which many erratics are now embedded, two major events took place. The earlier was the deposition of the Malpass Member, now on the more level, Calapooyia and Senecal, surfaces in the valley (17) and in swale positions immediately below the flats of the valley terrace. Because of the fine-textured nature of the material, it must be assumed that the deposition was in very still water, that is, not an in-and-out flood of short duration. A date of deposition of this material has not yet been established, except that it is older than 13, 500 years.

The later event was the deposition of pyroclastic materials (63) with materials that form the lower part of the Greenback Member in both Woodburn and Dayton soil profiles. Whether these were an air-fall ash bed, deposited on deep water, or deposited in eastern Washington and Oregon to be gathered with other materials and brought into the basin in a flood has not been determined. Flood water deposition is considered possible because Glacier Peak spread ash over eastern Washington more than 12, 000 years B. P. (38), and other volcanic activity provided material for ash beds in eastern Oregon 9, 000, 29, 000, and 30, 000 years ago (3). The last flood, or floods, capped all land forms with a "mantle of ash-gray to buff silt, containing erratic fragments, . . . in decreasing thickness to an elevation of about 400 feet above sea level" (4). The last catastrophic flood on the Columbia River across the Columbia Plateau seems to have occurred about 13, 000 years ago (81).

Both before and after deposition of the Malpass sediments, the surface of the valley terrace and adjacent lands continued to be modified by local erosion and by downcutting of through-flowing streams. Large, flat areas, destined to become part of the Calapooyia surface, remained flat, eroding mostly around the edges. These edges and sloping areas of the interfluves adjacent to larger streams developed steeper gradients and well-defined drainageways and have been mapped as the Senecal surface.

The low hills of the Dolph surface above 250 feet received neither Malpass nor much Irish Bend sediments. The hills and swales below 240 feet were covered to various depths by the Irish Bend Member. The Dolph surface is also recognized where the form of the older hill is still apparent. Where that land form is so completely cloaked and its appearance modified by younger material subject to more recent earth-shaping forces, a separate and distinct surface has been formed. Because the sediments under the Calapooyia surface were probably deposited in deep water, general elevations above sea level are important in differentiating surfaces. By definition (84), the Dolph surfaces above 400 feet can be considered relict paleo-landscapes. The Dolph surfaces between about 250 and 400 feet are both buried and exhumed paleo-landscapes, conforming to the original configurations, depending on the thickness of materials remaining after more recent erosion. Most of the Dolph surfaces below about 250 feet are buried or were entirely removed by erosion in post-Dolph time. Some remnants of exhumed paleo-landscapes are as low as 230 feet, one about two miles south of McCoy, while some buried surfaces are as high as

260 feet, the Quad at Oregon State University in Corvallis.

Hills and old terraces from 180 to 260 feet in elevation have been mapped as Dolph or Quad surfaces, the difference often dependent on relief above the main valley floor and whether or not the Quad represented a pre-Malpass, uplifted surface (16). The crests of the low hills near McCoy and Perrydale are about 200 to 240 feet above sea level. The Senecal and Calapooyia surfaces nearby are graded from about 200 feet near Bethel and about 170 feet at Holmes Gap to about 160 feet near Amity. These surfaces represent the main valley terrace, planed and grooved to conform to a base level present before the Malpass clay was deposited in the swales and on the flats. Some of the drainageways presently on the same grade as the Ingram surface had their banks cut during development of the Senecal surface.

The pre-Irish Bend relief of the Ash Swale drainage was greater than that of the main valley. This was because of the incompetency of the streams eroding the area and the small size of the watershed. Thus, where the main valley was carved and eroded until only the most resistant hills remained, in this area sedimentary hills of various sizes and forms remained at the end of Dolph surface time. Then began the deposition of Irish Bend sediments.

Where water-suspended sediments are deposited over irregular topography, a differential in thickness and compaction develops.

The deposits covering the topographic highs are thinner and, after loss of water, are less compact than the materials filling the topographic lows (19). In addition, density currents carry the more turbid sediments into lower areas. The coarser materials, coarse silts and sands, settle out more quickly than the fine silts and clays, which are carried down hill as density currents in otherwise still water (18). The fine-textured layers emphasize the bedding in the filled lows, while there is less apparent bedding on the highs. Deposits on high places tend to be coarser than the sediments in low places (96). There are presently about 35 feet of Willamette Silts over gravels between McCoy and Ash Swale[4] and thinner deposits on the hills (Figure 7).

The last of the Willamette Silts was deposited, probably an Irish Bend layer or the Malpass Member, preceeding several episodes of downcutting and deposition. These episodes formed several younger geomorphic surfaces. Of these, only Ingram is in the study area in delimitable quantity. The Ingram surface is younger than 5,250 ± 270 years and has been correlated with surfaces dated at 555 ± 100 years B. P. (16). The other post-Pleistocene surfaces were not formed because there was limited downcutting as a result of the small watershed and a higher local base level than for other regions in the

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[4] Vernon Maxon--personal communication.

Willamette Valley; the silts have a reverse grade north of the South Yamhill River (16, 66), indicating post depositional uplift. Although the stream channel itself is Horseshoe, the youngest surface recognized in the Willamette Valley, Ingram is the youngest surface mapped in the area (16).

Since the Greenback was deposited over the three higher surfaces in the area, there has been little removal of materials by sheet or gully erosion. This is shown by the uniform thickness of the dark brown silts over the brown silts in the upper cross-section in Figure 7. These sediments, probed at 30-foot intervals along a transect of the north slope, have a thickness varying less than two inches.

The hill diagramed in Figure 7 has previously been identified as part of the Dolph unit (16). The present slope of the hill probably dates from the same time as the Calapooyia unit, rather than being middle Pleistocene. The upper limit of the reddish brown clays represents the (buried) Dolph surface in this hill.

Since this hill is younger than Dolph and yet is obviously not a part of the Calapooyia unit because of the disparity of local relief between and within the surfaces, and since other highs of like elevation exhibit similar stratigraphy, it is proposed that a new surface, the Bethel unit, be recognized in order to include the silt-mantled "youthful-Dolph" surface. As an addition to the descriptions of the geomorphic mapping units in Appendix A (16), the following is suggested for the Bethel unit in the Willamette Valley.

Bethel unit. The Bethel unit is morphologically similar to the topographically higher Dolph unit. The Bethel unit is not extensive and may be restricted to the Yamhill River and Tualatin River valleys. The type locality is the collection of hills around McCoy and between that town and the town of Bethel.

The rolling hills of the Bethel unit are topographically above the Calapooyia surface and are in a position that is similar to the Quad unit, which has been considered to be an upfaulted area of the Calapooyia surface (16). The Bethel surface is comprised of landforms that are erosional remnants of an older surface cloaked by onlapping sediments. Deep incision of the Yamhill and Tualatin River Valleys was incomplete and the resultant highs, covered by, probably lacustrine, deposits, are present because of the persistence of protected remnants of the Dolph surface. The deposits are similar to the materials of the Irish Bend and Greenback members of the Willamette Formation (17). Erratics (4, 6) are on and within the sediments associated with the Bethel unit. The clayey Malpass deposits present on the Calapooyia surface are absent on the Bethel because the fine sediments were deposited on topographic lows. The higher elevations, the characteristic configuration, and the different deposits that underlie the Bethel surface, as contrasted to the Calapooyia and Quad surfaces, justify it as a unit for mapping.

The Bethel unit is characteristically of round hill form with an occasional level top. The hills have moderate relief and the gently sloping sides are graded to the next lower surfaces, Calapooyia and Senecal. Elevations of the hills above these surfaces of the valley terrace range from about 10 to 40 feet. Although the mantling sediments conformed to the underlying rock hill in a gross manner, the surface configuration developed as a result of erosion after the deposition of the Irish Bend sediments. Side valley alluvium of younger age is on a few of the hill flanks within the Bethel unit. It consists of reworked "dark brown silts" (Figures 7 and 8). With the exception of flats having nearly centripetal drainage on a few of the hill tops, precipitation drains freely from the surface, although not in a well-defined drainage system.

The Bethel unit is about the same age as the Quad surface, which is defined as being somewhat older than the Calapooyia unit. The older Dolph unit has portions that are similar to the Bethel unit and that seem to extend under the sediments that form the Bethel surface. In addition to its placement in a vertical sequence, the state of weathering of the materials under the surface places the formation of the Bethel unit at about the same time as that of the Quad and Calapooyia units. This concept indicates a late Pleistocene age for the Bethel surface.

In the Dolph unit description (16) there are some statements that now should be considered more pertinent to the Bethel unit description. The sentence beginning "Farther north, near McCoy, . . ." is more appropriately applied to the Bethel unit description. Further, the "More rounded landforms [that] characterize the Dolph surface in the northern parts of the valley," could be investigated to see if they are old enough for Dolph or if they are of an age to be included with the Bethel surface.

At this point, it is appropriate to differentiate between unit and surface. The unit is that delimited body on a map that may contain inclusions of small areas of other than the geomorphic surfaces by which it is named. A surface is specifically defined in space and time, and it is mappable. This definition by Ruhe (85) makes the two rather synonymous.

The map of the geomorphic surfaces in the study area (Figure 9) uses the definitions of the mapping units (16) given in Appendix A, substituting the suggested revisions above. It is quite similar to the map in Figure 6 except for the substitution of Bethel for Dolph.

Soils

Descriptions and Delineations

Following the summary of each of the soil series recognized in the area are descriptions of the mapping units delineated in Figure 10.

Figure 9. Geomorphic surface map of the McCoy study area. Be = Bethel unit; Ca = Calapooyia unit; In = Ingram unit; Se = Senecal unit.

Only officially recognized series have been used. Profiles representing soils that do not have all of the qualifications of the series descriptions have been named as variants. The variants were not delineated on the maps. All of the sampled profiles are described in detail in Appendix B, and their locations are shown on the map (Figure 10).

Amity series. Amity soils are deep, somewhat poorly drained, moderately fine-textured soils formed in silty alluvium on the Senecal and Calapooyia surfaces (16). They are in local depressions or against the lower slopes of hills where drainage is impeded. The series is a member of the fine-silty, mixed, mesic family of Argiaquic Xeric Argialbolls. The soils have an A1, A2, IIB2t, IIC horizon sequence.

Am--Amity silt loam. Amity silt loam is on the valley terrace at the footslope of the rounded hills and in depressions at the head of, and adjacent to, the depressed drainageways tributary to Ash Swale. Slopes are from 0 to 3 percent. The unit includes the gradation from Woodburn soils and to Concord soils as shown in Figure 8.

Amity soils have a very dark brown[5] silt loam A1 horizon 12 to 16 inches thick over dark gray silt loam A2 horizons 0 to 8 inches thick. The IIB2t horizon is dark brown and grayish brown silty clay loam with common moderately thick, but indistinct, clay films on ped

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[5] All colors given are for moist soil. All textures are field determined.

faces. The IIC horizon, below about 40 inches, is brown silty clay loam, silt loam, and silty clay in poorly to well defined strata. There are mottles throughout the solum.

Concord series. Concord soils are deep, poorly drained, fine-textured soils formed in modified silty and clayey strata on the Senecal and Calapooyia surfaces (16). They are in local depressions and on level terraces. The series is a member of the fine, montmorillonitic, mesic family of Typic Ochraqualfs. The soils have an A1, A2, IIBt, IIIC horizon sequence.

Co--Concord silt loam. Concord silt loam is on the level valley terrace and in depressed drainageways tributary to Ash Swale. Slopes are from 0 to 2 percent. The unit includes the gradation from Amity or Woodburn soils to Dayton soils as shown in Figure 8.

Concord soils have a very dark grayish brown silt loam A1 horizon 5 to 8 inches thick over a dark gray silt loam A2 horizon 6 to 10 inches thick. The IIB2t horizons are dark gray silty clay with prismatic and subangular blocky structure. The IIIC horizon, below 30 to 36 inches, is grayish brown to brown, silty clay loam, silt loam, and silty clay in poorly to well defined strata and has thin, indistinct clay films on ped faces.

Dayton series. Dayton soils are deep, poorly drained, fine-textured soils formed in modified silty and clayey strata on the Calapooyia and Senecal surfaces (16). They are in local depressions and on level terraces. The series is a member of the fine, montmorillonitic, mesic family of Typic Albaqualfs. The soils have a A2, IIBt, IIIC horizon sequence.

Da--Dayton silt loam. Dayton silt loam is on the level valley terrace and in depressed drainageways tributary to Ash Swale. Slopes are from 0 to 2 percent. The unit includes the gradation from Amity or Concord soils as shown in Figures 7 and 8.

Dayton soils have a dark grayish brown, silt loam Ap horizon 5 to 9 inches thick over a dark grayish brown and grayish brown silt loam A2 horizon 4 to 10 inches thick. The IIB2t horizon is dark gray and dark grayish brown clay and silty clay with prismatic structure and thin continuous clay films or pressure faces. The IIIC horizon, below 30 to 36 inches, is grayish brown silty clay loam, silt loam, and silty clay in poorly to well defined strata and has dark grayish brown clay films in pores and on ped faces.

Wapato series. Wapato soils are deep, poorly drained, moderately fine-over fine-textured soils formed of slightly modified silty alluvium on the Ingram surfaces (16). The soils are on bottomlands and basin-like areas. The series is a member of the fine-silty, mixed, noncalcareous, mesic family of Fluventic Haplaquolls. The soils have a A, B, C horizon sequence.

Wa--Wapato silt loam. Wapato silt loam is on the stream terrace and flood plain of the major drainageways, including Ash Swale.

Slopes are from 0 to 1 percent. The unit varies in surface texture from silt loam to silty clay loam.

Wapato soils have a very dark gray, silt loam Ap horizon 10 to 16 inches thick over a very dark gray and dark grayish brown silty clay loam B2 horizon. The IIC horizon, below 30 inches, is dark gray and grayish brown stratified silty clay and heavy silty clay loam with gray pore fillings. There are mottles throughout the solum.

Willamette series. Willamette soils are deep, well drained, moderately fine-textured soils formed in silty alluvium on the Senecal, Calapooyia, and Bethel surfaces (16). They are on hills, broad terraces, terrace fronts and along drainageways where the drainage is good. The series is a member of the fine-silty, mixed, mesic family of Pachic Ultic Argixerolls. The soils have a A, B1, IIB2t, IIC horizon sequence.

WiA--Willamette silt loam, 0 to 3 percent slopes. The Willamette silt loam, with 0 to 3 percent slopes, is on the nearly level valley terrace, on the nearly level hill tops, and on the gently sloping, rounded banks adjacent to drainageways tributary to Ash Swale. The unit includes soils that grade to Woodburn soils and to the variants, soils with surfaces that are not dark enough to the depths that are typical of the series.

Willamette soils have a very dark grayish brown silt loam A horizon 12 to 26 inches thick over a very dark grayish brown to dark brown silty clay loam or silt loam B1 horizon that is 6 to 13 inches thick. The IIB2t horizon is dark brown and brown silty clay loam with moderately thick reddish brown clay films on ped faces. The IIC horizon, below about 40 to 60 inches, is brown and dark brown silty clay loam, silt loam, clay loam and silty clay in poorly to well defined strata. Glei mottles, if present, are below 40 inches.

WiB Willamette silt loam, 3 to 12 percent slopes. The Willamette silt loam with 3 to 12 percent slopes, is on the gently and moderately sloping hill sides above the valley terrace and on gently sloping terrace fronts above and adjacent to drainageways tributary to Ash Swale. The unit includes soils that grade to Woodburn soils and to the variants and soils with slopes less than 3 percent.

Woodburn series. Woodburn soils are deep, moderately well drained, moderately fine-textured soils formed in silty alluvium on the Senecal, Calapooyia, and Bethel surfaces (16). They are on nearly level, broad terraces and hill tops where drainage is impeded. The series is a member of the fine-silty, mixed, mesic family of Aquultic Argixerolls. The soils have a A, B1, IIB2t, IIC horizon sequence.

Wn--Woodburn silt loam. Woodburn silt loam is in depressions and on flat areas of the valley terraces and hill tops where slopes are from 0 to 3 percent. The mapping unit includes soils with characteristics grading from those of the Willamette to the Amity series.

Woodburn soils have a very dark brown silt loam A horizon 12

Figure 10. Soil map of the McCoy study area. Sample sites, major roads, and railroad are shown. Am = Amity silt loam; Co = Concord silt loam; Da = Dayton silt loam; Wa = Wapato silt loam; WiA = Willamette silt loam, 0 to 3 percent slopes; WiB = Willamette silt loam, 3 to 12 percent slopes; Wn = Woodburn silt loam soils.

to 18 inches thick over a dark brown and very dark grayish brown silty clay loam B1 horizon. The IIB2t horizon, below about 24 inches, is dark brown, dark yellowish brown, and grayish brown silty clay loam with moderately brown and reddish brown clay films on ped faces. The IIC horizon, below 40 to 60 inches, is brown, dark brown, and pale brown silty clay loam, silt loam, clay loam, and silty clay in poorly to well defined strata. Mottles indicating restricted drainage are below 30 inches.

Morphology and Characterization

The Willamette, Woodburn, and Willamette-variant soils in the study area have similar horizon sequences. They all have A1, A3, B1, IIB2t, and IIC horizons. The soil profiles are described in Appendix B.

Amity soils differ in that they have an A1, A2, IIB2t, IIC horizon sequence. They all have a very dark grayish brown and dark brown silt loam A1 horizon with granular and platy structure, a dark yellowish brown and dark brown heavy silt loam and silty clay loam IIB2t horizon with reddish brown clay films on faces of prisms and subangular blocks, and a dark brown, dark grayish brown, and dark yellowish brown silt loam and silty clay loam IIC horizon. At the depths the Willamette group of soils have very dark grayish brown to dark yellowish brown silt loam and silty clay loam A3 and B1 horizons, the Amity soils have dark gray silt loam A2 horizons.

The Concord and Dayton soils in the study area have similar horizon sequences: Ap, A2, IIB2t, IIIC. The IIB2t horizons of the two soils are dark gray and dark grayish brown to olive gray silty clay. The IIIC horizon is dark grayish brown to olive gray silty clay loam with prominent grayish brown and olive gray clay flows in pores and few thin indistinct brown clay films on faces of ped remnants. Concord soils have a very dark grayish brown silt loam Ap horizon over dark gray A2 and AB horizons. Dayton soils have dark grayish brown silt loam Ap and A2 horizons 12 to 15 inches deep over the IIB2t horizon. The differences between these soils are the color of the Ap horizons, the depth to, and the thickness of the IIB2t horizon; the Concord soils have a darker Ap are deeper to the IIB2t, and have thinner IIB2t horizon than do Dayton soils. The A2-IIB2t horizons boundary in the Dayton soils is abrupt, not clear as in the Concord soils.

The Wapato soils have a very dark gray silt loam Ap horizon over very dark gray and dark gray silty clay loam B horizons. The IIC horizon is massive dark gray and grayish brown silty clay and silty clay loam. There are no clay films or other evidences of clay illuviation into the B horizons.

Table 2 gives the particle size data for the profile studied. All of the soils consist dominantly of silt size particles and contain only small quantities of sand. Willamette and Woodburn soils have from

Table 2. Particle Size Distribution Data of Related Soils in the McCoy Area.

			Sand %					Silt %		Clay	
Sample Number	Horizon	Depth inches	vc 2-1 mm	c 1-0.5 mm	med 0.5-0.25 mm	fine 0.25-0.1 mm	vf 0.1-0.05 mm	coarse 0.05-0.02 mm	fine 0.02-0.002 mm	% <0.002	Text. Class
						Willamette					
W-1-1	Ap	0-10	0.1	0.2	0.4	0.9	1.1	25.0	51.1	21.2	sil
W-1-2	A12	10-18	0.1	0.2	0.4	0.9	1.0	18.3	55.8	23.3	sil
W-1-3	A3	18-26	0.0[a]	0.1	0.2	0.4	1.0	24.7	50.7	22.9	sil
W-1-4	B1	26-39	0.1	0.2	0.4	1.4	2.0	28.3	50.3	17.3	sil-
W-1-5	IIB21t	39-52	0.1	0.2	0.4	1.3	2.4	23.1	47.1	25.4	sil
W-1-6	IIB22t	52-60	0.0	0.3	0.3	1.7	4.9	30.9	39.6	22.3	sil
						Willamette variant					
W-2-1	Ap	0-10	0.3	0.9	1.1	1.5	2.2	28.7	47.3	18.0	sil
W-2-2	A3	10-15	0.2	0.7	0.8	1.1	1.7	24.6	48.8	22.1	sil
W-2-3	B1	15-21	0.7	0.8	0.9	1.4	2.1	22.6	47.3	24.2	sil
W-2-4	IIB21t	21-37	0.2	0.3	0.5	1.8	4.1	21.0	49.4	22.7	sil
W-2-5	IIB22t	37-56	0.1	0.3	0.3	1.5	5.6	27.6	42.2	22.4	sil
W-2-6	IIB3t	56-65	0.1	0.4	0.3	0.9	6.7	35.6	35.4	20.6	sil
						Carlton-like					
W-3-1	Ap1	0- 3 1/2	0.0	0.2	0.3	0.9	1.5	26.9	49.1	21.1	sil
W-3-2	Ap2	3 1/2- 9	0.0	0.2	0.3	1.0	1.7	26.3	49.9	20.6	sil
W-3-3	A13	9-15	0.0	0.2	0.3	0.9	1.6	25.1	48.9	23.0	sil
W-3-4	A3	15-24	0.1	0.2	0.3	0.8	1.5	26.8	49.2	21.1	sil
W-3-5	B1	24-41	0.1	0.2	0.3	0.8	2.0	29.0	49.1	18.5	sil
W-3-6	IIB21t	41-52	0.1	0.3	0.4	0.8	3.3	28.7	41.3	25.1	sil
W-3-7	IIB22t	52-58	0.0	0.2	0.2	0.7	2.4	32.4	41.3	22.8	sil
W-3-8	IIC1	58-62	0.1	0.2	0.3	0.6	1.8	25.7	46.6	24.7	sil
W-3-9	IIC2	62-90	0.1	0.2	0.1	0.3	2.3	26.5	45.3	25.2	sil

Table 2 (Continued)

			Sand %					Silt %		Clay	
Sample Number	Horizon	Depth inches	vc 2-1 mm	c 1-0.5 mm	med 0.5-0.25 mm	fine 0.25-0.1 mm	vf 0.1-0.05 mm	coarse 0.05-0.02 mm	fine 0.02-0.002 mm	% <0.002	Text. Class
					Woodburn						
W-4-1	Ap1	0-4 1/2	0.4	1.0	1.2	1.5	1.9	24.0	48.8	21.2	sil
W-4-2	Ap2	4 1/2-10	0.3	1.1	1.2	1.6	2.0	23.7	49.0	21.2	sil
W-4-3	A3	10-17	0.4	1.0	1.1	1.5	1.9	22.6	48.6	22.9	sil
W-4-4	B1	17-22	0.7	1.3	1.1	1.3	1.8	26.7	45.8	21.3	sil
W-4-5	B21	22-29	0.6	1.4	1.2	1.6	2.1	23.6	47.8	21.7	sil
W-4-6	IIB22t	29-44	0.1	0.4	0.5	1.3	2.8	26.5	47.3	21.1	sil
W-4-7	IIB23t	44-62	0.3	0.5	0.6	1.2	3.3	23.7	46.5	23.9	sil
W-4-8	IIB3t	62-73	0.2	0.3	0.4	0.9	3.0	32.4	44.5	18.3	sil
W-4-9	IIC	73-87	0.1	0.4	0.4	0.8	2.3	23.5	50.3	22.2	sil
					Willamette						
W-5-1	Ap1	0- 4	0.4	1.1	1.2	1.7	1.4	18.3	52.1	23.8	sil
W-5-2	Ap2	4- 9	0.6	0.7	1.0	1.4	1.0	18.6	52.2	24.5	sil
W-5-3	A3	9-15	0.2	0.9	1.1	1.4	1.0	17.6	50.3	27.5	sicl
W-5-4	B1	15-20	0.6	1.2	1.3	1.5	1.0	17.8	52.0	24.6	sil
W-5-5	B21	20-32	1.2	2.1	1.9	2.1	0.4	20.4	51.5	20.3	sil
W-5-6	IIB22t	32-40	0.1	0.5	0.7	1.9	2.7	16.2	57.2	20.7	sil
W-5-7	IIB23t	40-56	0.0[a]	0.3	0.2	0.8	1.5	20.5	52.8	23.9	sil
W-5-8	IIC	56-70	0.1	0.1	0.1	0.6	2.1	21.3	53.3	22.4	sil
					Willamette variant						
W-6-1	Ap1	0- 4	0.2	0.6	0.7	1.3	2.0	28.1	49.3	17.8	sil-
W-6-2	Ap2	4-9 1/2	0.3	0.5	0.8	1.3	1.9	23.5	51.4	20.3	sil
W-6-3	A3	9 1/2-15	0.2	0.4	0.6	1.1	1.6	24.0	49.3	22.8	sil
W-6-4	B1	15-20	0.2	0.5	0.7	1.1	1.6	24.0	48.1	23.8	sil
W-6-5	B21t	20-29	0.1	0.5	0.6	1.3	2.1	20.8	48.1	26.4	sil
W-6-6	IIB22t	29-44	0.2	0.4	0.7	2.2	4.0	25.1	52.0	15.4	sil-
W-6-7	IIB23t	44-59	0.3	0.5	0.6	1.5	4.0	28.1	42.2	22.8	sil
W-6-8	IIC	59-78	0.1	0.2	0.1	0.4	2.0	26.1	47.8	23.3	sil

Table 2 (Continued)

			Sand %					Silt %		Clay	
Sample Number	Horizon	Depth inches	vc 2-1 mm	c 1-0.5 mm	med 0.5-0.25 mm	fine 0.25-0.1 mm	vf 0.1-0.05 mm	coarse 0.05-0.02 mm	fine 0.02-0.002 mm	% < 0.002	Text. Class
					Willamette variant						
W-7-1	Ap1	0- 5	0.1	0.6	0.7	1.0	1.2	27.7	49.4	19.3	sil
W-7-2	Ap2	5-10	0.3	0.7	0.9	1.4	1.5	17.9	57.4	19.9	sil
W-7-3	A3	10-15	0.1	0.5	0.7	1.0	1.1	23.9	57.5	15.2	sil-
W-7-4	B1	15-20	0.2	0.6	0.8	1.1	1.3	23.2	51.3	21.5	sil
W-7-5	B21	20-30	0.1	0.5	0.6	1.0	1.2	20.3	50.7	25.6	sil
W-7-6	IIB22t	30-36	0.0[a]	0.5	0.3	0.8	1.7	19.6	49.9	27.2	sicl-
W-7-7	IIB23t	36-48	0.2	0.6	0.3	0.9	1.9	20.3	49.8	26.0	sil
					Willamette						
W-8-1	Ap1	0- 5	0.3	1.0	1.4	2.0	1.3	23.3	48.5	22.2	sil
W-8-2	Ap2	5-10	0.3	1.2	1.6	1.9	1.3	20.9	50.8	22.0	sil
W-8-3	A3	10-17	0.4	1.3	1.6	2.0	1.4	20.3	48.0	25.0	sil
W-8-4	B1	17-28	0.4	1.1	1.5	2.2	1.3	18.6	48.4	25.5	sil
W-8-5	IIB21t	28-33	0.1	0.3	0.5	1.1	1.7	22.3	47.1	26.9	sil+
W-8-6	IIB22t	33-49	0.0[a]	0.1	0.2	0.6	1.5	21.3	47.9	28.4	sicl
W-8-7	IIB3t	49-60	0.2	0.2	0.2	0.7	2.4	23.9	49.7	21.7	sil
W-8-8	IIC	60-74	0.0	0.1	0.1	0.6	2.6	27.6	46.9	22.1	sil
					Willamette-like variant[b]						
8118	Ap	0- 6	0.1	0.4	0.5	1.7	1.8	17.6	60.8	17.1	sil-
8119	A12	6-15	[c]	0.3	0.5	0.9	2.1	14.2	58.9	23.1	sil
8120	A3	15-24	0.1	0.3	0.5	0.8	2.2	14.4	59.7	22.0	sil
8121	B1	24-33	0.1	0.3	0.5	1.1	1.6	13.9	57.4	25.1	sil
8122	IIB21t	33-46	[c]	0.1	0.2	0.5	1.2	16.7	50.0	31.3	sicl
8123	IIB22t	46-56	0.0	0.1	0.1	0.6	3.9	31.7	37.6	26.0	sil
8124	IIB3	57-74	0.1	0.2	0.2	0.8	2.9	25.6	44.9	25.3	sil

Table 2 (Continued)

			Sand %					Silt %		Clay	
Sample Number	Horizon	Depth inches	vc 2-1 mm	c 1-0.5 mm	med 0.5-0.25 mm	fine 0.25-0.1 mm	vf 0.1-0.05 mm	coarse 0.05-0.02 mm	fine 0.02-0.002 mm	% <0.002	Text. Class
					Willamette series[d]						
59691	Ap	0- 6	0.1	0.3	0.4	1.1	0.8	26.7	50.3	20.3	sil
29692	A12	6-13	0.1	0.4	0.4	1.0	0.8	27.8	50.4	19.1	sil
59693	A3	13-24	-c	0.2	0.4	1.0	0.7	25.6	49.9	22.2	sil
59694	B1	24-33	-	0.2	0.4	1.0	0.9	24.4	49.6	23.5	sil
59695	IIB2t	33-45	-	0.1	0.2	0.9	0.9	28.5	43.9	25.5	sil
59696	IIB3t	45-53	-	0.1	0.1	0.6	1.0	28.7	43.8	25.7	sil
59697	IIC	53-60	0.1	-c	0.1	0.4	2.5	34.2	41.2	21.5	sil
						Dayton					
D-1-1	Ap1	0- 3	0.9	0.7	0.4	0.7	0.9	24.1	61.6	10.7	si
D-1-2	Ap2	3- 7	0.9	0.5	0.3	0.7	0.8	23.9	63.5	9.4	si
D-1-3	A2	7-14	1.0	0.6	0.3	0.8	0.7	22.3	59.2	15.5	sil
D-1-4	IIB2t	14-25	0.2	0.5	0.3	1.0	0.9	14.4	38.1	44.6	sic
D-1-5	IIB3t	25-30	0.2	0.3	0.3	0.6	1.2	15.6	43.6	38.2	sicl+
D-1-6	IIIC	30-41	0.2	0.4	0.4	0.6	1.3	18.8	49.3	28.9	sicl-
						Dayton					
D-2-1	Ap1	0- 4	1.6	0.7	0.4	0.7	1.1	27.4	56.1	12.1	si
D-2-2	A-2	4- 9	1.2	0.6	0.4	0.6	1.1	26.9	56.4	12.8	sil-
D-2-3	A2	9-13	1.4	0.8	0.5	0.6	1.2	25.9	53.3	16.3	sil
D-2-4	IIB2t	13-24	0.3	0.6	0.5	0.7	0.9	13.9	36.7	46.4	sic
D-2-5	IIIB3t	24-34	0.1	0.5	0.4	0.6	1.2	16.1	45.4	35.7	sicl+
D-2-6	IIIC	34-44	0.1	0.4	0.6	1.1	2.7	23.9	53.3	17.9	sil

Table 2 (Continued)

			Sand %					Silt %		Clay	
Sample Number	Horizon	Depth inches	vc 2-1 mm	c 1-0.5 mm	med 0.5-0.25 mm	fine 0.25-0.1 mm	vf 0.1-0.05 mm	coarse 0.05-0.02 mm	fine 0.02-0.002 mm	% < 0.002	Text. Class
						Concord					
C-1-1	Ap	0- 8	1.1	0.9	0.4	0.6	0.7	17.9	58.9	19.5	sil
C-1-2	A2	8-15	1.7	1.3	0.5	0.4	0.6	20.6	54.9	20.0	sil
C-1-3	AB	15-22	0.7	1.2	0.5	0.5	0.6	18.7	52.9	24.9	sil
C-1-4	IIB2t	22-28	0.4	0.9	0.5	0.7	0.7	16.4	35.7	44.7	sic
C-1-5	IIB3t	28-42	0.3	0.5	0.4	0.6	0.8	23.5	34.1	39.8	sicl+
C-1-6	IIIC	42-48	0.1	0.3	0.3	0.5	1.0	17.1	51.2	29.5	sicl
						Wapato					
X-1-1	Ap1	0- 7	0.4	0.5	0.2	0.4	0.7	18.8	53.9	25.1	sil
X-1-2	Ap2	7-13	0.3	0.4	0.3	0.3	1.2	17.1	56.3	24.1	sil
X-1-3	B21	13-20	0.1	0.2	0.3	0.7	0.9	24.3	52.0	21.5	sil
X-1-4	B22	20-30	0.9	0.7	0.5	0.6	0.9	13.7	56.8	25.8	sil
X-1-5	IIC1	30-42	1.0	0.8	0.4	0.3	0.4	11.4	53.9	32.9	sicl
X-1-6	IIC2	42-48	0.6	0.4	0.2	0.2	0.1	11.4	51.0	36.1	sicl+

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[a] 0.0 indicates less than 0.05 percent.

[b] Unpublished data, Soil Conservation Service and Oregon State University. Soil-geomorphology Project, Corvallis, Oregon.

[c] No sand of this size retained on the sieve.

[d] Unpublished data, Soil Survey Laboratory, Soil Conservation Service, USDA, Riverside, California.

15 to 31 percent clay with the lesser amounts usually in the surface horizons. Dayton and Concord soils have from 9 to 46 percent clay with the least in the A2 horizons. The solum of the Wapato soil contains as much clay as the Willamette soils and the IIC horizons are textually similar to the B3 horizons of the Dayton and Concord soils.

Depths to the lithologic discontinuity in the Willamette "group" of soils vary according to the landscape position of the soil and the thickness of the most recent deposits on the various land surfaces. Thickness of the mollic epipedon is similarly related.

Willamette soils on the Senecal surface, W-5 and W-8, have 32 and 28 inch depths to the IIB2t horizon and have mollic epipedons to 20 and 28 inches respectively. As shown in Table 2, they have more sand above than below the discontinuity, and similar amounts of clay. The typifying profile of the Willamette Series as described in Linn County, Oregon on the Senecal surface is 33 inches deep to the as-yet-officially-unrecorded lithologic discontinuity (70) and the mollic epipedon extends to 24 inches. There is more sand and as much as 5 percent more silt above than below the discontinuity. The clay content is between 19 and 26 percent throughout. There is slightly more clay in the Bt horizons than in the A, B1, or C horizons. The laboratory felt that dispersion of these samples was incomplete.[6] The data are

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[6] Unpublished data, Soil Survey Laboratory, Soil Conservation Service, USDA, Riverside, California.

given the laboratory numbers of 59691-59697.

The Willamette variants and the Woodburn soils on the Bethel surface at or below about 200 feet above sea level; W-6, W-7, and W-4 have 29-, 30-, and 29-inch depths, respectively, to the lithologic discontinuity. The mollic epipedon in each of these soils extends to 15, 15, and 17 inches, respectively. Willamette variant W-6 has less sand above than below the discontinuity and about equal silt contents, and generally more clay above than below the discontinuity. Willamette variant W-7 is lower on the slope than W-6. There are nearly equal amounts of sand, slightly greater above, and more silt and less clay above than below the discontinuity. The Woodburn soil, W-4, has more sand and about equal amounts of clay above as compared to below the lithologic discontinuity.

The Willamette variant on the Bethel surface at about 220 feet, W-2, is only 21 inches deep to the lithologic discontinuity and the mollic epipedon is, as are the other soils on this surface, only 15 inches thick. The characteristics defining the lower limit of this epipedon are moist colors with chromas of 4 within whole peds and about 3.5 when crushed. There is less sand and somewhat more silt above than below the discontinuity; the clay is about equal, with the B1 containing more clay than any other horizon.

Willamette silt loam W-1 and Carlton-like silt loam W-3 are on the Bethel surface intermediate between the hill top and the valley terrace. The depth to the discontinuity in the Willamette soil is 39 inches and in the variant is 41 inches. The mollic epipedon is 26 inches thick in the former and 24 inches thick in the latter. In both profiles there is less sand and more silt above than below the discontinuity, although there is an overlap of silt percentages in the variant. The greatest amounts of clay in the profiles are in the IIB21t.

An unnamed soil similar to Willamette was studied at the 225 foot elevation in a walnut orchard south of Monmouth. Data[7] for this soil is also in Table 2; lab numbers are 8118 to 8124. This soil is on the intermediate surface above the valley terrace, Senecal surface, and below the Dolph surface. Depth to the lithologic discontinuity is 33 inches. The soil has an ochric rather than a mollic epipedon although, were it at the surface, the A12 horizon at the 6 to 15 inch depth would qualify as mollic. The least sand is just below, but otherwise the sand is about equal and the silt is greater above than below the discontinuity. There is more clay below than above.

The change in clay content clearly defines the two discontinuities in the Concord, C-1, and Dayton, D-1 and D-2, profiles. The IIB3t horizons in these profiles seem to be a product of mixing of the overlying clays and silt loam materials below (68). The IIC horizons in

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[7] Unpublished data; work from OSU soil testing and soil physics laboratories.

the Wapato, X-1, are also distinguished by the clay content. The material is somewhat different from the clayey horizon of the Concord and Dayton soils. In all of these soils the silt size fraction is dominant in all horizons.

The very fine sand content of the horizons also changes abruptly, often with an increase at the lithologic discontinuity.

The fine and very fine sand contents of the various soils differ generally according to the landscape position of the soil. The profiles on the hill tops--W-2, W-4, and W-6--contain greater amounts of both fine and very fine sand than do any of the other profiles. The very fine sand size dominates the sand fraction. The profiles on the valley terrace--W-5, W-8, and 59691--have about equal amounts of fine and very fine sand with greater fine sand percentage in the upper solum. The profiles in intermediate positions--W-1, W-3, W-7, and 8118--have less fine than very fine sand throughout the profile.

The organic matter contents of the various horizons are in Table 3. In all cases the plowed layer contains more organic matter than any of the other horizons. The organic matter content decreases with increasing depth. The percentage by weight of organic matter and the depth to which the organic matter content is at a moderately high level (1.0 percent organic matter or greater) are related to the position of the soil in the landscape and to the drainage characteristics of the soil. The thickness of the mollic epipedon is similarly related.

Table 3. Chemical Data of Related Soils in the McCoy Area

Sample Number	Horizon	Depth inches	pH paste	Organic matter %	Extractable Cations								
					Ca	Mg	Na	K	H	CEC^a	CEC^b	%BS^a	%BS^b
					- - - - - - - - -	meq/100g soil	- - - - - - - - - - - -						
					<u>Willamette</u>								
W-1-1	Ap	0-10	5.7	3.6	9.5	1.0	0.1	0.8	10.2	16.5	21.6	69	53
W-1-2	A12	10-18	5.7	3.0	8.9	1.3	0.1	0.6	10.6	16.4	21.5	62	51
W-1-3	A3	18-26	5.9	1.1	8.0	1.0	0.1	0.5	7.8	13.8	17.4	70	55
W-1-4	B1	26-39	5.9	0.9	10.4	2.4	0.2	0.4	7.7	16.0	21.1	84	64
W-1-5	IIB21t	39-52	5.9	0.1	18.2	4.8	0.3	0.5	6.1	24.0	29.9	99	80
W-1-6	IIB22t	52-60	5.9	0.1	18.8	4.5	0.3	0.5	3.9	23.0	28.0	100	86
					<u>Willamette variant</u>								
W-2-1	Ap	0-10	5.5	3.1	6.6	0.7	0.1	0.7	10.0	13.0	18.1	62	45
W-2-2	A3	10-15	5.6	1.7	9.5	1.1	0.1	0.6	9.9	12.8	21.2	88	53
W-2-3	B1	15-21	5.5	1.0	8.9	1.6	0.1	0.5	7.9	14.2	19.0	79	58
W-2-4	IIB21t	21-37	5.6	0.4	16.9	5.1	0.2	0.6	8.9	23.6	31.7	97	72
W-2-5	IIB22t	37-56	5.8	0.2	16.3	4.8	0.3	0.5	6.4	21.7	28.3	100	77
W-2-6	IIB3t	56-65	5.9	0.1	15.0	3.9	0.3	0.4	4.1	18.4	23.7	100	83
					<u>Carlton-like</u>								
W-3-1	Ap1	0-3 1/2	5.6	4.4	8.3	1.7	0.1	0.6	12.3	15.4	22.6	67	46
W-3-2	Ap2	3 1/2- 9	5.5	4.2	8.0	1.9	0.1	0.5	13.3	15.3	23.3	64	43
W-3-3	A13	9-15	5.9	3.0	8.2	2.0	0.1	0.5	11.3	15.4	21.5	66	47
W-3-4	A3	15-24	5.9	1.7	7.8	2.2	0.1	0.3	9.0	13.4	18.8	73	52
W-3-5	B1	24-41	6.0	0.6	8.9	3.4	0.2	0.3	5.8	12.6	17.8	95	64
W-3-6	IIB21t	41-52	6.0	0.3	16.0	6.3	0.3	0.4	5.4	20.2	26.9	100	80
W-3-7	IIB22t	52-58	6.0	0.2	15.7	5.9	0.3	0.4	4.5	18.8	25.1	100	82
W-3-8	IIC1	58-62	6.1	0.1	16.6	6.1	0.5	0.4	4.6	19.4	26.5	100	83
W-3-9	IIC2	62-90	5.9	0.1	16.9	6.3	0.5	0.5	5.0	20.3	28.0	100	82

Table 3. (Continued)

Sample Number	Horizon	Depth inches	pH paste	Organic matter %	Extractable Cations								
					Ca	Mg	Na	K	H	CEC^a	CEC^b	%BS^a	%BS^b
					meq/100g soil								
					Woodburn								
W-4-1	Ap1	0-4 1/2	5.7	4.7	8.3	1.0	0.1	0.8	13.0	16.6	23.2	61	44
W-4-2	Ap2	4 1/2-10	5.7	4.6	8.9	1.3	0.2	0.7	13.8	16.8	24.9	67	45
W-4-3	A3	10-17	5.9	2.4	8.0	1.6	0.1	0.6	12.0	15.0	22.3	69	46
W-4-4	B1	17-22	5.8	1.3	7.5	1.8	0.1	0.4	9.6	12.6	19.4	78	50
W-4-5	B21	22-29	5.7	1.2	8.0	2.7	0.2	0.4	9.2	13.8	20.5	82	55
W-4-6	IIB22t	29-44	5.6	0.2	16.9	6.3	0.2	0.4	7.7	22.2	31.5	100	76
W-4-7	IIB23t	44-62	5.8	0.2	16.9	6.0	0.3	0.6	5.3	21.4	29.1	100	82
W-4-8	IIB3t	62-73	6.1	0.2	15.0	5.1	0.3	0.5	5.1	18.0	26.0	100	80
W-4-9	IIC	73-87	6.0	0.1	14.8	4.9	0.3	0.5	4.7	19.6	25.2	100	81
					Willamette								
W-5-1	Ap1	0- 4	5.8	4.3	9.3	1.3	0.1	0.7	11.6	17.0	23.0	67	50
W-5-2	Ap2	4- 9	5.9	4.3	9.3	1.2	0.1	0.6	11.3	17.7	22.5	63	50
W-5-3	A3	9-15	5.9	3.0	8.4	1.3	0.1	0.6	11.4	16.9	21.8	62	48
W-5-4	B1	15-20	5.9	1.9	6.9	1.8	0.1	0.5	9.8	14.4	19.1	65	49
W-5-5	B21	20-32	5.8	1.0	6.9	2.1	0.1	0.5	8.0	14.3	17.6	67	54
W-5-6	IIB22t	32-40	5.6	0.4	16.0	5.8	0.1	0.6	8.1	25.6	30.6	88	74
W-5-7	IIB23t	40-56	5.9	0.3	16.7	6.4	0.2	0.5	5.1	25.5	29.0	93	82
W-5-8	IIC	56-70	6.1	0.1	17.3	6.8	0.3	0.5	4.3	25.3	29.2	98	85
					Willamette variant								
W-6-1	Ap1	0- 4	5.9	3.2	8.4	1.7	0.1	0.6	8.5	13.4	18.6	75	54
W-6-2	Ap2	4-9 1/2	5.8	3.1	7.8	1.5	0.1	0.6	8.3	13.6	23.1	70	41
W-6-3	A3	9 1/2-15	5.9	1.4	7.5	1.7	0.1	0.6	7.9	12.9	22.1	71	42
W-6-4	B1	15-20	5.7	1.2	7.5	2.2	0.1	0.5	7.5	13.4	17.6	75	57
W-6-5	B21	20-29	5.7	1.1	9.6	3.8	0.1	0.5	8.2	16.8	21.9	82	63
W-6-6	IIB22t	29-44	5.7	0.4	15.4	6.4	0.1	0.6	7.7	24.9	30.8	93	75
W-6-7	IIB23t	44-59	5.8	0.4	14.2	6.4	0.2	0.5	6.1	21.5	26.5	95	77
W-6-8	IIC	59-78	5.8	0.3	15.4	6.3	0.2	0.4	5.0	20.6	25.7	100	80

Table 3. (Continued)

Sample Number	Horizon	Depth inches	pH paste	Organic matter %	Extractable Cations								
					Ca	Mg	Na	K	H	CEC[a]	CEC[b]	%BS[a]	%BS[b]
					- - - - - - - - - -	meq/100g soil			- - - - - - - - - - - -				
					Willamette variant								
W-7-1	Ap1	0- 5	5.7	3.6	8.1	1.0	0.1	0.5	9.1	13.9	18.8	70	52
W-7-2	Ap2	5-10	5.9	3.3	8.1	1.0	0.1	0.5	9.3	13.3	19.1	74	51
W-7-3	A3	10-15	5.8	1.6	7.2	1.0	0.1	0.5	8.0	12.1	16.9	74	53
W-7-4	B1	15-20	5.7	1.2	7.2	1.2	0.1	0.6	8.0	11.7	17.1	78	53
W-7-5	B21	20-30	5.6	0.9	8.4	2.4	0.1	0.5	8.0	14.7	19.4	78	59
W-7-6	IIB22t	30-36	5.4	0.5	14.2	6.8	0.1	0.6	8.0	23.9	29.7	92	73
W-7-7	IIB23t	36-48	5.5	0.5	16.7	7.5	0.2	0.6	6.9	25.1	31.9	100	78
					Willamette								
W-8-1	Ap1	0- 5	5.9	3.9	9.0	2.0	0.1	0.6	10.5	16.0	22.2	73	53
W-8-2	Ap2	5-10	6.1	4.0	11.2	2.0	0.1	0.6	9.3	17.0	23.2	82	60
W-8-3	A3	10-17	5.8	3.0	9.6	2.6	0.1	0.6	10.4	17.2	23.3	75	55
W-8-4	B1	17-28	5.7	1.4	10.5	4.4	0.1	0.4	8.4	17.4	23.8	88	65
W-8-5	IIB21t	28-33	5.6	0.8	14.8	7.4	0.2	0.5	7.6	23.4	30.6	98	75
W-8-6	IIB22t	33-49	6.0	0.5	18.4	9.6	0.3	0.5	5.8	25.9	34.6	100	83
W-8-7	IIB3t	49-60	6.5	0.2	18.2	9.2	0.4	0.5	3.9	24.6	32.2	100	88
W-8-8	IIC	60-74	6.5	0.2	17.6	10.4	0.4	0.5	3.8	24.4	32.7	100	88
					Willamette-like variant[c]								
8118	Ap	0- 6	5.4	3.2	5.5	2.1	0.1	0.8	9.8	12.9	18.3	65.1	46.2
8119	A12	6-15	5.6	1.6	6.1	2.5	0.1	0.4	8.3	13.3	17.4	67.7	52.0
8120	A3	15-24	5.8	0.8	7.6	3.2	0.1	0.2	6.9	13.4	18.0	82.8	61.7
8121	B1	24-33	5.7	0.5	8.8	4.3	0.1	0.2	6.8	15.4	20.2	86.4	66.2
8122	IIB21t	33-46	5.7	0.1	11.7	6.6	0.2	0.3	6.8	21.7	25.6	86.6	73.4
8123	IIB22t	46-57	5.8	0.5	10.9	5.5	0.3	0.2	5.7	19.9	22.6	84.9	74.8
8124	IIB3t	57-74	5.9	0.2	11.2	6.3	0.2	0.3	5.3	19.1	23.3	94.2	77.3

Table 3. (Continued)

Sample Number	Horizon	Depth inches	pH paste	Organic matter %	Extractable Cations								
					Ca	Mg	Na	K	H	CEC[a]	CEC[b]	%BS[a]	%BS[b]
					meq/100g soil								
					Willamette series[d]								
59691	Ap	0- 6	5.6	2.7	7.7	1.7	0.1	0.7	10.3	20.9	20.5	49	50
59692	A12	6-13	5.6	2.7	7.7	1.5	0.1	0.7	10.3	19.8	20.3	50	49
59693	A3	13-24	5.6	2.3	7.4	1.9	0.2	0.5	8.5	19.0	18.5	53	54
59694	B1	24-33	5.8	1.0e	9.0	2.8	0.3	0.4	7.4	19.9	19.9	63	63
59695	IIB2t	33-45	5.8	0.4	16.7	6.0	0.2	0.6	6.5	33.7	30.0	70	78
59696	IIB3t	45-53	5.8	0.3	17.5	6.5	0.5	0.5	5.3	31.1	30.2	80	83
59697	IIC	53-60	5.9	0.2	16.3	6.0	0.3	0.4	4.5	29.7	27.5	77	84
					Dayton								
D-1-1	Ap1	0- 3	5.3	1.8	4.5	1.8	0.1	0.2	5.9	9.3	12.5	71	53
D-1-2	Ap2	3- 7	5.1	1.4	4.5	1.8	0.1	0.2	5.4	9.4	12.0	70	55
D-1-3	A2	7-14	5.5	1.3	7.4	3.6	0.2	0.2	5.3	11.6	16.8	99	68
D-1-4	IIB2t	14-25	6.0	0.7	25.6	15.5	0.8	0.6	5.9	36.8	48.4	100	88
D-1-5	IIB3t	25-30	6.7	0.4	27.0	16.0	0.1	0.6	3.4	35.7	47.1	100	93
D-1-6	IIIC	30-41	6.9	0.3	24.4	14.8	0.1	0.6	3.5	31.4	43.4	100	92
					Dayton								
D-2-1	Ap1	0- 4	5.4	1.6	5.7	2.3	0.2	0.3	6.6	10.2	51.1	83	56
D-2-2	Ap2	4- 9	5.6	1.6	5.7	2.6	0.2	0.2	6.6	13.3	15.3	65	57
D-2-3	A2	9-13	5.7	1.5	7.5	3.9	0.5	0.3	5.1	10.6	17.3	100	70
D-2-4	IIB2t	13-24	6.6	0.9	23.8	14.8	1.4	0.6	4.4	35.6	45.0	100	90
D-2-5	IIB3t	24-34	7.1	0.3	26.2	14.9	1.7	0.6	2.6	35.6	46.0	100	94
D-2-6	IIIC	34-44	7.1	0.2	18.4	12.4	1.1	0.5	2.2	27.0	34.6	100	94

Table 3. (Continued)

Sample Number	Horizon	Depth inches	pH paste	Organic matter %	Extractable Cations					CEC^a	CEC^b	%BS^a	%BS^b
					Ca	Mg	Na	K	H				
					meq/100g soil								
					Concord								
C-1-1	Ap	0- 8	5.6	3.3	7.8	2.4	0.1	0.2		16.6		63	
C-1-2	A2	8-15	5.7	1.5	8.5	2.8	0.2	0.2		15.4		76	
C-1-3	AB	15-22	5.6	0.9	11.3	5.0	0.3	0.3		18.2		68	
C-1-4	IIB2t	22-28	5.5	0.8	20.0	10.8	0.6	0.5		33.4		95	
C-1-5	IIB3t	28-42	5.6	0.6	22.6	10.9	0.6	0.5		38.2		91	
C-1-6	IIIC	42-48	6.0	0.3	21.4	10.0	0.6	0.5		30.5		100	
					Wapato								
X-1-1	Ap1	0- 7	5.8	5.2	11.0	4.7	0.3	0.4		22.4		73	
X-1-2	Ap2	7-13	6.3	3.7	12.2	5.9	0.5	0.3		21.1		90	
X-1-3	B21	13-20	6.4	3.6	11.9	7.4	0.5	0.3		21.2		95	
X-1-4	B22	20-30	6.8	2.8	11.9	8.9	0.5	0.3		21.1		100	
X-1-5	IIC1	30-42	7.1	1.4	11.9	12.4	0.6	0.4		24.5		100	
X-1-6	IIC2	42-48	7.3	1.2	13.8	15.5	0.7	0.5		28.0		100	

[a] Cation Exchange Capacity (CEC) and Base Saturation (BS) determined by NH$_4$OAc.

[b] CEC and BS determined by sum of cations.

[c] Unpublished data, Soil Conservation Service and Oregon State University, Soil-geomorphology Project, Corvallis, Oregon.

[d] Unpublished data, Soil Survey Laboratory, Soil Conservation Service, USDA, Riverside, California.

[e] About 0.97% rounded to 1.0% organic matter (O.M.).

The well drained Willamette variants in the hill top positions, W-2 and W-6, have the lowest organic matter content; below 21 inches in W-2 and below 29 inches in W-6 it is less than one percent. The well drained Willamette-like variant soil near Monmouth has more than three percent in the surface horizon but less than one percent organic matter below 15 inches. With higher amounts of organic matter, but still less than four percent, are the Willamette W-1 and the variant W-7 soils which are in intermediate landscape positions; the organic matter is less than one percent below 26 and 20 inches respectively in the profiles.

The well drained Willamette soils on the terrace have four or more percent with the better drained profile, W-5, having greater amounts of organic matter to 32 inches as compared to the lesser amounts in W-8 to 28 inches. When sampled in 1959, the Willamette silt loam, 59691 et seq., of the southern valley had between 2 and 3 percent organic matter to 24 inches. The well drained Carlton-like soil, W-3, is on a younger surface in the Bethel unit and has organic matter exceeding four percent in the plowed layer and greater than one percent to a depth of 24 inches.

The moderately well drained Woodburn soil, W-4, on the nearly level Bethel surface, has nearly five percent organic matter in the plowed layer and above one percent to 29 inches. The poorly drained Dayton and Concord soils contain more than one percent organic matter in the Ap and A2 horizons, above 13 to 15 inches. The poorly drained Wapato soils have more than one percent organic matter in all horizons, decreasing with depth from over five percent in the surface.

The data in Table 3 for extractable cations includes not only the ions adsorbed on the exchange complex but also the ions, if any, present in the soil solution. The exchangeable acidity is a measure of the hydrogen and aluminum ions extracted at pH 8.2. The bases were extracted and the cation exchange capacity was determined at pH 7.0. Since the level of exchangeable acidity is pH dependent and greater amounts are measured at higher pH levels, the cation exchange capacity calculated by sum of cations is always greater than when determined by direct exchange.

In the Willamette group, the extractable cations Ca, Mg, and Na are each at about the same level above the discontinuity in all soils: below 10, usually below 4, and near 0.1 milliequivalents per one hundred grams of soil, respectively. They are above 10, above 4, and variably from 0.1 to 0.5 milliequivalents below the discontinuity. The changes in Ca, Mg, and C.E.C. across the discontinuity substantiated the visual macromorphology and the changes in particle size distribution, the latter especially as seen in the ratios listed in Table 4, as a lithologic discontinuity. The B1 horizons in profiles W-1, W-5, W-8, 8118, and 59691 and the B21 horizons in W-5 and W-7 seem to be transitional between the upper and lower materials. The

Table 4. Calculations from Physical and Chemical Data

Sample Number	Horizon	Depth (inches)	Clay-free Basis				Clay:CEC	Ca:Mg
			vrs:fsi	vfs:ms	vfs %	silt %		
				Willamette				
W-1-1	Ap	0-10	0.02	2.8	1.4	95.9	1.3	9.5
W-1-2	A12	10-18	0.02	3.0	1.4	96.3	1.4	6.8
W-1-3	A3	18-26	0.02	4.6	1.2	98.0	1.7	8.0
W-1-4	B1	26-39	0.04	5.5	2.4	94.3	1.1	4.3
W-1-5	IIB21t	39-52	0.05	6.4	3.2	93.3	1.0	3.8
W-1-6	IIB22t	52-60	0.12	16.2	6.3	90.2	1.0	4.2
				Willamette variant				
W-2-1	Ap	0-10	0.05	1.9	2.7	92.7	1.4	9.4
W-2-2	A3	10-15	0.03	2.0	2.1	94.0	1.7	8.6
W-2-3	B1	15-21	0.04	2.4	2.8	92.3	1.7	5.6
W-2-4	IIB21t	21-37	0.08	9.1	5.4	91.5	1.0	3.3
W-2-5	IIB22t	37-56	0.13	16.3	7.2	89.3	1.0	3.4
W-2-6	IIB3t	56-65	0.19	22.1	8.4	89.5	1.1	3.8
				Carlton-like				
W-3-1	Ap1	0-31/2	0.03	4.8	1.9	95.8	1.4	6.4
W-3-2	Ap2	31/2-9	0.03	5.4	2.1	96.0	1.4	6.2
W-3-3	A13	9-15	0.03	5.5	2.2	96.2	1.5	6.4
W-3-4	A3	15-24	0.03	4.9	1.9	95.8	1.6	4.9
W-3-5	B1	24-41	0.04	6.2	2.5	96.1	1.5	3.4
W-3-6	IIB21t	41-52	0.08	10.0	4.5	93.1	1.2	3.3
W-3-7	IIB22t	52-58	0.06	10.4	3.1	95.8	1.2	3.7
W-3-8	IIC1	58-62	0.04	7.2	2.4	96.2	1.3	3.8
W-3-9	IIC2	62-90	0.05	17.3	3.0	95.5	1.2	3.3

Table 4. (Continued)

Sample Number	Horizon	Depth (inches)	Clay-free Basis				Clay:CEC	Ca:Mg
			vrs:fsi	vfs:ms	vfs %	silt %		
				Woodburn				
W-4-1	Ap1	0- 4 1/2	0.04	1.6	3.4	91.7	1.3	8.3
W-4-2	Ap2	4 1/2-10	0.04	1.7	2.5	91.6	1.3	6.8
W-4-3	A3	10-17	0.04	1.6	2.4	92.5	1.5	5.0
W-4-4	B1	17-22	0.04	1.6	2.2	91.4	1.7	4.2
W-4-5	B21	22-29	0.05	1.8	2.8	91.4	1.6	3.0
W-4-6	IIB22t	29-44	0.06	5.4	3.5	93.0	1.0	2.7
W-4-7	IIB23t	44-62	0.07	6.1	4.4	92.0	1.1	2.8
W-4-8	IIB3t	62-73	0.07	7.8	3.6	93.8	1.0	2.9
W-4-9	IIC	73-87	0.04	5.8	2.9	94.5	1.1	3.0
				Willamette				
W-5-1	Ap1	0- 4	0.03	1.2	1.9	92.2	1.4	7.2
W-5-2	Ap2	4- 9	0.02	1.0	1.3	92.7	1.4	7.8
W-5-3	A3	9-15	0.02	0.9	1.4	94.4	1.6	6.5
W-5-4	B1	15-20	0.02	0.7	1.3	92.8	1.7	3.8
W-5-5	B21	20-32	0.01	0.2	0.5	90.0	1.4	3.3
W-5-6	IIB22t	32-40	0.05	4.1	3.4	92.5	0.8	2.8
W-5-7	IIB23t	40-56	0.03	7.0	1.9	96.8	0.9	2.6
W-5-8	IIC	56-70	0.04	15.4	2.8	95.5	0.9	2.5
				Willamette variant				
W-6-1	Ap1	0- 4	0.05	2.9	2.5	94.4	1.3	8.4
W-6-2	Ap2	4- 9 1/2	0.04	2.6	2.4	93.6	1.5	7.8
W-6-3	A3	9 1/2-15	0.03	2.6	2.1	95.3	1.8	7.5
W-6-4	B1	15-20	0.03	2.4	2.1	95.2	1.8	3.8
W-6-5	B21	20-29	0.04	3.3	2.8	93.2	1.6	2.7
W-6-6	IIB22t	29-44	0.08	6.0	4.8	91.0	0.6	2.2
W-6-7	IIB23t	44-59	0.09	7.2	5.2	91.4	1.1	2.6
W-6-8	IIC	59-78	0.04	15.4	2.6	96.1	1.1	3.3

Table 4. (Continued)

Sample Number	Horizon	Depth (inches)	Clay-free Basis				Clay:CEC	Ca:Mg
			vrs:fsi	vfs:ms	vfs %	silt %		
			Willamette variant					
W-7-1	Ap1	0- 5	0.02	1.8	1.5	94.8	1.4	8.1
W-7-2	Ap2	5-10	0.03	1.6	1.9	94.1	1.5	8.1
W-7-3	A3	10-15	0.02	1.6	1.3	96.0	1.3	7.2
W-7-4	B1	15-20	0.02	1.7	1.6	94.6	1.8	6.0
W-7-5	B21	20-30	0.02	2.0	1.7	95.8	1.7	3.5
W-7-6	IIB22t	30-36	0.04	5.8	2.5	97.3	1.1	2.1
W-7-7	IIB23t	36-48	0.04	5.6	2.5	94.6	1.0	2.2
			Willamette					
W-801	Ap1	0- 5	0.03	0.93	1.7	91.9	1.4	4.5
W-8-2	Ap2	5-10	0.03	0.83	1.7	91.8	1.3	5.6
W-8-3	A3	10-17	0.03	0.91	1.9	90.8	1.4	3.7
W-8-4	B1	17-28	0.03	0.85	1.8	91.8	1.5	2.4
W-8-5	IIB21t	28-33	0.04	3.78	2.4	95.1	1.2	2.0
W-8-6	IIB22t	33-49	0.03	7.6	2.0	95.5	1.1	1.9
W-8-7	IIB3t	49-60	0.05	9.4	3.0	95.5	0.9	2.0
W-8-8	IIC	60-74	0.05	19.3	3.2	95.4	0.9	1.7
			Willamette-like variant[a]					
8118	Ap	0- 6	0.03	3.4	2.2	94.1	1.3	2.6
8119	A12	6-15	0.04	3.8	2.7	95.0	1.7	2.4
8120	A3	15-24	0.04	4.4	2.8	94.8	1.6	2.4
8121	B1	24-33	0.03	3.7	2.2	95.0	1.6	2.0
8122	IIB21t	33-46	0.02	7.8	1.8	96.7	1.4	1.8
8123	IIB22t	46-57	0.10	28.9	5.2	93.6	1.3	2.0
8124	IIB3	57-74	0.06	11.9	3.8	93.8	1.3	1.8

Table 4. (Continued)

Sample Number	Horizon	Depth (inches)	Clay-free Basis				Clay:CEC	Ca:Mg
			vrs:fsi	vrs:ms	vfs %	silt %		
				Willamette series[b]				
59691	Ap	0- 6	0.02	2.0	1.0	96	1.0	4.5
59692	A12	6-13	0.02	2.0	1.0	96	1.0	5.1
59693	A3	13-24	0.01	1.8	0.9	97	1.2	3.9
59694	B1	24-33	0.02	2.3	1.2	97	1.2	3.2
59695	IIB2t	33-45	0.02	4.4	1.2	97	0.8	2.8
59696	IIB3t	45-53	0.02	10.0	1.4	98	0.8	2.7
59697	IIC	53-60	0.06	24.6	3.2	96	0.7	2.3
				Dayton				
D-1-1	Ap1	0- 3	0.01	2.2	1.0	95.9	1.2	2.5
D-1-2	Ap2	3- 7	0.01	2.5	0.9	95.3	1.0	2.5
D-1-3	A2	7-14	0.01	2.5	0.8	96.2	1.3	2.1
D-1-4	IIB2t	14-25	0.02	2.9	0.7	95.6	1.2	1.7
D-1-5	IIB3t	25-30	0.03	3.9	2.0	95.3	1.1	1.7
D-1-6	IIIC	30-41	0.03	3.4	1.9	96.2	0.9	1.6
				Dayton				
D-2-1	Ap1	0- 4	0.02	2.5	1.3	95.2	1.2	2.5
D-2-2	Ap2	4- 9	0.02	2.8	1.2	95.8	1.0	2.2
D-2-3	A2	9-13	0.02	2.4	1.4	94.2	1.5	1.9
D-2-4	IIB2t	13-24	0.02	1.7	1.7	93.6	1.3	1.6
D-2-5	IIB3t	24-34	0.03	3.0	1.9	95.9	1.0	1.8
D-2-6	IIIC	34-44	0.05	4.5	3.2	94.2	0.7	1.5

Table 4. (Continued)

Sample Number	Horizon	Depth (inches)	Clay-free Basis				Clay:CEC	Ca:Mg
			vrs:fsi	vrs:ms	vfs %	silt %		
				Concord				
C-1-1	Ap	0- 8	0.01	1.7	0.9	96.0	1.2	3.2
C-1-2	A2	8-15	0.01	1.2	0.7	94.4	1.3	3.0
C-1-3	AB	15-22	0.01	1.4	0.9	95.2	1.4	2.3
C-1-4	IIB2t	22-28	0.02	1.3	1.3	94.8	1.3	1.9
C-1-5	IIB3t	28-42	0.02	1.9	1.3	96.2	1.0	2.1
C-1-6	IIIC	42-48	0.02	4.0	1.6	97.7	1.0	2.1
				Wapato				
X-1-1	Ap1	0- 7	0.01	3.2	1.1	96.7	1.1	2.3
X-1-2	Ap2	7-13	0.02	3.9	1.5	96.9	1.1	2.1
X-1-3	B21	13-20	0.02	2.9	1.2	97.7	1.0	1.6
X-1-4	B22	20-30	0.02	1.8	1.2	95.2	1.2	1.3
X-1-5	IIC1	30-42	0.01	0.9	0.5	95.8	1.3	1.0
X-1-6	IIC2	42-48	0.0 [c]	1.0	0.2	97.3	1.3	0.9

[a] Unpublished data, Soil Conservation Service and Oregon State University, Soil-geomorphology Project, Corvallis, Oregon.

[b] Unpublished data, Soil Survey Laboratory, Soil Conservation Serivce, USDA, Riverside, California.

[c] 0.0 indicates less than 0.005.

characteristics could be a product of mixing of materials or leaching and transformation processes across the discontinuity (70).

The Dayton soils have similar variations in Ca, Mg, Na, and C. E. C. between the materials above and below the discontinuities. The decrease in Ca, Mg, and C. E. C. is not so great between the IIB3t and IIIC in the D-1 profile as in the D-2. The Concord profile, C-1, is similar, but the breaks between the A and IIB and the IIB and IIIC horizons are not as clearly defined by the bases as by the cation exchange capacities.

The Dayton and Concord profiles have less potassium in the surface than in the lower horizons. In the Willamette group of profiles the potassium content decreases, then increases, with increasing depth. The addition of a potassium fertilizer could produce this distribution. The application of agricultural lime could account for the increase in the calcium content of the surface horizons of some of the Willamette group profiles.

The Wapato profile has only a slight depth variation in calcium content. The cation exchange capacity has little variation above but increases with the clay content below the lithologic discontinuity. The magnesium and sodium increase with depth.

The exchange acidity generally decreases with increasing depth for all soils. Although the exchangeable acidity is, in general, less below than above, the discontinuity is not marked by an obvious change.

The base saturation percentage is an indication of the extent to which the exchange sites of the soil are saturated with exchangeable cations other than hydrogen and aluminum. The base saturation and pH increase and the exchangeable acidity decreases with depth in each profile, but the changes are not directly proportional between horizons.

Two values for base saturation percentage and cation exchange capacity are listed in Table 3 for comparative purposes. One column is based on the NH_4OAc method of determining cation exchange capacity; the other is based on the sum of cations, including hydrogen and aluminum.

The textural calculations in Table 4 are on a clay-free basis, where the sum of the sand and silt fractions are considered as 100 percent. The very fine sand (vfs) percentage shows a marked change at the lithologic discontinuity in most of the profiles. In these soils there seems to be a transitional horizon above the discontinuity: W-1, W-4, W-5, 8118, and 59691. The very fine sand to fine silt ratios are fairly uniform in all profiles above the discontinuity and increase below. These ratio components exhibited the change most clearly. Although less uniform above, the very fine sand to medium sand ratios also show a marked increase below the lithologic discontinuity. The silt content is quite uniform with a range of 89.3 to 98.0 on a clay-free basis. In general, there is more silt in the upper sola of profiles W-1, W-2, and W-6. The opposite is true in profiles W-4 and W-8. There is no obvious trend in the other soils.

The ratios of clay to cation exchange deviate most from 1.0 in the upper parts of the sola and least below the lithologic discontinuity. The ratios increase with depth from the surface horizons, as the organic matter content decreases (Table 3). In the horizon just above or below the major stratigraphic break, the ratio is reduced by as much as one-third. In Figure 11, the clay and organic matter distributions may be compared to the C. E. C.

The ratios of extractable calcium to extractable magnesium decrease with depth. The range is from 9.5 to 1.7 in the Willamette group of soils, 3.2 in the Dayton, and 1.5 in the Concord soils. In the Wapato profile, the ratio decreases from 2.3 to 0.9.

Classification

"The system [of soil classification] has taxa defined in terms of observable or measurable soil properties, selected primarily to group soils of similar genesis. . . . Genesis, however, does not appear in the definitions. It lies behind them" (91). Only those properties that now exist or can be demonstrated are used. These are the morphological features as described in the field and the physical and chemical properties as determined in the laboratory. Calculations based on the laboratory data are also important.

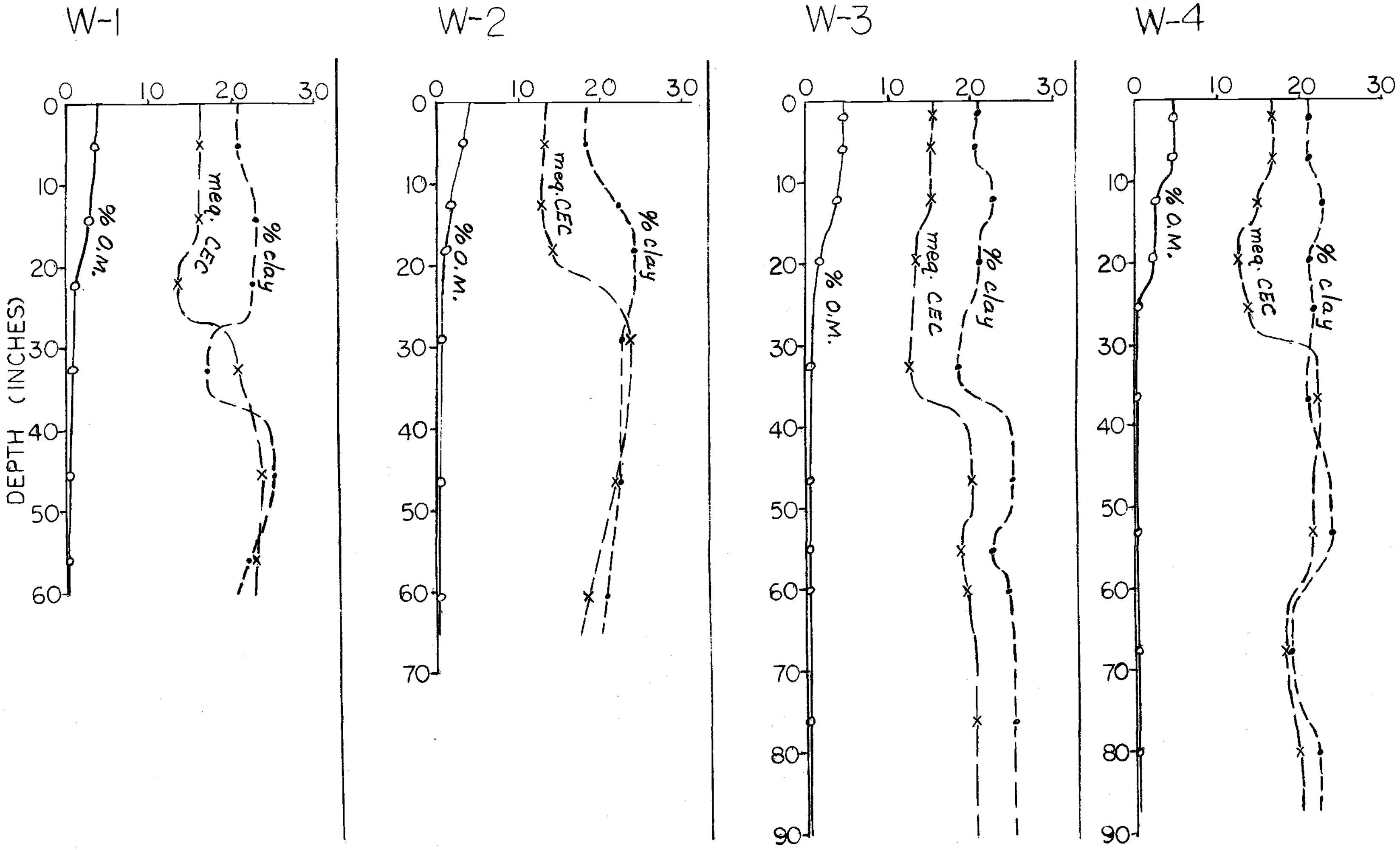

Figure 11A. Depth distribution curves of percent Organic Matter (o), meq/100 gm. Cation Exchange Capacity (X), and percent clay (.) for W-1, W-2, W-3, and W-4 profiles of the Willamette group of soils.

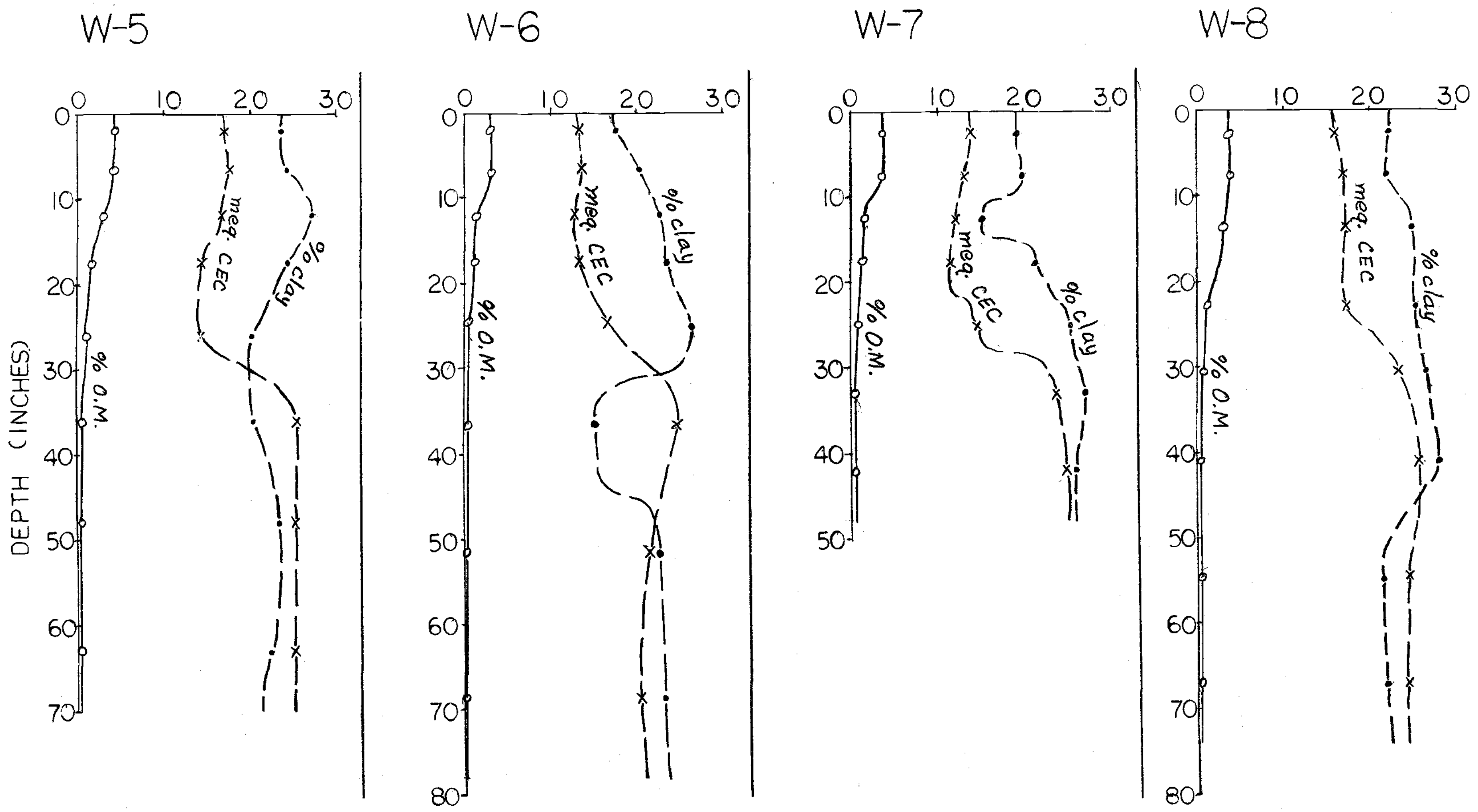

Figure 11B. Depth distribution curves of percent Organic Matter (o), meq/100 gm. Cation Exchange Capacity (X), and percent clay (.) for W-5, W-6, W-7, and W-8 profiles of the Willamette group of soils.

Using the criteria of the new classification system (98, 100), the profiles studied are classed in Subgroup, Family, and Series in Table 5. The series names used are those recognized by the Soil Conservation Service Cooperative Soil Survey in Oregon. Where the characteristics do not fit a series, the soil is identified as a variant of the Willamette series.

The most important of the criteria for classing most of these soils is the presence or absence of a mollic epipedon. Organic matter (determined as carbon) content and color, coupled with depth are critical in the definition of the mollic epipedon and in defining the series. Soils of the Willamette, Woodburn, Amity, Wapato, and Carlton series have mollic epipedons and are Mollisols. The Dayton and Concord soils lack mollic epipedons and are Alfinsols. The epipedon in Willamette and Carlton is thicker than 20 inches, and, therefore, the soils are in Pachic subgroups. The other Mollisols have thinner epipedons and are not Pachic.

In some part of the upper 30 inches of each of the Willamette "group" of Mollisols, the base saturation is less than 75 percent as determined by the ammonium acetate method, and the soils are placed in Ultic subgroups. The Woodburn soil has mottles with chromas of two or less within the upper 30 inches and is in an Aquic subgroup. All, except for the Carlton soils, have argillic horizons (horizons which exhibit evidences of clay illuviation) within 40 inches of the

Table 5. Placement of the Soils in the Classification System (98, 100)

Profile No.	Subgroup Name	Family	Series
W-1	Pachic Ultic Argixerolls[a]	fine-silty, mixed, mesic	Willamette
W-2	Ultic Argixerolls[a]	fine-silty, mixed, mesic	Willamette variant
W-3	Pachic Ultic Haploxerolls	fine-silty, mixed, mesic	Carlton-like
W-4	Aquultic Argixerolls[a]	fine-silty, mixed, mesic	Woodburn
W-5	Pachic Ultic Argixerolls[a]	fine-silty, mixed, mesic	Willamette
W-6	Ultic Argixerolls[a]	fine-silty, mixed, mesic	Willamette variant
W-7	Ultic Argixerolls[a]	fine-silty, mixed, mesic	Willamette variant
W-8	Pachic Ultic Argixerolls[a]	fine-silty, mixed, mesic	Willamette
8118	Typic Haploxeralfs	fine-silty, mixed, mesic	Willamette-like variant
A-1	Argiaquic Xeric Argialbolls	fine-silty, mixed, mesic	Amity
X-1	Fluventic Haplaquolls	fine-silty, mixed noncalcareous, mesic	Wapato
C-1	Typic Ochraqualfs	fine-montmorillonitic, mesic	Concord
D-1	Typic Albaqualfs	fine, montmorillonitic, mesic	Dayton
D-2	Typic Albaqualfs	fine, montmorillonitic, mesic	Dayton

[a] The presence of the lithologic discontinuities in these soils negates the requirement of a 1.2 clay ratio between the argillic and eluvial horizons (100).

surface, and all are in the suborder Xerolls, the dry season Mollisols.

The classification of the variant outside the area as a Xeralf also is in recognition of the dry summer in western Oregon. This unnamed Willamette variant, near Monmouth, has an ochric epipedon, mottles with chromas of 2 above 40 inches (not above 30 inches, a criterion of moderately well-drained soils), and base saturation above 75 percent (by sum) in some portion of the argillic horizon. This soil is classed in the Typic Haploxeralfs subgroup.

Amity soils have an albic horizon with a gradual textural change into the argillic horizon and, although they exist in a climate with an annual dry season, are affected by a high water table as evidenced by low chromas within 24 inches of the surface. These characteristics place the soils in the Argiaquic Xeric Argialbolls subgroup.

Wapato soils have, in addition to the mollic epipedon, chromas of 2 or less throughout, no argillic horizon, and are presumed to have irregularly decreasing organic matter contents of at least one percent within 50 inches of the surface. The soil is placed in the Fluventic Haploxerolls on the basis of these characteristics.

Concord and Dayton soils are quite similar. They have ochric epipedons. Both soils are saturated with water during the winter and have chromas of 2 or less in the A horizons, and have albic horizons. Dayton soils have an abrupt textural change to an argillic horizon.

Dayton soils are Typic Albaqualfs. Concord soils are Typic Ochraqualfs.

Soil climatic criteria are used in placing soils in a Xeric suborder of Mollisols or Alfisols, or in a Xeric subgroup. The soil climate can be inferred from the climate of the atmosphere as given in Table 1. The Xeric suborders include soils with mean annual soil temperatures of $47^{\circ}F$ ($8^{\circ}C$) or more. This temperature at 20 inches is about 2 degrees higher than the temperature of the atmosphere. The soils must also be dry for at least 60 consecutive days in more than 7 out of 10 years in all parts of the soil between 4 and 12 inches. This period is usually during July and August and into September, as interpreted from Table 1. The climatic criterion for the Xeric subgroup of the Argialbolls is that the soil is dry in all parts between 7 and 20 inches for more than 30 consecutive days.

The families in which the soils are classified are determined on at least three characteristics, texture, mineralogy, and climate. Mean annual soil temperatures from 47 to $59^{\circ}F$ are required for soils in a mesic family. The textural families are groupings of soil textural classes based on the standard USDA textural triangle. Fine family indicates clayey textures and fine-silty includes heavy silt loams and light silty clay loams.

The mineralogy classes are based on the composition of the sand, silt, and clay fractions of the soil. The meaning of mixed mineralogy is evident. Montmorillonitic means that there is more of this kind of clay mineral present than of any other. The noncalcareous reaction class is used with calcareous as differentiae in the Aquolls.

Genesis

In attempting to determine the major effects on the formation of a soil, it is traditional to consider the five factors of soil formation: time, parent material, topography, climate, and organisms (52). The influence of each of these factors will be considered, but the specific terms will not be used extensively in discussing the characteristics of the soils in the study area.

Since the soils of the Willamette group are the primary interest of this study, the discussion of the other soils will not be extensive. The other soils occur on one or two geomorphic surfaces. Concord, Dayton, and Amity are on the Calapooyia and Senecal surface and Wapato is on the Ingram surface. The fact that each of the former is on similar surfaces reduces the probability of differences between profiles or, conversely, increases the chances for similarities.

Parsons and Balster described the genesis of Dayton soils (68), and Parsons, Simonson, and Balster discussed the similarities in the genesis of Dayton, Concord, and Amity soils (70). In general, these soils are in flat to concave or nearly level positions on the landscape from which surface runoff is restricted (Figure 8). Furthermore, the internal drainage is restricted by the Malpass Member in the Dayton and Concord soils and by proximity to the Malpass as well as by position in the Amity soils, which seldom have water standing on the surface. In the study area, surface and ground water drain from higher levels over and through the Amity to the Dayton soils. When movement to the lower area is restricted by the volume of water already present, it does not move from within the Amity soils.

The A2 horizons have formed in these soils on the flat terrace positions because of the water held in the soil during the rainy season with subsequent iron reduction and leaching. The nearer the soil is to the concavity of the terrace surface and the thicker the Malpass clay, the thinner the A1 horizon and the less well drained the soil. Because of the degree of saturation of the soils in the winters, a greater variety of crops can be grown on the Amity than on the Concord or Dayton soils. This influence of drainage on vegetation is reflected in the thickness of the A1 horizons. In addition, the wet conditions, during the cool part of the year, prevent rapid decomposition of organic matter as indicated in Table 3.

There has been little movement of clay into the IIB2t horizons of these soils from the A2 horizon. In Concord and Dayton soils, the eluviation of gray clay has been from the IIB2t horizons into the material below. In places it appears as though the IIB2t and IIC materials are interstratified. The brown clay films in Amity and

Concord soils are below the lithologic discontinuity.

Wapato soils are on the level stream terrace of the Ingram surface. This soil has formed in deposits of silty alluvium. The clayey material deep in the profile was apparently deposited in quiet water and the later layers in slowly moving water, as indicated by the different textures. The sources of the materials could have been the Dayton B horizon (Malpass Member) for the finer textures and the A and B horizons of the Willamette and Amity soils for the coarser, silty textures.

The position of the Wapato, X-1, soil is such that surface and ground water accumulate and the clayey layers restrict the downward movement of water. The organic matter content is high throughout the soil, although it presumably decreases irregularly with depth. Microbial decomposition is limited because of saturated conditions in the winter and dry conditions in summer.

The B horizons show little alteration from what is presumed to have been parent material derived from the erosion of silty soils upstream. The A and B horizons are quite similar and differ primarily in organic matter content, structure and lighter colors in the lower B horizon. The minimal soil development can be attributed to the relative youthfulness (16) of the material associated with the Ingram surface and the inhibitory effects of poor drainage.

Parsons, Simonson, and Balster also developed some conclusions about the genesis of Willamette and Woodburn soils on the valley terrace in the southern Willamette Valley (70). They recognized the discontinuities in the upper sola, below which brown clay films had developed.

All of the soils in the Willamette group in the McCoy area have brown or reddish brown clay films below the lithologic discontinuity. The clay-CEC ratios and the CEC values indicate montmorillonitic clays in these horizons. There are also thin clay films in the B1 horizon of profile W-1, the B21 of W-5, the B21t of profile W-6, and the B1 and B21 horizons of W-7. As mentioned previously, the reddish brown and brown clay films at the discontinuity are increasingly less prominent in the soils with increasingly poor drainage in the Willamette, Woodburn, and Amity catena.

Because of the regional extent of the deposits, it is concluded that the deposits associated with the Bethel, Calapooyia, and Senecal surfaces in the Yamhill River Valley are the same as those recognized in the southern Willamette Valley (17). The upper three members of the Willamette Formation are present in the study area. The Malpass Member is discontinuous as has been previously reported (16, 17, 68, 70). The Irish Bend Member constitutes the basal sediments beneath the Bethel, as well as the Calapooyia and Senecal surfaces, which were later mantled by the sediments of the Greenback Member. The similarities between the materials above and below the lithologic discontinuities on the three surfaces have been previously noted in this paper. The relative constancy of the mantle thickness has been discussed under Stratigraphy.

Materials moved from the crests of the hills have accumulated in positions intermediate between the hilltops and the valley terraces. The Willamette W-1 and the Carlton-like W-3 profiles typify the over-thickened epipedon of this position. Both soils have IIB21t horizons, but in the Carlton-like profile the argillic horizon is below one meter, a depth which is important in the classification system. Although there is "side-valley" alluvium, there are very few places that were obviously the source of the material. That is, there are very few places on the landscape where the depth to the lithologic discontinuity is obviously less than about 20 inches. This suggests either uniform sheet erosion of the whole mantle on the hills or the addition of material from outside sources. A combination of the two mechanisms is possible.

Interestingly, the upper sola of the Willamette W-5 and W-8 profiles on the terrace are not as thick as those described above. With depths of about 30 inches to the discontinuity, these soils are similar to those described in the southern valley (70).

The organic matter content of all of the Willamette group of soils is sufficiently high to depths of 20 or more inches that all of the profiles would not only qualify as having mollic epipedons, but would also be classified in the Pachic subgroup of Argixerolls. The light color of part of the matrix in the upper solum in each of four of the profiles precluded placement in the Pachic extragrade. As noted previously, the soils on the Bethel surface have lower organic matter contents than do the soils of the valley terrace. In the higher positions the only source of the organic matter is the vegetation growing there. Lower on the hills of the Bethel unit, organic matter from vegetation at the site as well as organic material contained in the slopewash may add to the profile.

Well drained soils of the hills have less organic matter than the Woodburn, a somewhat poorly drained soil. Wetness restricts decomposition in this case while on the valley terrace it also restricts plant growth. The better drained Willamette soil, W-5, has a higher organic matter content than W-8, which is not quite so well drained.

The kinds and amounts of extractable cations present on the exchange complex are indicative of the stage of weathering of the minerals in the various parts of the solum (51). The material in the upper sola of all the soils except Wapato is apparently, from the relative amounts of Ca, Mg, and K in the various horizons, in an intermediate stage of weathering (51). This is deduced from the values of the exchangeable cations, the cation exchange capacities, and the clay-CEC ratio; the latter must also consider the organic matter content. Whether or not the material was weathered primarily before or since deposition is problematical. However, it seems logical to conclude that the material was in an early intermediate stage when deposited and has further weathered in place.

Considering the bases in decreasing order of mobility under leaching conditions: Na, Ca, Mg, and K, the Ca-Mg ratios in Table 4 should increase with depth (51). One of the most obvious reasons that the ratios are large and generally decrease with depth, to a lower limit, is that Ca has been added in the form of agricultural lime. Another reason is the effect of nutrient cycling of calcium, but not magnesium, by the vegetation. However, instead of having very high base saturation in the surfaces, the soils are sufficiently acid that there is only a slight increase in the base saturation percentages, if any, in all of the soils, except Wapato and the Willamette soil from the southern Willamette Valley.

The abrupt change in base saturation below the discontinuity marks a difference in weathering from that above and an accumulation of basic cations. This distribution reflects "normal" weathering for some soils, such as the Miami series of the Mid-West (13), except that the boundary between A and B horizons of the Gray Brown Podzolics (Udalfs) is not abrupt and often consists of a transitional horizon (94). Because Willamette-like soils have been classified previously as Gray Brown Podzolics transitional to Prairie soils (74), they may be compared with soils of the Miami (94) or Grundy and

Pershing (104) series. The B horizons are much deeper in the Willamette group, a fact most probably due to cool, moist climatic influences on soil forming processes as well as to more recent deposits of alluvium. Movement of bases and accumulations of organic matter seem to be greater than in the Brunizenic soils (104).

Depths to the break in physical and chemical properties are not similar for all of the Willamette group of soils in the different landscape positions. There are evidences of two breaks in some properties of soil profiles W-1, W-3, W-5, W-7, W-8, 8118 and 59691. As previously mentioned the B1 and B21 horizons could be transitional between the A and IIBt horizons, or there is the possibility that the B1 and B21 horizons may be remnants of a paleosolic A horizon formed in the lower sediments (Irish Bend Member). However, a more probable explanation is that these are degraded B horizons (7). Leaching could have destroyed the clay films and increased the downward movement of bases. These profiles are in the low hill and valley terrace positions, so runoff water containing additional organic acids than provided by the local vegetation could have increased the depth of weathering. The profiles of the higher parts of the Bethel surface do not exhibit the "transition" tendency.

Grainy gray ped coatings, similar to those described in Brunizems (8) and later called neo-skeletans (7), have been described in the upper B horizons of most of the soils of the Willamette group.

They are also in the soils of the Willamette catena (70). That the coatings are no more prominent in the terrace soils than in the hill soils suggests that intensity of weathering has been similar for both geomorphic situations. It is probable that the oaks, which grow on the better drained hill sites (47), provided more acid conditions than would have been available had the hill been in grass.

The downward movement of water through these soils seems to be retarded by the IIBt horizons. Reducing conditions exist in the upper horizons for variable amounts of time. The bleached grains may be eluviated to ped faces from the A horizon as water moves through the profile. The A2 horizon in Amity soils is a more pronounced example of the leaching. The deeper rooted grasses growing on the soils of the Willamette group tend to offset the effects of leaching by recycling the bases.

The cation exchange capacity and the clay-CEC ratio values suggest a change in clay mineralogy between the upper and lower sola of all the soil profiles except the Wapato. Microscopic examination of very fine sand and coarse silt grains revealed red coatings of metallic oxides on the surfaces of some feldspars. The clay films in the IIB horizons have a similar color.

The cursory examination of sand and silt grains provides evidence of differences between the upper and lower strata within the sola. The most obvious difference is that there is less biotite above than below the discontinuity. This distribution would be expected for the stage of weathering assumed were there not approximately equivalent amounts of hornblende and hypersthene below and above the lithologic discontinuity. Some feldspars have been etched, but the rest of the minerals are quite fresh, except for rounded edges.

CONCLUSIONS

The formation of the Willamette group of soils, Willamette, Woodburn, Amity, and Willamette variants, seems to be much like the sequential models II and III that Arnold developed for Iowa (7). In the McCoy area, as in the rest of the Willamette Valley where these soils occur (16, 17, 70), a portion of the soils was removed and a somewhat similar parent material was deposited on the truncated paleosol. This hypothesis requires only one unstable phase, whereas in the study area at least three episodes of instability took place.

One of these was the period of erosion creating hills and broad valleys. The downcutting was interrupted by deposition of the Irish Bend silts over all the land forms to an elevation of about 250 feet in the vicinity of the study area. The geomorphic surfaces represented by the upper limits of these deposits are the Calapooyia and Bethel units. Major drainageways began to be cut into the sediments, initiating a second period of instability. As the paleo-valley floor was eroded, and drainage patterns integrated on the terrace, the basic configuration of the Senecal unit began to be formed. Preceding and during the long period of formation of the Senecal surface, soil forming processes were in action.

The Malpass clays were probably deposited from turbidity currents in quiet water after the period of downcutting that formed the

Senecal unit. The apparent uniformity of the clay inside and outside of the study area (68) indicates similar deposits. Following the clay was the deposition of one or more strata of silts, the Greenback unit, with attendent erratics. There are erratics buried in the Irish Bend silts, but they are more weathered than those found on the surface.

The third major unstable phase of any consequence in the McCoy area was the completion of the incision of the drainageways and the attendant back filling to form the Ingram surface. The Winkle surface is not represented, and the Horseshoe surface, the stream channel, is of minor consequence.

An additional geomorphic surface, distinct from the Dolph unit, which it resembles in part, is suggested for the study area and the Willamette Valley. The name Bethel is proposed for the surface. The Bethel surface is similar in age to the Quad surface, but has a different configuration. Forming the surface of Bethel unit, as well as the two lower geomorphic units, seem to be at least two geologic strata correlative with those of the southern Willamette Valley, the Irish Bend and Greenback Members of the Willamette Formation (17).

The Bethel surface, at least in the study area, has not been subject to sedimentation since the last major inundation filled the valley. The only other possible source of material of the sizes found on this surface is loess. However, medium and coarse sand and pebbles, the erratics, are too coarse to have been transported by wind (9, 10). The Calapooyia and Senecal surfaces most probably received sediments from at least local runoff until incision created the Ingram surface and restricted all but the most severe floods to these channels. Present flooding from runoff is restricted to the Ingram surface. Most of the valley terrace floods by ponding during the wet season because there is little runoff and water seeps from the hills to the flats, but there is no overbank flooding from streams. Downhill movement of sediment is apparently minimal--the sediments seem to accumulate in intermediate positions only over a long period of time.

There is adequate evidence of a lithologic discontinuity in the soils of the study area. Although the pronounced change in any one of the physical, chemical, or mineralogical characteristics is not wholly definitive for a discontinuity in itself, the data support the same places or points in the Willamette, Woodburn, and Amity soil profiles as breaks between strata and are considered to be sufficient evidence of the discontinuities. The data for the Concord and Dayton profiles reaffirm the conclusions of previous studies that there are two discontinuities and three stratigraphic units associated with the Calapooyia and Senecal surfaces in the Yamhill as well as the southern Willamette Valleys (16, 17).

Morphologic recognition of the exact place in the profile where the discontinuity occurs is sometimes difficult. The "transitional" B1 and B21 horizons of some "Willamette" profiles are more likely the products of degradation of genetic horizons than of aggradative processes in different strata. The mineralogy of the horizons suggests that these horizons are below the discontinuity. It is probable that the uniform thickness of the dark brown silts on the hill in Figure 7 is at least partly due to pedogenetic processes of organic matter accumulation and illuviation of bases. It is usually easier to recognize the argillic horizon than the discontinuity.

The argillic horizons in the profiles of the Willamette group of soils seem to be a product of late Wisconsin rather than of Recent time. That is, they began to form no later than the Hypsithermal Interval. The last deposit on the tops of the Bethel surface probably occurred about 13,000 years ago; therefore the soils of the higher portions of the surface are relict soils (85) in that some of the soil characteristics may be attributed to previous environments. Similar soils lower on the hills, and probably those on the valley terrace, may be truncated and "buried" soils as suggested by Glenn (45) and Balster and Parsons (17). The brown paleosol was covered by materials of the Malpass and Greenback Members after development of the thin surface Willamette variants. However, the mantling sediments apparently are not deep enough to prevent continuing soil development in the underlying soil remnant, and therefore, the argillic horizons are being modified. Presumably the relict soils are in equilibrium with the environment in the hill top position with less water moving through the profile and less organic matter providing acids for leaching and weathering of mineral components. The probable source of most of the montmorillonitic-type clay and the colloids in the argillic horizon in the Willamette group of soils is the sediment in which the horizon formed. Some of the clay was very likely eluviated from the overlying strata. It is also possible that some of the clays might have settled from the Malpass clay materials as that stratum was deposited. Although Malpass-like clays were deposited above 350 feet in the Willamette Valley (personal observation), these gray clays probably did not mantle all of the inundated surfaces but remained as density currents moving into depressional regions and away from the ridges and knolls. Most of these clays (Malpass Member) are on the Calapooyia surface. Degraded clay films on ped faces below the layer of gray clay indicate that the hypothesis that brown clay films are from gray clayey sediments is improbable.

The gray clayey material in the Wapato profile is similar to the Malpass clay and could have been eroded from the Dayton and Concord soils in various places and, mixed with siltier sediments, deposited under what are now younger surfaces. The mixed deposits are exemplified by the Wapato IIC horizons.

Soils of the Willamette group are similar to soils of the Miami series as described by Thorp, Cady, and Gamble (94) in that they have neo-skeletans on ped faces and have clay films that were formed under a different climatic regime and are, in part, degrading. However, the soils of the Willamette group are intergrades toward Ultisols from Mollisols rather than being Alfisols (Gray Brown Podzolics) as are the Miami soils. In this light they are similar to the Brunizems (Mollisols) described by White and Riecken (104) and by Arnold (8) as having grainy gray coatings formed under deciduous forest before the vegetative cover shifted to grass. As implied earlier, the well drained thin surface Willamette variants on the high Bethel surface could have formed under oak cover with the neo-skeletans resulting from acid leaching. The Willamette soils on the valley terrace have grainy gray ped coatings that are probably the result of reducing conditions produced by water standing in the profile for some length of time during the rainy season.

From these considerations it may be concluded that the effect of forest vegetation on soil formation is similar in this regard to the effects of restricted soil drainage. That is, acid leaching and restricted drainage, along with other factors, provide reducing conditions, cause eluviation of bases, and create neo-skeletans. There need to be observations and studies made of the soils developing under oak groves in and near the study area.

Low chroma mottles and/or matrix colors are considered indicative of restricted drainage and are created under reducing conditions. However, they are present when water has saturated the soil for periods of weeks rather than days. Low chroma colors are not necessarily formed if the soil profile is saturated with water for only a few days following a rainy period and then drains to field capacity. However, under these conditions, the ped coatings could form. Unless the soils are irrigated, most reactions must take place when soil temperatures are low, since this is when the moisture is available. The cool, moist conditions inhibit rapid soil forming processes. The components involved react slowly, and reducing conditions tend to prevail.

The "Willamette group" is a topo-chrono-litho-(and perhaps bio-) sequence of soils and includes the better drained soils of the Willamette catena (74): Willamette, Woodburn, and Amity series. Soils in Ultic, Pachic Ultic, and Aquultic subgroups of Argixerolls and Haploxerolls occur in the study area as well as Argiaquic Xeric Argialbolls. Typic and Aquultic Haploxeralfs, from outside the study area, may also be considered as part of the group.

Of the soils observed, the only one that might be recommended as a new soil series is the member of the Ultic Argixerolls on the high Bethel surface. The other soil variants may be included as aberrents within various mapping units, taxadjuncts. It is unlikely, however, that there is sufficient acreage of the Ultic Argixeroll (possible name--Zena) to recognize a new tentative series. During the progress of the soil survey of Polk County by the Soil Conservation Service, additional observations of the soils associated with the high Bethel surface will confirm whether or not a series in an Ultic subgroup is of sufficient extent to be recognized.

Should the acreage of Ultic Argixerolls on the Bethel surface be insufficient for a new soil series, the Willamette mapping units will include these soils, recognizing the differences. On the premise that no new series will be recognized, the soils of the Willamette group recognized in the study area are included in mapping units presently used by the Soil Conservation Service, which are previously established members of the catena. The mapping units for the study area are shown on the map (Figure 10) and described in the section on Descriptions and Delineations.

In the Polk County soil survey of 1927, Torgerson, et al., (95) mapped Carlton where there now would be Willamette or Woodburn soils. Willamette soils were mapped for areas that now would include Woodburn and, in a few places, Carlton soils. This may be illustrated by comparing Figure 2 and 10. As noted before, Woodburn soils were not recognized in 1927. The survey party had a strong appreciation of geomorphology and delimited the soils accurately within the soil definitions available at that time. The present use of aerial photographs facilitates accurate mapping and the criteria of the new classification system makes possible the recognition of many new soil series. Greater accuracy than available previously is desirable, but the feasibility of using more soil series than in use at present is questionable.

The importance of soil-geomorphic relationships cannot be overemphasized, although the concept can be overused. Geomorphology and topography can be related directly to time and often to parent material and reflect the influence of climate, which in turn influences the vegetation. Through wise application of geomorphology and geomorphic principles and judicious use of the soil auger, accurate and highly useful soil surveys can be made available to the public. Soil mapping should be accomplished with understanding and enjoyment, not just with mechanical observation of the morphology of the soil continuum at one point in the landscape.

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APPENDICES

APPENDIX A: GEOMORPHIC SURFACES

These descriptions of the geomorphic surface mapping units are from Balster and Parsons (16).

> Dolph unit. The Dolph unit is the next youngest group of landforms below the Eola unit and is named for Dolph Corner, which is about 3 miles north of Dallas.
>
> Topography of the Dolph surface varies, but locally the surface is well above the general level of the valley floor as extensive flats. Most of these flats have been dissected to form a rolling topography composed of a complex group of landforms that could be further divided into about three units for detailed mapping. In many places dissection has formed landscapes that are mapped as Looney if they are large enough to warrant delineation. Numerous small pediments that grade from broken topography of the Looney unit down to the main valley floor are also included in the Dolph unit. The boundary between these Dolph pediments and the steep Looney slopes is usually marked by a distinct change in slope gradient. The small valleys and their sideslopes that have been formed by dissection of the flats are also included in the Dolph unit.
>
> Characteristics of the Dolph surfaces progressively change over the length of the valley. Extensive flats underlain by very weathered gravel, sands, and clays are well expressed near Alvadore. Similar flats near Corvallis have a layer of light gray, massive silt above weathered gravel. At Dolph Corner the surface is immediately underlain by weathered gravel and numerous erratics (4, 6)[8] are scattered on the surface. Farther north, near McCoy, thick massive or contorted silts with numerous erratics completely mask any weathered gravel that may be there. More rounded landforms characterize the Dolph surface in the northern parts of the valley. Strath terraces along the eastern margin of the Willamette Valley in Linn County were also mapped as Dolph.
>
> Most of the erratics that caused Allison (2) to relate the Willamette Silts to glacial meltwaters are associated with the Dolph surface and the massive unbedded silts that

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[8] Reference numbers have been changed to coincide with this bibliography.

occur beneath it. The bedded Willamette Silts seem to be entirely restricted to the Calapooyia and Senecal surfaces, which are much younger.

Most of the weathered gravel so common beneath the Dolph surface probably correlates with the Lacomb and Leffler deposits. It seems, then, that the age of the Dolph surface should be considered to be middle Pleistocene.

Quad unit. The Quad unit is similar in morphology to the topographically slightly lower Calapooyia unit. The Quad unit is not extensive. For lack of a better known type locality, the quadrangle on the campus of Oregon State University serves as a source for the name.

The most satisfactory explanation of the Quad unit seems to be that faulting uplifted an area of Calapooyia surface before cutting of the landform was complete. The latest deposits that are present on the Calapooyia surface are lacking on the Quad unit. The higher elevations and the different deposits that underlie the Quad surface justify it as a unit for mapping.

Characteristically, the Quad surface has only a few feet of relief except along the slightly dissected scarp that marks its boundaries. For this reason, it belongs to the group of surfaces associated with the Willamette Valley floor.

The Quad unit is obviously somewhat older than the Calapooyia surface. It is probably much younger than the Dolph surface. Weathering of materials underlying the soils of the Dolph surface is extreme compared to the weathering of materials underlying the Quad land forms. Inadequate as the state of weathering is for estimating age, it is the only criterion available here other than placement in vertical sequence. On the basis of morphology and state of weathering, the Quad surface is considered to be more closely related to the Calapooyia unit than to the Dolph unit. A late Pleistocene age seems most reasonable.

Calapooyia unit. The Calapooyia unit is an extensive landscape on the main valley floor. The Calapooyia unit is best expressed in the southern part of the valley and is particularly prominent along the eastern side of the Calapooyia River, from which it takes its name.

Absence of appreciable local relief is characteristic of the Calapooyia topography. Maximum difference in elevation usually does not exceed 2 or 3 feet. In the southern part of the valley, the surface declines in a northwesterly direction at a rate of about 5 feet per mile. As is expected on a surface with these characteristics, drainage is unorganized, or very poorly organized at best; and drainage of surface water is extremely slow.

* * * * *

The Calapooyia surface is a product of deposition of a thin mantle of materials on a valley floor surface that was eroded from earlier materials, predominantly Willamette Silts (2). Allison postulated that the valley floor was formed by deposition of Willamette Silts. Detailed investigations, however, show that the Calapooyia surface extends many miles beyond any parallel-bedded silts that can be safely assigned to Willamette Silts. Therefore, it must be concluded that the Calapooyia surface is considerably younger than the Willamette Silts. At least three important events occurred between the deep incision of the valley below the Delph surface and deposition of the final units on the Calapooyia. First, the deeply incised valley was filled by a great thickness of alluvium, which was then covered by Willamette Silts. Second, the depositional surface of the Willamette Silts, which very likely had been exposed long enough for a soil to develop, was eroded. Third, clay was deposited over the eroded plain and subsequently was covered by a thin mantle of silt to form the Calapooyia surface. Erosion during the second episode completely removed any silts that may have been deposited in the southernmost part of the valley and cut deeply into the underlying gravel. The uppermost clay and silt units of most of the area south of Harrisburg lie directly on the older gravel deposits. Willamette Silts are also absent in the vicinity of Canby and were probably completely removed by erosion to expose the underlying alluvium.

No samples of wood or charcoal have been found in the Willamette Silts. Samples from the underlying units have all been beyond the reach of radiocarbon dating. An absolute age for the Calapooyia surface is unavailable, but its development probably took place during late Pleistocene.

Senecal unit. Modification of the Calapooyia surface and the development of drainage produced the landscape of the Senecal unit. The area around Senecal Creek near Woodburn has been chosen as the type expression of the unit and furnishes its name.

In the southern part of the Willamette Valley, organization of drainage of the Calapooyia surface has resulted in minor incision of the drainways. Consequently, modification of the Calapooyia surface has been minor. Locally, it appears that the drainage organization has been produced by overland flooding of a nearby major stream shortly after deposition of the final blanket of silty material.

* * * * *

Farther north in the valley, incision of streams and drainageways into the Calapooyia surface has resulted in two kinds of modification. The organization of drainage with little or no incision results in small areas of the Senecal unit surrounding major drainageways to their outer fringes. Deeper incision resulting in the deep, narrow valleys could be mapped as Ingram unit with a larger map scale. However, it was necessary to include them in the Senecal unit for this study.

There is a marked change in the character of the Senecal landforms between the area south of the Salem Hills and the area north of the Salem Hills and east of the Willamette River. The Senecal surface south of the Salem Hills is typified by very slight relief and organization of drainage with little incision. The Senecal surface north of the Salem Hills and east of the Willamette River is typified by more deeply incised drainage with only minor amounts of the slightly incised organized drainage of the southern part of the valley. North of Salem and west of the Willamette River, Senecal landscapes include both of the above kinds of landforms. Extensive plains with only slight relief are cut by deeply incised valleys of the major streams.

Ingram unit. The Ingram unit includes the higher of two flood plain levels of the Willamette River and its tributaries within the main valley floor. It is named for Ingram Island, along the Willamette River northwest of Harrisburg.

* * * * *

Surfaces of the Ingram unit that are associated with smaller streams have correspondingly less relief simply because there was less water to cut the channels. Thus, the Ingram unit contains landscapes with a limited variety of relief characteristics. These characteristics are related to the stream that flowed through the particular area to form the surface.

APPENDIX B: SOIL PROFILE DESCRIPTIONS

Willamette silt loam W-1

August 24, 1967 Parsons-Gelderman

Classification: Pachic Ultic Argixerolls; fine silty, mixed, mesic

Location: 475' north, 4,450' west of SE corner Section 18, T6S, R4W, Polk County, Oregon

Vegetation: fallow following barley

Climate: microthermal, humid (40")

Parent material: alluvium from mixed sources, dominantly sandstone, siltstone, shale, and reworked alluvium

Physiography: sideslope of rounded hill--near slope break

Tts--Tuffaceous marine sediments--Oligocene

Dolph-Senecal surfaces boundary

Relief: simple, convex

Moisture: dry to 30±"

Elevation: 196'

Root distribution: normal--roots to 47+"

Slope: 2-3%

Salt or alkali: none

Aspect: SW

Stoniness: class 0

Drainage: well; medium runoff

Erosion: slight to none

Ground water: deep

Permeability: moderate

Notes: "upper solum may be 'surficial silts'"--RBP

--recommended as Willamette silt loam by A. O. Ness

--farmer burns grain stubble annually

--pH by Hellige-Truog Reaction Kit

Horizon	Depth (inches)	Morphology
Ap	0-10	Very dark grayish brown (10YR3/2) silt loam, grayish brown

Horizon	Depth (inches)	Morphology
		(10YR5/2) dry; moderate medium granular structure; hard, friable, slightly sticky and slightly plastic; common very fine tubular and very fine and very fine interstitial pores; worm worked; medium acid (pH 6.0); abrupt smooth boundary.
A12	10-18	Very dark brown (10YR2/2) light silty clay loam, dark grayish brown (10YR4/2) dry; moderate fine and medium granular and subangular blocky structure; slightly hard, friable, sticky and slightly plastic; common very fine, fine, and medium tubular and very fine and fine interstitial pores; worm worked; medium acid (pH 6.0); clear smooth boundary.
A3	18-26	Very dark grayish brown (10YR3/2) silty clay loam, grayish brown (10YR5/2) dry; moderate fine and medium subangular blocky structure;hard, friable, sticky and plastic; many very fine and medium, common fine tubular and common very fine and fine interstitial pores; worm worked; medium acid (pH 6.0); clear smooth boundary.
B1	26-39	Very dark grayish brown (10YR3/2) and brown (10YR4/3) silty clay loam, light brownish gray (10YR6/2) and brown (10YR5/3) dry; moderate fine and medium granular and moderate medium and coarse subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; many very fine, fine, and medium tubular and common very fine and fine interstitial pores; very few thin dark yellowish brown (10YR3/4) clay films, brown (7.5YR4/4) dry, on faces of small included peds; gray silt grains on 15 percent of vertical ped faces; worm worked; medium acid (pH 6.0); abrupt smooth boundary.

Horizon	Depth (inches)	Morphology
IIB21t	39-52	Dark brown (10YR3/3) and brown (10YR4/3) clay loam, pale brown (10YR6/3) dry; weak medium prismatic and moderate fine and medium subangular and angular blocky structure; hard, friable, slightly sticky and slightly plastic; many very fine, common fine tubular, and common very fine interstitial pores; common thin dark reddish brown (5YR3/4) clay films on ped faces, reddish brown (5YR4/4) dry; and few moderately thick dark brown (7.5YR4/4) clay films in pores, very few gray silt grains on ped faces; somewhat brittle; few rounded black (5YR2/1) concretions; slightly acid (pH 6.2); clear smooth boundary.
IIB22t	52-60	Brown (10YR4/3) clay loam, pale brown (10YR6/3) dry; massive and weak medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; many very fine, common fine and medium tubular and few fine insterstitial pores; very few thin dark brown (7.5YR4/4) clay films on ped faces, brown (7.5YR5/4) dry and few moderately thick dark reddish brown (5YR2/2) pore coatings, dark reddish brown (5YR3/2) dry; slightly acid (pH 6.4).

Willamette silt loam, thin surface variant W-2

August 24, 1967 Parsons-Gelderman

Classification: Ultic Argixerolls; fine silty, mixed, mesic

Location: 2,300' N, 4,225' W of SE corner, Section 18, T6S, R4W, Polk County, Oregon

Vegetation: fallow after barley

Climate: microthermal, humid (40")

Parent material: alluvium from mixed sources, dominantly sandstone

Physiography: rounded hill, near top; Its--Tuffaceous marine sediments--Oligocene; Dolph surface

Relief: complex, convex

Elevation: 220'

Slope: 2-3%

Aspect: SE

Drainage: well; medium runoff

Ground water: deep

Moisture: dry to 24"

Root distribution: normal--roots to 47"

Salt or alkali: none

Stoniness: class 0

Erosion: slight to none

Permeability: moderate

Notes: In solum there is a scattering of 1/4 to 1/2" pebbles of quartzite and granite to 37". At 37" is a stone line of 1 to 2" quartzite, sandstone, granite (and rhyolite?). "Bt seems to cross the stone line with development"--RBP. Recommended as Willamette by A. O. Ness.

Horizon	Depth (inches)	Morphology
Ap	0-10	Dark brown (10YR3/3) silt loam, brown (10YR5/3) dry; moderate fine and medium granular structure; slightly hard, very friable, slightly sticky and slightly plastic; common very fine and fine tubular and many very fine interstitial pores; strongly acid (pH 5.5); abrupt smooth boundary.
A3	10-15	Dark brown (10YR3/3) heavy silt loam, brown (10YR5/3) dry; moderate fine and medium granular and very weak medium subangular blocky structure; hard, friable, slightly sticky and slightly

Horizon	Depth (inches)	Morphology
		plastic; common very fine and medium tubular and very fine and fine interstitial pores; very few fine distinct black (5YR2/1) concretions; strongly acid (pH 5.5); clear smooth boundary.
B1	15-21	Dark brown and dark yellowish brown (10YR3/3, 3/4) clay loam, brown (10YR5/3) dry; moderate fine subangular blocky structure; hard, friable, slightly sticky and slightly plastic; common very fine and fine tubular and few very fine interstitial pores; gray silt grains on up to 20 percent of the ped faces; medium acid (pH 6.0); abrupt smooth boundary.
IIB21t	21-37	Dark brown (10YR4/3 and 7.5YR4/4) clay loam, pale brown and brown (10YR6/3, 5/3) dry; moderate medium prismatic and moderate fine and medium subangular and angular blocky structure; slightly hard, friable, slightly sticky and plastic; common very fine and fine tubular and interstitial pores; common thin reddish brown (5YR3/4) and dark reddish brown (5YR3/4) clay films on ped faces, few thin in pores; brown (7.5YR4/4) dry; very few gray silt grains on 5 percent of the ped faces; few fine distinct black (5YR2/1) concretions; somewhat brittle; medium acid (pH 6.0); clear smooth boundary.
Quartzite, sandstone and granitic pebbles--"stone line"-like		
IIB22t	37-56	Dark brown and brown (10YR4/3), 5/3) silty clay loam or clay loam, pale brown and very pale brown (10YR6/3, 7/3) dry; weak coarse prismatic and moderate medium and coarse angular and subangular blocky structure; very hard, friable, sticky and slightly plastic; common very fine and fine tubular and very fine

Horizon	Depth (inches)	Morphology
		interstitial pores; common moderately thick reddish brown (5YR3/4, 4/4) clay films on ped faces, reddish brown (5YR4/4) dry, few thin in pores, brown (7.5YR4/4) dry; gray silt grains on 15 percent of the ped faces and over the clay films; common fine distinct black (5YR2/1) segregations; somewhat brittle; medium acid (pH 6.0); clear smooth boundary.
IIB3t	56-65	Dark brown and brown (10YR4/3, 5/3) clay loam or silty clay loam, pale brown and very pale brown (10YR6/3, 7/3) dry; common fine distinct pale brown (10YR6/3) mottles, light gray (10YR7/1) dry; massive and weak coarse subangular blocky structure; hard, friable, slightly sticky and slightly plastic; common very fine tubular and few very fine interstitial pores; common thin, few moderately thick dark yellowish brown (10YR3/4) clay films on ped faces, brown (7.5YR4/4) dry, few thin in pores; medium acid (pH 6.0).

Carlton-like silt loam W-3

October 4, 1967

Classification: Pachic Ultic Haploxerolls; fine silty, mixed, mesic

Location: 3,225' S, 1,050' E of NW corner Section 20, T6S, R2W, Polk County, Oregon

Vegetation: fallow from small grain to clover

Climate: microthermal, humid (40")

Parent material: alluvium from mixed sources, dominantly sandstone, siltstone, and reworked alluvium

Physiolography: undulating hillside; Qws--Willamette Silt--Pleistocene adjacent to Tts--Tuffaceous marine sediments--Oligocene; Dolph surface

Relief: complex, convex

Elevation: 180'

Slope: 2-3%

Aspect: S

Drainage: well, medium runoff

Ground water: deep

Moisture: moist to 7" and below 30"

Root distribution: normal; roots to 27"

Salt or alkali: none

Stoniness: class 0

Erosion: slight to none

Permeability: moderate

Horizon	Depth (inches)	Morphology
Ap1	0- 3 1/2	Very dark grayish brown (10YR3/2) loam, grayish brown (10YR5/2) dry; moderate fine and medium granular structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine and fine tubular and interstitial pores; worm worked with few worm casts; strongly acid (pH 5.5); abrupt smooth boundary.
Ap2	3 1/2- 9	Very dark grayish brown (10YR3/2) loam, brown (10YR5/3) dry; moderate fine and medium granular structure; slightly hard, very friable, slightly sticky and slightly plastic; common very fine and fine tubular and interstitial pores; worm worked; strongly acid

Horizon	Depth (inches)	Morphology
		(pH 5.5); abrupt smooth boundary.
A13	9-15	Very dark grayish brown (10YR3/2) heavy silt loam, brown (10YR 5/3) dry; moderate fine and medium granular and weak medium subangular blocky structure; hard, very friable, slightly sticky and slightly plastic; many very fine, common fine tubular and common very fine interstitial pores; worm worked; strongly acid (pH 5.5); abrupt smooth boundary.
A3	15-24	Very dark grayish brown (10YR3/2) heavy silt loam, brown (10YR 5/3) dry; moderate fine and medium subangular blocky structure; hard, very friable, sticky and slightly plastic; common very fine, fine, and medium tubular and few very fine and fine interstitial pores; few worm casts; strongly acid (pH 5.5); clear smooth boundary.
B1	24-41	Dark brown and very dark grayish brown (10YR4/3, 3/2) light clay loam, pale brown and brown (10YR6/3, 5/3) dry; weak medium prismatic breaking to moderate fine and medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; common very fine and fine tubular and interstitial pores; few gray silt grains on 20 percent of ped faces; medium acid (pH 5.7); clear smooth boundary.
IIB21t	41-52	Dark brown and dark yellowish brown (10YR4/3, 4/4) clay loam, pale brown and light yellowish brown (10YR6/3, 6/4) dry; moderate medium and coarse prismatic parting to weak medium angular and subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few very fine tubular and common very fine interstitial

Horizon	Depth (inches)	Morphology
		pores; very few thin clay films on ped faces; gray silt grains on 10 percent of ped faces and obscuring clay films; micaceous; medium acid (pH 6.0); clear smooth boundary.
IIB22t	52-58	Dark brown (10YR4/3) clay loam, pale brown (10YR6/3) dry, with common fine distinct gray (10YR6/1) and strong brown (7.5YR5/6) mottles in peds and pores, light gray (N7/) and yellowish brown (10YR5/6) dry; massive weak coarse subangular blocky structure to hard, friable, slightly sticky and slightly plastic; common very fine and fine tubular and few very fine interstitial pores; very few thin clay films on ped faces; very few gray silt grains on 5 percent of ped faces; medium acid (pH 6.0); clear smooth boundary.
IIC1	58-62	Dark brown and dark yellowish brown (10YR4/3, 4/4) clay loam, pale brown (10YR6/3) dry, common fine distinct gray (10YR6/1) mottles, light gray (N7/) dry; massive; very hard, friable, slightly sticky and plastic; few very fine and fine tubular and few very fine interstitial pores; common thin dark reddish brown (5YR3/4) clay films on ped faces and in pores, dark brown (7.5YR4/4) dry; medium acid (pH 6.0); clear smooth boundary.
IIC2	62-90	Dark yellowish brown (10YR4/4) clay loam, light yellowish brown (10YR6/4) dry, with common fine distinct gray (10YR6/1) and few medium distinct dark brown (10YR4/3) mottles, light gray (10YR 7/1) and dark brown (7.5YR4/4) dry; massive; very hard, friable, sticky and slightly plastic; few very fine tubular pores; weakly acid (pH 6.5).

Woodburn silt loam W-4

October 9, 1967 Gelderman

Classification: Aquultic Argixerolls, fine silty, mixed, mesic

Location: 2,350' S, 1,150' E of NW corner, Section 20, T6S, R4W, Polk County, Oregon

Vegetation: fallow after wheat, returned to wheat

Climate: thermal, humid (40")

Parent material: alluvium from mixed sources, dominantly sandstone, silt-stone, shale, reworked alluvium

Physiography: rounded hilltop--Tts--Qws transition; tuffaceous marine sediments, --Oligocene and Willamette silts--Pleistocene; Dolph surface

Relief: complex, convex

Elevation: 200'

Slope: 1-1/2%

Aspect: N

Drainage: moderately well; medium runoff

Ground water: deep

Moisture: moist to 7" and below 30"

Root distribution: normal--roots to 45"

Salt or alkali: none

Stoniness: class 0

Erosion: slight to none

Permeability: moderate

Notes: There are four, 18" square and in diameter--3 granitic, 1 basaltic--100 yards E of the site, placed around an abandoned well.

Horizon	Depth (inches)	Morphology
Ap1	0-4 1/2	Very dark brown (10YR2/2) silt loam, brown (10YR5/3) dry; moderate fine and medium granular structure; slightly hard, very friable, slightly sticky and slightly plastic; common very fine, fine, and medium tubular and very fine and fine interstitial pores; medium acid (pH 5.8); abrupt smooth boundary.
Ap2	4 1/2-10	Very dark brown (10YR2/2) silt loam, brown (10YR5/3) dry; massive and moderate fine and medium granular structure; hard,

Horizon	Depth (inches)	Morphology
		friable, slightly sticky and slightly plastic; many very fine, common fine and medium tubular and interstitial pores; medium acid (pH 6.0); abrupt smooth boundary.
A3	10-17	Very dark brown (10YR2/2) light silty clay loam, brown (10YR5/3) dry; weak medium subangular blocky, and weak medium granular structure and massive; hard, very friable, sticky and slightly plastic; many fine tubular and common very fine and medium interstitial pores; many worm casts; medium acid (pH 6.0); clear smooth boundary.
B1	17-22	Very dark grayish brown (10YR3/2) silty clay loam, brown (10YR 5/3) dry, few fine faint brown (10YR5/3) splotchy mottles, pale brown (10YR6/3) dry; moderate fine and medium subangular blocky structure; hard, friable, sticky and slightly plastic; many very fine and fine tubular and interstitial pores; medium acid (pH 6.0); clear smooth boundary.
B21	22-29	Dark brown (10YR3/3) silty clay loam, brown (10YR5/3) dry few fine faint dark brown (10YR4/3) splotchy mottles, pale brown (10YR 6/3) dry; weak medium and coarse subangular blocky structure; hard, very friable, sticky and slightly plastic; many very fine and fine tubular and interstitial pores; gray silt grains on up to 5 percent of the ped faces; medium acid (pH 6.0); abrupt wavy boundary.
IIB22t	29-44	Dark brown (10YR4/3) clay loam, pale brown (10YR6/3) dry, few fine faint grayish brown (10YR5/2) mottles, light gray (10YR7/2) dry; moderate fine and medium prismatic and strong fine parting to medium angular and subangular blocky structure; hard, firm, sticky

Horizon	Depth (inches)	Morphology
		and plastic; common very fine and few fine tubular and common very fine interstitial pores; common moderately thick reddish brown (5YR 4/3) clay films on ped faces, brown (7.5YR4/4) and reddish brown (5YR4/4) dry; gray silt grains on up to 15 percent of the vertical ped faces and over clay films; few rounded black (5YR2/1) concretions; medium acid (pH 6.0); clear smooth boundary.
IIB23t	44-62	Grayish brown and brown (10YR5/2, 5/3) clay loam, pale brown and very pale brown (10YR6/3, 7/3) dry; moderate fine and medium subangular and angular blocky structure; hard, firm, sticky and plastic; few very fine and fine tubular and common very fine interstitial pores; common moderately thick dark brown (7.5YR4/2) clay films on ped faces, brown (7.5YR4/4) and reddish brown (5YR4/3) dry; gray silt grains and flows on about 10 percent of ped faces and in pores; few rounded black (5YR2/1) concretions; slightly acid (pH 6.3); clear smooth boundary.
IIB3t	62-73	Dark brown (10YR4/3) clay loam, pale brown and very pale brown (10YR6/3, 7/3) dry, common fine distinct light gray (10YR7/1) and dark yellowish brown (10YR4/4) mottles, white and yellowish brown (10YR8/1, 5/6) dry; weak medium subangular blocky structure and massive; slightly hard, friable, slightly sticky and plastic; few very fine and fine tubular and few very fine interstitial pores; few moderately thick brown (10YR5/3) clay films on ped faces and in pores, brown (7.5YR5/4) dry; few gray silt grains on up to 5 percent of ped faces; few black (5YR2/1) concretions; slightly acid (pH 6.3); clear smooth boundary.

Horizon	Depth (inches)	Morphology
IIC	73-87+	Brown, dark brown, and pale brown (10YR5/3, 4/3, 6/3) light silty clay loam, pale brown, yellowish brown, and light gray (10YR6/3, 5/4, 7/2) dry; massive; slightly hard to hard, friable, slightly sticky and plastic; few very fine and fine tubular pores; very few moderately thick clay films in pores; slightly acid (pH 6.3).

Willamette silt loam W-5

October 6, 1967

Classification: Pachic Ultic Argixerolls; fine silty, mixed, mesic

Location: 400' S, 1,075' E of NW corner of Section 20, T6S, R4W, Polk County, Oregon

Vegetation: clover

Climate: microthermal, humid (40")

Parent material: alluvium from mixed sources

Physiography: stream terrace above an Ash Swale tributary; Qws--Willamette Silt--Pleistocene; Senecal surface

Relief: simple, convex

Moisture: to 7" and below 26"

Elevation: 173'

Root distribution: normal; roots to 44"

Slope: 0-0.5%

Salt or alkali: none

Aspect: NNW

Stoniness: class 0

Drainage: moderately well; medium to slow runoff

Erosion: slight to none

Ground water: deep

Permeability: moderate

Horizon	Depth (inches)	Morphology
Ap1	0- 4	Very dark grayish brown (10YR3/2) heavy silt loam, brown (10YR 5/3) dry; weak and moderate fine and medium granular structure; hard, friable, sticky and slightly plastic; many very fine, common fine tubular, common very fine and fine interstitial pores; worm worked; medium acid (pH 6.0); abrupt smooth boundary.
Ap2	4- 9	Very dark grayish brown (10YR3/2) silt loam, brown (10YR5/3) dry; moderate fine, medium, and coarse granular structure; hard, friable, slightly sticky and slightly plastic; common very fine and fine tubular and interstitial pores; worm worked; medium acid (pH 6.0); abrupt smooth boundary.

Horizon	Depth (inches)	Morphology
A3	9-15	Very dark brown and very dark grayish brown (10YR2/2, 3/2) silt loam, brown and dark brown (10YR5/3, 4/3) dry; weak medium subangular blocky and moderate fine granular structure; hard, friable, slightly sticky and slightly plastic; common very fine and fine tubular and interstitial pores; common medium worm casts; medium acid (pH 6.0); clear smooth boundary.
B1	15-20	Dark brown (10YR3/3) silty clay loam, brown (10YR5/3) dry; moderate fine and medium subangular blocky structure; hard, friable, sticky and slightly plastic; common very fine and medium and few fine tubular and few very fine and fine interstitial pores; common fine and medium worm casts; medium acid (pH 6.0); clear smooth boundary.
B21	20-32	Dark brown and dark yellowish brown (10YR3/3, 3/4) silty clay loam, pale brown and brown (10YR6/3, 5/3) dry; weak medium prismatic and moderate fine and medium subangular blocky structure; hard, friable, sticky and slightly plastic; common very fine, fine, and medium tubular and few very fine and fine interstitial pores; gray silt grains cover 10 to 15 percent of ped faces and are over ghosts of thin brown clay films; very few very fine black (5YR2/1) concretions; few fine and medium worm casts; medium acid (pH 6.0); abrupt smooth boundary.
IIB22t	32-40	Dark grayish brown and dark brown (10YR4/2, 4/3) clay loam, pale brown (10YR6/3) dry, few fine distinct gray (N6/) mottles, white (10YR8/1) dry; moderate fine and medium prismatic parting to subangular and angular blocky structure; hard, firm, sticky and plastic;

Horizon	Depth (inches)	Morphology
		common very fine, fine, and medium tubular and common very fine interstitial pores; common thin and moderately thick dark reddish brown (5YR3/4) clay films on ped faces, reddish brown gray silt grains on 10 to 20 percent of the ped faces, without obscuring clay films; dry; few fine distinct black (5YR2/1) strains; medium acid (pH 6.0); clear smooth boundary.
IIB23t	40-56	Dark grayish brown and dark brown (10YR4/2, 4/3) clay loam, pale brown (10YR6/3) dry; with common medium distinct gray (N6/) mottles, light gray (10YR7/1) dry; weak coarse prismatic parting to weak medium subangular and angular blocky structure; hard, firm, sticky and plastic; few very fine and fine tubular and common very fine interstitial pores; few moderately thick dark reddish brown (5YR3/4) clay films on ped faces, reddish brown (5YR4/4) dry; gray silt grains on 10 percent of vertical ped faces, not on clay films; few fine distinct black (5YR2/1) stains; slightly acid (pH 6.3); clear smooth boundary.
IIC	56-70	Dark grayish brown (10YR4/2) clay loam or silty clay loam, very pale brown (10YR7/3) dry, few medium distinct gray (N6/) mottles, light gray (10YR7/1) dry, common fine distinct strong brown (7.5YR5/6) mottles, moist and dry; massive; hard, friable, sticky and slightly plastic; few very fine and medium tubular pores; few thin reddish brown (5YR4/4) clay films in pores; slightly acid (pH 6.3).

Willamette silt loam, thin epipedon variant W-6

October 6, 1967 Gelderman

Classification: Ultic Argixerolls; fine-silty, mixed, mesic

Location: 1,400' N, 1,150' E of SW corner Section 17, T6S, R2W, Polk County, Oregon

Vegetation: gray oats to clover

Climate: microthermal, humid (40")

Parent material: alluvium from mixed sources, dominantly sandstone, siltstone, and reworked alluvium

Physiography: rounded side of hill, near low top; Tts--Qws transition--Tuffaceous marine sediments--Oligocene and Willamette Silts--Pleistocene; Dolph surface

Relief: complex, convex

Elevation: 200'

Slope: 3-4%

Aspect: SW

Drainage: well; medium runoff

Ground water: deep

Moisture: to 7" and below 30"

Root distribution: normal; roots to 48"

Salt or alkali: none

Stoniness: class 0

Erosion: slight to none

Permeability: moderate

Notes: the B21, 20-29" is like an arentic horizon; the peds with clay films seem to be remnants of a reworked Bt horizon.

Horizon	Depth (inches)	Morphology
Ap1	0- 4	Dark brown and very dark grayish brown (10YR3/3, 3/2) loam, brown and light brownish gray (10YR5/3, 6/2) dry; moderate medium and coarse granular structure; slightly hard, very friable, slightly sticky and slightly plastic; many very fine and few fine and medium tubular and many very fine and fine interstitial pores; worm worked; medium acid (pH 6.0); abrupt smooth boundary.
Ap2	4-9 1/2	Dark brown (10YR3/3) heavy silt loam, brown (10YR5/3) dry;

Horizon	Depth (inches)	Morphology
		weak and moderate medium and coarse granular structure; hard, friable, sticky and slightly plastic; common very fine and fine tubular and interstitial pores; silt coatings in pores; worm worked; medium acid (pH 6.0); abrupt smooth boundary.
A3	9 1/2-15	Dark brown (10YR3/3) heavy silt loam, brown (10YR5/3) dry; weak medium subangular blocky structure and massive; hard, friable, sticky and slightly plastic; many very fine and tubular and very few very fine and fine interstitial pores; worm worked; silt coatings in pores; medium acid (pH 6.0); clear smooth boundary.
B1	15-20	Dark yellowish brown (10YR3/4) silty clay loam, brown (10YR5/3) dry; moderate fine and medium subangular blocky structure and massive; hard, very friable, sticky and slightly plastic; many very fine and fine tubular and few very fine and fine interstitial pores; worm worked; gray silt grains on about 10 percent of the ped faces; medium acid (pH 5.7); clear smooth boundary.
B21t	20-29	Dark yellowish brown and dark brown (10YR3/4, 4/3) clay loam, pale brown and brown (10YR6/3, 5/3) dry; moderate fine and medium subangular blocky structure; slightly hard, very friable, sticky and plastic; many very fine and fine tubular and few very fine and fine interstitial pores; few thin dark yellowish brown (10YR 3/4) clay films on ped faces, brown (75.YR5/4) dry; gray silt grains as coatings on 15 percent of the ped faces; some worm casts; medium acid (pH 6.0); abrupt smooth boundary.
IIB22t	29-44	Dark brown (10YR3/3) clay loam, pale brown (10YR6/3) dry, few fine distinct black (5YR2/1) crystal-like mottles near pores; weak

Horizon	Depth (inches)	Morphology
		fine and medium prismatic and strong fine and medium subangular and angular blocky structure; hard, friable, sticky and slightly plastic; common very fine and few medium tubular and common very fine and fine interstitial pores; common moderately thick dark reddish brown (5YR3/4) clay films on ped faces and in pores, reddish brown (5YR4/4) dry; gray silt grains on 15 percent of the ped faces and obscuring 5 percent of the clay films; worm casts; medium acid (pH 6.0); clear smooth boundary.
IIB23t	44-59	Dark brown (10YR4/3) clay loam, pale brown (10YR6/3) dry, few fine distinct black (5YR2/1) mottles; moderate fine and medium subangular blocky structure; hard, friable, sticky and slightly plastic; common very fine and fine tubular and interstitial pores; common thin dark reddish brown (5YR3/4) clay films on ped faces and in pores, very few thick in pores, brown (7.5YR5/4) dry; gray silt grains on 10 percent of ped faces and obscuring the clay films; medium acid (pH 6.0); clear smooth boundary.
IIC	59-78	Dark brown (10YR4/3) silty clay loam, pale brown (10YR6/3) dry with common fine distinct light brownish gray (10YR6/2) mottles; light gray (10YR7/1) dry; massive; hard, very friable, slightly sticky and slightly plastic; few very fine tubular pores; few fine pebbles at 62 inches of varied lithology; medium acid (pH 6.0).

Willamette silt loam, thin epipedon variant W-7

October 11, 1967 Gelderman

Classification: Ultic Argixerolls; fine-silty, mixed, mesic

Location: 1,875' N, 25' W of SE corner of Section 18, T6S, R4W, Polk County, Oregon

Vegetation: wheat

Climate: microthermal, humid

Parent material: alluvium from mixed sources, dominantly sandstone, siltstone, and overwashed alluvium

Physiography: level top of low rounded hill above the stream terrace--Qws, Willamette Silts; Pleistocene--Dolph surface

Relief: simple, convex

Elevation: 181'

Slope: 1-2%

Aspect: SSW

Drainage: well, medium runoff

Ground water: deep

Moisture: moist to 7" and below 26"

Root distribution: norma--roots to 40"

Salt or alkali: none

Stoniness: class 0

Erosion: slight to none

Permeability: moderate

Horizon	Depth (inches)	Morphology
Ap1	0- 5	Very dark grayish brown (10YR3/2) loam, brown (10YR5/3) dry; moderate very fine and fine granular structure; slightly hard, very friable, slightly sticky and slightly plastic; common very fine and fine tubular and many very fine, fine, and medium interstitial pores; medium acid (pH 6.0); abrupt smooth boundary.
Ap2	5-10	Very dark grayish brown (10YR3/2) heavy loam brown (10YR5/3) dry; moderate fine granular structure; slightly hard, friable, slightly sticky and slightly plastic; few very fine and fine tubular and common very fine, fine, and medium interstitial pores; medium acid

Horizon	Depth (inches)	Morphology
		(pH 6.0); abrupt smooth boundary.
A3	10-15	Dark brown (10YR3/3) heavy loam, brown (10YR5/3), rubbed dry; moderate very fine and medium granular and weak medium subangular blocky structure and massive; hard, friable, slightly sticky and slightly plastic; common very fine and fine tubular and interstitial pores; medium acid (pH 6.0); clear smooth boundary.
B1	15-20	Dark yellowish brown and dark brown (19YR3/4, 4/3) clay loam, brown, pale brown, rubbed, (10YR5/3, 6/3) dry; weak and moderate medium subangular blocky structure; hard, firm, sticky and plastic; common very fine and fine tubular and few fine interstitial pores; very few very thin clay films in the pores; medium acid (pH 6.0); clear smooth boundary.
B21	20-30	Dark brown (10YR3/3, 4/3) heavy silt loam, brown (10YR5/3) pale brown, rubbed, (10YR6/3) dry; moderate medium subangular blocky structure; hard, friable, slightly sticky and plastic; few fine tubular and interstitial pores; very few thin clay films in pores; very few gray silt grains on 5 percent of ped faces; medium acid (pH 6.0); abrupt smooth boundary.
IIB22t	30-36	Dark brown (10YR3/3, 4/3) clay loam, brown and pale brown (10YR5/3, 6/3) dry; moderate fine and medium prismatic parting to angular and subangular blocky structure; hard, firm, sticky and plastic; few fine tubular and common very fine interstitial pores; few moderately thick dark reddish brown (5YR3/3) clay films on ped faces, reddish brown and dark reddish brown (5YR5/4, 3/4) dry and few thin dark brown (7.5YR4/4) clay films in pores; few gray silt

Horizon	Depth (inches)	Morphology
		grains on 10 percent of ped faces; few fine black (5YR2/1) concretions; medium acid (pH 6.0); clear smooth boundary.
IIB23t	36-48	Dark brown and pale brown (10YR4/3, 6/3) clay loam, brown (10YR5/3) dry, few fine distinct dark brown (7.5YR4/2) mottles, light gray (2.5YR7/2) dry; moderate medium angular and subangular blocky structure; hard, friable, sticky and plastic; many very fine tubular and few very fine interstitial pores; few thin dark brown (7.5YR4/4, 3/2) clay films on ped faces and few moderately thick reddish brown (5YR4/4) clay films in pores; medium acid (pH 6.0).

Willamette silt loam W-8

October 11, 1967 Gelderman

Classification: Ultic Argixerolls

Location: 1,675' N, 925' W of SE corner of Section 18, T6S, R4W, Polk County, Oregon

Vegetation: wheat stubble

Climate: microthermal, humid (40")

Parent material: alluvium from mixed sources and reworked alluvium

Physiography: stream terrace above an Ash Swale tributary; Qws--Willamette Silts--Pleistocene; Senecal surface

Relief: simple, planoconvex

Elevation: 162'

Slope: 0-0.5%

Aspect: NW

Drainage: well drained; medium runoff

Ground water: deep

Moisture: moist to 7" and below 25"

Root distribution: normal, roots to 30"

Salt or alkali: none

Stoniness: class 0

Erosion: slight to none

Permeability: moderate

Notes: There are scattered pebbles at 57" (145 cm).

Horizon	Depth (inches)	Morphology
Ap1	0- 5	Very dark grayish brown and dark brown (10YR3/2, 3/3) silt loam, grayish brown and brown (10YR5/2, 5/3) dry; moderate fine platy and moderate fine and medium granular structure; slightly hard, very friable, slightly sticky and slightly plastic; few very fine and fine tubular and many very fine and fine interstitial pores; medium acid (pH 6.0); abrupt smooth boundary.
Ap2	5-10	Very dark grayish brown (10YR3/2) silt loam, brown (10YR5/3) dry; massive, and weak fine and medium granular structure; hard, friable, slightly sticky and slightly plastic; many very fine and fine tubular

Horizon	Depth (inches)	Morphology
		and common very fine and fine interstitial pores; slightly acid (pH 6.5); abrupt smooth boundary.
A3	10-17	Very dark grayish brown and dark brown (10YR3/2, 3/3) silt loam, brown and pale brown (10YR5/3, 6/3) dry; moderate fine and medium granular and weak medium subangular blocky structure; hard, friable, sticky and slightly plastic; many very fine and common fine tubular and common very fine and fine interstitial pores; few worm casts in pores; medium acid (pH 6.0); clear smooth boundary.
B1	17-28	Dark brown (10YR3/3) silt loam, brown (10YR5/3) dry; moderate fine and medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; common very fine and fine tubular and interstitial pores; few worm casts in pores; gray silt grains on up to 15 percent of the ped faces; medium acid (pH 6.0); abrupt smooth boundary.
IIB21t	28-33	Dark brown (10YR4/3) silty clay loam, brown (10YR5/3) dry, few fine distinct black (5YR2/1) and light reddish brown (5YR6/3) mottles, pinkish gray (7.5YR7/2) dry; moderate fine and medium subangular blocky structure; very hard; very friable, slightly sticky and slightly plastic; common very fine and fine tubular and interstitial pores; few thin dark reddish brown (5YR3/4) clay films on ped faces, brown (7.5YR4/4) when dry; up to 10 percent gray silt grains on ped faces obscuring clay films, medium acid (pH 6.0); abrupt smooth boundary.
IIB22t	33-49	Dark brown (10YR4/3) clay loam, pale brown (10YR6/3) dry, few fine distinct black (5YR2/1) and pale brown (10YR6/3) mottles,

Horizon	Depth (inches)	Morphology
		light gray (N7/) dry; moderate fine and medium prismatic and subangular blocky structure; very hard, very friable, slightly sticky and plastic; common very fine and fine tubular and few very fine and fine interstitial pores; common thin and moderately thick brown (7.5YR4/4) and dark reddish brown (5YR3/4) clay films in pores and on ped faces, brown and reddish brown (7.5YR4/4) and 5YR4/4) dry; few gray silt grains on 10 percent of vertical ped faces; medium acid (pH 6.0); abrupt smooth boundary.
IIB3t	49-60	Dark brown (10YR4/3) silt loam, light gray (10YR7/2) dry, few fine distinct black (5YR2/1) mottles; massive and weak medium and coarse subangular blocky structure; very hard, friable, sticky and plastic; common very fine, few fine and medium tubular and few very fine interstitial pores; few thin and moderately thick dark brown (7.5YR4/4) clay films in pores and on ped faces, dark brown dry; neutral (pH 7.0); clear smooth boundary.
IIC	60-74	Dark brown and gray (10YR4/3, 6/1) heavy silt loam, pale brown and light gray (10YR6/3, 7/1) dry with few fine distinct strong brown (7.5YR5/6) mottles; massive; hard, friable, slightly sticky and slightly plastic; very few very fine tubular pores; very few thin clay films in the pores; neutral (pH 7.0).

Willamette silt loam, light color surface variant 8118-8124

July 17, 1968 Gelderman-Parsons

Classification: Typic Haploxeralfs; fine-silty, mixed, mesic

Location: 900' N, 600' W of SE corner, Section 31, T8S, R4W, Polk County, Oregon

Vegetation: harrowed in walnut orchard

Climate: microthermal, humid 40"

Parent Material: alluvium from mixed sources

Physiography: hill slope above the valley terrace, below hill tops; Qws--Willamette Silts; Dolph surface

Relief: simple, convex (A)

Elevation: 225'

Slope: 1-3%

Aspect: north

Drainage: well to moderately well drained

Ground Water: deep

Moisture: moist below 6"

Root distribution: normal, few roots to 57 inches

Salt or Alkali: none

Stoniness: class 0

Erosion: none to slight

Permeability: moderately slow

Notes: Sampled for analysis under SES, USDA number 68Ore27-2-(1-7) from pit. pH with chlorophenol red

Horizon	Depth (inches)	Morphology
Ap	0- 6	Dark grayish brown (10YR4/2) silt loam, pale brown (10YR6/3) dry; moderate fine and medium granular and fine platy structure; slightly hard, friable, slightly sticky and slightly plastic; slightly acid (pH 6.2); abrupt smooth boundary.
A12	6-15	Dark brown (10YR3/3) silt loam, brown (10YR5/3) dry; weak medium platy structure to massive; slightly hard, friable, slightly sticky and plastic; medium acid (pH 6.0); clear smooth boundary.
A3	15-24	Dark brown (10YR4/3) silt loam; weak coarse subangular blocky

Horizon	Depth (inches)	Morphology
		structure; slightly hard, friable, slightly sticky and plastic; common gray silt grains on ped faces; medium acid (pH 6.0); clear smooth boundary.
B1	24-33	Dark brown (10YR4/3) silt loam; weak and moderate medium and coarse subangular blocky structure; slightly hard, friable, sticky and plastic; common gray silt grains on ped faces; medium acid (pH 5.8); clear smooth boundary.
IIB21t	33-46	Dark brown (10YR4/3) silty clay loam, few fine distinct grayish brown (10YR5/2) mottles; moderate medium subangular blocky structure; slightly hard, firm, sticky and plastic; somewhat brittle; common thin brown (10YR4/4) clay films on ped faces; medium acid (pH 5.8); gradual smooth boundary.
IIB22t	46-57	Dark brown (10YR4/3) silty clay loam, common fine and medium distinct grayish brown (10YR5/2) mottles; moderate medium subangular blocky structure; slightly hard, firm, sticky and plastic; somewhat brittle; common moderately thick brown (10YR4/4) clay films on ped faces; common gray silt grains; medium acid (pH 5.8); gradual smooth boundary.
IIB3t	57-74	Dark brown (10YR4/3) silty clay loam, common fine and medium distinct grayish brown (10YR5/2) mottles; weak and moderate subangular blocky structure; slightly hard, firm, sticky and plastic; somewhat brittle; few thin brown (10YR4/4) clay films on ped faces; medium acid (pH 5.8).

Amity silt loam A-1

September 4, 1968 Gelderman

Classification: Argiaquic Xeric Argialbolls; fine-silty, mixed, mesic

Location: 1975'N, 575'E of SW corner Section 20, T6S, R4W, Polk County, Oregon

Vegetation: wheat stubble

Climate: microthermal, humid 40"

Parent Material: alluvium from mixed sources; shale, reworked alluvium, sandstone

Physiography: toe slope of hill on high edge of valley terrace, Calapooyia, -Dolph surfaces;

QWS--Willamette Silts--Pleistocene

Relief: simple, concave (A)

Elevation: 178'

Slope: 0-1%

Aspect: south

Drainage: somewhat poor

Ground Water: deep

Moisture: moist below 15"

Root Distribution: normal - roots to 34"

Salt or Alkali: none

Stoniness: class 0

Erosion: none to slight

Permeability: moderately slow

Notes: hand dug pit and auger. pH with chlorophenol red

Horizon	Depth (inches)	Morphology
Ap1	0- 4	Very dark grayish brown (10YR3/2) silt loam, brown (10YR5/3) dry; moderate fine and medium granular structure; slightly hard, very friable, slightly sticky and slightly plastic; many fine interstitial pores; medium acid (pH 5.6); abrupt smooth boundary.
Ap2	4- 9	Very dark brown (10YR2/2) silt loam, grayish brown (10YR5/2) dry; moderate fine and medium granular structure; slightly hard, very friable, slightly sticky and slightly plastic; many fine interstitial and few fine tubular pores; common worm casts; medium acid (pH 5.7); abrupt smooth boundary.

Horizon	Depth (inches)	Morphology
A13	9-15	Very dark brown (10YR2/2) silt loam, grayish brown (10YR5/2) dry; moderate medium and coarse granular structure; slightly hard, very friable, slightly sticky and slightly plastic; common fine interstitial and tubular pores; common worm casts; medium acid (pH 5.6); clear smooth boundary.
A2	15-25	Dark grayish brown (10YR4/2) silt loam, light brownish gray (10YR6/2) dry, common fine distinct brown (7.5YR4/4) mottles, strong brown (7.5YR5/6) dry; massive; slightly hard, friable, slightly sticky and slightly plastic; common fine tubular pores; medium acid (pH 5.8); clear smooth boundary.
IIB21t	25-34	Dark grayish brown and brown (10YR4/2, 4/3) silty clay loam, pale brown (10YR6/3) dry, common medium faint grayish brown (10YR 5/2) mottles, light gray (10YR7/2) dry; weak medium prismatic and moderate fine and medium subangular blocky structure; hard, firm, sticky and plastic; common very fine and fine interstitial and tubular pores; few thin and moderately thick brown (7.5YR4/4) clay films on ped faces; gray silt grains on about 50 percent of ped faces; few rounded black (5YR2/1) concretions and stains; medium acid (pH 6.0); gradual smooth boundary.
IIB22t	34-45	Brown (10YR4/3) silty clay loam, pale brown (10YR6/3) dry, few fine faint grayish brown (10YR5/2) mottles, light gray (10YR7/2) dry; weak coarse prismatic and moderate medium subangular blocky structure; hard, firm, sticky and plastic; common very fine and fine interstitial pores; common moderately thick brown (7.5YR4/4) clay films on ped faces; gray silt grains on about 15 percent of the ped faces; few

Horizon	Depth (inches)	Morphology
		rounded black (5YR2/1) concretions; slightly acid (pH 6.2); gradual wavy boundary.
IIC	45-65	Dark brown (10YR4/3) light silty clay loam, pale brown and light gray (10YR6/3, 7/2) dry, few fine light gray (2.5Y7/2) mottles, mostly around tubular pores; weak coarse prismatic structure to massive; hard friable, slightly sticky and plastic; few very fine and fine interstitial and tubular pores; few thin brown (10YR5/3) clay films on ped faces, brown (7.5YR5/4) dry; slightly acid (pH 6.4).

Dayton silt loam D-1

October 4, 1967 Gelderman

Classification: Typic Albaqualfs; fine, montmorillonitic, mesic

Locations: 1525'S, 1050'E of NW corner Sec. 20, T65, R4W, Polk County, Oregon

Vegetation: from grass to fallow, will go to vetch

Climate: microthermal, humid 40"

Parent Material: alluvium from mixed sources

Physiography: swale on stream terrace above Ash Swale tributary - Calapooyia surface - Qws--Willamette Silts--Pleistocene

Relief: simple, concave (A)

Elevation: 176'

Slope: 0 to 0.25 percent

Aspect: northwest

Drainage: very poor

Ground Water: deep

Moisture: moist to 6" and below 13"

Root Distribution: normal-fine roots to 15"

Salt or Alkali: none

Stoniness: class 0

Erosion: none to slight

Permeability: slow to very slow

Notes: Tile drain line on top of clay layer nearby. Rainy season has begun, two or more inches since Sept. 30. pH with Hellige-Truog Reaction Kit.

Horizon	Depth (inches)	Morphology
Ap1	0- 3	Dark grayish brown (2.5Y4/2) silt loam, light brownish gray (2.5Y6/2) dry, very fine distinct yellowish brown (10YR5/6) mottles; moderate fine granular structure; slightly hard, firm, slightly sticky and slightly plastic; few very fine and fine tubular and interstitial pores; very strongly acid (pH 5.0); abrupt smooth boundary.
Ap2	3- 7	Dark grayish brown (2.5Y4/2) silt loam, light brownish gray (2.5Y6/2) dry; moderate fine granular structure to massive; slightly hard, firm, slightly sticky and slightly plastic; few very fine

Horizon	Depth (inches)	Morphology
		tubular and interstitial pores; few fine distinct black (10YR2/1) concretions; very strongly acid (pH 4.7); abrupt smooth boundary.
A2	7-14	Dark grayish brown (2.5Y4/2) silt loam, light gray (2.5Y7/2) dry with few very fine distinct yellowish brown (10YR5/6) mottles; weak medium and coarse granular structure to massive; slightly hard, firm, slightly sticky and slightly plastic; common very fine tubular and few very fine interstitial pores; few fine distinct black (10YR2/1) concretions; very strongly acid (pH 4.5); abrupt smooth boundary.
IIB2t	14-25	Dark grayish brown (2.5Y4/2) clay, olive gray (5Y5/2) dry with very few fine distinct yellowish brown (10YR5/6) mottles; weak coarse prismatic structure; very hard, very firm, very sticky and plastic; few very fine tubular and interstitial pores; few fine distinct black (5Y2/1) concretions; common pressure faces and few slickensides; slightly acid (pH 6.5); abrupt smooth boundary.
IIIB3t	25-30	Dark grayish brown (2.5Y4/2) heavy silty clay loam, light gray (5Y7/2) dry with few fine distinct yellowish brown (10YR5/6) mottles; weak medium subangular blocky structure to massive; hard, firm, slightly sticky and slightly plastic; common very fine interstitial pores; few moderately thick very dark grayish brown (10YR 3/2) clay films on ped faces, grayish brown (2.5Y5/2) dry; neutral (pH 7.0); abrupt smooth boundary.
IIIC	30-41	Olive gray (5Y5/2) silty clay loam, light gray (5Y7/2) dry, few fine distinct yellowish brown (10YR5/6) mottles; massive; hard, friable, sticky and slightly plastic; common very fine and fine tubular

Horizon	Depth (inches)	Morphology
		pores; very few thin dark grayish brown (2.5Y4/2) clay films in pores, grayish brown (2.5Y5/2) dry; mildly alkaline (pH 7.5).

Dayton silt loam D-2

October 4, 1967 Gelderman

Classification: Typic Albaqualfs; fine, montmorillonitic, mesic

Location: 2175'S 225'E of NW corner of Sec 20, T6S, R4W, Polk County, Oregon

Vegetation: fallow from grass to vetch

Climate: microthermal, humid 40"

Parent Material: alluvium from mixed sources

Physiography: flat on stream terrace above an Asli Swale tributary - Calapooyia surface, Qws--Willamette Silts--Pleistocene

Relief: plane, concave (A)

Elevation: 176'

Slope: 0-0.5 percent

Aspect: northwest

Drainage: very poor

Ground Water: deep

Moisture: moist to 6" and below 12"

Root Distribution: normal - roots to 14"

Salt or Alkali: none

Stoniness: class 0

Erosion: none to slight

Permeability: slow to very slow

Notes: approximately 2 inches of rain since September 30. pH determined with Hellige-Truog Reaction Kit.

Horizon	Depth (inches)	Morphology
Ap1	0- 4	Dark grayish brown (10YR4/2) silt loam, light brownish gray (2.5Y 6/2) dry, very few very fine distinct yellowish brown (10YR5/6, 5/4) mottles; moderate fine and medium granular structure; slightly hard, firm, sticky and slightly plastic; few very fine tubular and interstitial pores; very strongly acid (pH 5.0); abrupt smooth boundary.
Ap2	4- 9	Dark grayish brown (10YR4/2) silt loam, light brownish gray (2.5Y 6/2) dry, common fine distinct light gray (2.5Y7/2) and very few very fine distinct yellowish brown (10YR5/6) mottles, white (N 8/)

Horizon	Depth (inches)	Morphology
		and yellowish brown (10YR5/6) dry; moderate fine granular structure; slightly hard, friable, slightly sticky and slightly plastic; few very fine interstitial pores; very strongly acid (pH 4.5); abrupt smooth boundary.
A2	9-13	Dark grayish brown (10YR4/2) silt loam, gray (2.5Y6/1) dry, common fine distinct grayish brown (10YR5/2) and yellowish brown (10YR5/6) mottles, white (N 8/) and yellowish brown (10YR5/6) dry; moderate fine subangular blocky structure to massive; slightly hard, friable, sticky and slightly plastic; common very fine tubular and few fine interstitial pores; common fine black (10YR2/1) concretions; strongly acid (pH 5.5); abrupt smooth boundary.
IIB2t	13-24	Dark gray, olive gray, and light olive gray (5Y4/1, 5/2, 6/2) clay, light olive gray and olive gray (5Y6/2, 5/2) dry, very few very fine distinct yellowish brown (10YR5/6) mottles; weak coarse prismatic structure; very hard, very firm, very sticky and plastic; common very fine tubular and interstitial pores; few pressure faces and slickensides; few fine and medium black (5Y2/1) concretions; neutral (pH 7.0); abrupt smooth boundary.
IIIB3t	24-34	Olive (5Y5/3) heavy silty clay loam, pale olive and light olive gray (5Y6/3, 6/2) dry, common fine distinct light olive brown (2.5Y5/6) mottles; weak coarse prismatic structure and massive; hard, firm, sticky and plastic; common very fine tubular and interstitial pores; many moderately thick dark gray (5Y4/1) clay films on ped faces and in pores, olive gray (5Y5/2) dry; mildly alkaline (pH 7.7); abrupt smooth boundary.

Horizon	Depth (inches)	Morphology
IIIC	34-44	Dark grayish brown (2.5Y4/2) silty clay loam, pale olive (5Y 6/3) dry, few very fine distinct yellowish brown (10YR5/6) mottles; weak medium subangular blocky structure to massive; hard, friable, sticky and slightly plastic; few very fine tubular pores; very few thin olive gray (5Y5/2) clay films on ped faces, light olive gray (5Y6/2) dry; few fine black (5Y2/1) concretions; neutral (pH 6.8).

Concord silt loam C-1

August 4, 1968 Gelderman

Classification: Typic Ochraqualfs, fine, montmorillonitic, mesic

Location: 1700'S, 1350' E of NW corner of section 20, T6S, R4W, Polk County, Oregon

Vegetation: wheat stubble

Climate: microthermal, humid 40"

Parent Material: alluvium from mixed sources

Physiography: flat valley terrace, below break from toe slope - Calapooyia surfaces, Qws--
Willamette Silts--Pleistocene

Relief: simple, concave (A)

Moisture: moist

Elevation: 180'

Root Distribution: normal - roots to 20"

Slope: 0-0.5%

Salt or Alkali: none

Aspect: N

Stoniness: class 0

Drainage: poorly

Erosion: none to slight

Ground Water: 18'

Permeability: slow to very slow

Notes: "stone line" of 1/4 to 3/8" subangular pebbles at 8". Reaction determined on pH meter.

Horizon	Depth (inches)	Morphology
Ap	0- 8	Very dark grayish brown (10YR3/2) and dark grayish brown (10YR 4/2) silt loam, grayish brown (10YR5/2) and light brownish gray (10YR6/2) dry; moderate fine and medium granular structure; slightly hard, very friable, slightly sticky and slightly plastic; common fine tubular and interstitial pores; medium acid (pH 5.6); abrupt smooth boundary.
A2	8-15	Dark gray (10YR4/1) silt, gray (10YR6/1) dry, few fine distinct brown (7.5YR4/4) mottles; yellowish brown and strong brown (10YR5/6, 7.5YR5/6) dry; massive; slightly hard, very friable,

Horizon	Depth (inches)	Morphology
		nonsticky and slightly plastic; few very fine and fine tubular and interstitial pores; 5 to 10 percent shot; medium acid (pH 5.6); clear smooth boundary.
AB	15-22	Dark gray (10YR4/1) silt loam, gray (10YR6/1) dry, common fine distinct brown (7.5YR4/4) mottles, yellowish brown (10YR5/6) dry; weak medium subangular blocky structure; slightly hard, very friable, nonsticky and slightly plastic; few very fine and fine tubular and interstitial pores; 2 to 5 percent shot; common fine gray (N 7/) grains coating pores; medium acid (pH 5.6); clear smooth boundary.
IIB2t	22-28	Dark gray (10YR4/1) silty clay, gray (10YR5/1) dry, common fine faint brown (10YR5/3) mottles, pale brown (10YR6/3) dry; moderate medium subangular blocky structure; very hard, firm, slightly sticky and plastic; few very fine tubular and interstitial pores; many moderately thick and thick dark gray (10YR4/1) clay films on ped faces and in pores; 1 to 5 percent shot; strongly acid (pH 5.5); clear smooth boundary.
IIIB3t	28-42	Brown (10YR5/3) and light grayish brown (10YR4/2) heavy silty clay loam, pale brown (10YR4/2) and grayish brown (10YR5/2) dry; weak medium subangular blocky structure; very hard, friable, slightly sticky and slightly plastic; common very fine and medium tubular and few very interstitial pores; common moderately thick gray (10YR5/1) clay films in pores, few thin indistinct gray clay films on ped faces; 1 to 5 percent shot; medium acid (pH 5.6); gradual smooth boundary.
IIIC	42-48	Grayish brown (2.5Y5/2) and brown (10YR5/3) heavy silt loam,

Horizon	Depth (inches)	Morphology
		light gray (2.5Y7/2) and very pale brown (10YR7/3) dry; weak medium coarse subangular blocky structure to massive; hard, very friable, slightly sticky and slightly plastic; common very fine and fine tubular and few very fine interstitial pores; few moderately thick dark yellowish brown (10YR4/4) and grayish brown (10YR5/2) clay films in pores; yellowish brown (10YR5/4) and light gray (10YR7/2) dry, and very few thin dark brown (7.5YR4/4) clay films on ped faces, brown (7.5YR5/4) dry; common gray (N 7/) grains in pores, medium acid (pH 6.0).

Wapato silt loam X-1

October 25, 1968 Gelderman

Classification: Fluventic Haplaquolls; fine-silty, mixed, noncalcareous, mesic

Location: 300'S, 2500'E NW corner Sec. 19, T6S, R4W, Polk County, Oregon; Vernon Maxon farm.

Vegetation: pasture

Climate: microthermal, humid 40"

Parent Material: reworked materials of the Willamette formation

Physiography: swale bottom; Ingram surface; Qws--Willamette Silts--Pleistocene

Relief: plano-concave (A)

Elevation: 155'

Slope: 0-0.2%

Aspect: NW

Drainage: poor to very poor

Ground Water: at 6"

Moisture: wet

Root Distribution: normal - roots to 24"

Salt or Alkali: none

Stoniness: class 0

Erosion: slight

Permeability: moderate over slow

Notes: Described and sampled with an Oakfield probe. Reaction determined with pH meter.

Horizon	Depth (inches)	Morphology
Ap1	0- 7	Very dark gray (10YR3.5/1) silt loam, gray (10YR5/1) dry, with many fine distinct yellowish red (5YR5/6) mottles in root pores, yellowish brown (10YR5/6) dry; moderate fine and medium granular structure; slightly hard, very friable, slightly sticky and slightly plastic; many fine tubular and interstitial pores; medium acid (pH 5.8); clear smooth boundary.
Ap2	7-13	Very dark gray (10YR3/1) silt loam, gray (10YR5/1) dry, many fine distinct yellowish red (5YR5/6) mottles in the root pores, yellowish brown (10YR5/6) dry; moderate fine and medium granular structure; slightly hard, very friable, slightly sticky and slightly

Horizon	Depth (inches)	Morphology
		plastic; common fine tubular and interstitial pores; slightly acid (pH 6. 3); clear smooth boundary.
B21	13-20	Very dark gray (10YR3/1) silty clay loam, gray (10YR5/1) dry; massive; hard, friable, slightly sticky and plastic; few fine tubular pores; slightly acid (pH6. 4); clear smooth boundary.
B22	20-30	Dark gray and dark grayish brown (10YR4/1, 4/2) silty clay loam, gray and light gray (10YR5/1, 6/1) dry, few fine distinct yellowish red (5YR4/6) mottles, yellowish brown (10YR5/6) dry; massive, hard, friable, slightly sticky and plastic; very few very fine tubular pores; about 5 percent shot; neutral (pH 6. 8); abrupt smooth boundary.
	Layer 1" thick of 2 to 6 mm shot	
IIC1	30-42	Dark gray (10YR4/1) silty clay, gray (N 6/) dry, grayish brown (10YR5/2) extraneous silty material, pale brown (10YR6/3) dry, and few fine distinct dark yellowish brown (10YR4/4) mottles, yellowish brown (10YR5/6) dry; massive; very hard firm, sticky and plastic; very few very fine tubular pores; neutral (pH 7. 1); clear smooth boundary.
IIC2	42-48	Grayish brown and dark gray (2. 5YR5/2, 4/0) silty clay, light gray and gray (2. 5YR7/2, 10YT5/1) dry; massive; very hard, firm, sticky and plastic; very few very fine tubular pores; neutral (pH 7. 3).

APPENDIX C: LABORATORY PROCEDURES

I. Particle size distribution (54)

A. Apparatus and reagents

1. analytic balance
2. graduated cylinders, 1 liter
3. nursing bottles with stoppers
4. reciprocating shaker
5. automatic pipette and rack
6. beakers, 250 ml. and 50 ml.
7. nest of sieves
8. hydrogen peroxide
9. sodium hexametaphosphate (Calgon) solution

B. Procedure

1. Preparation of the sample. The air-dried sample is mixed and quartered. The quarter reserved for analysis is rolled with a wooden rolling pin to break up the clods. The sample is then passed through a sieve with 2-mm. round holes.

2. Removal of organic matter. A 10-gm. sample of the air-dry soil containing no particles larger than 2 mm. is weighed on a rough balance and placed in a 250-ml. electrolytic pyrex beaker. About 50 ml. of water is

added followed by a few milliliters of 30 percent hydrogen peroxide. The beaker is then covered with a watch glass. If a violent reaction occurs, the cold hydrogen peroxide treatment is repeated periodically until no more frothing occurs. The beaker is then heated to about 90° C. on an electric hot plate. Hydrogen peroxide is added in 5-ml. quantities at about 45-minute intervals until the organic matter is essentially removed as determined by visual inspection. Heating is then continued for about 30 minutes to remove any excess hydrogen peroxide.

3. Removal of dissolved mineral matter. Following the hydrogen peroxide treatment, the sample is washed with successive additions of distilled water removed by suction through a glass tube, drawn to a point, after the solids have settled to the bottom of the beaker. This step of the procedure works only if soluble salts are low and there is no dispersion. Ammonium carbonate, which volatilizes on heating to dryness, may be used to flocculate the sample. The beaker is placed overnight in an oven at 110° C., cooled in a desiccator, and then weighed to the nearest milligram. After the sample is quantitatively transferred to a nursing bottle for

dispersion, the oven-dry weight of the beaker is obtained. The weight of the oven-dry organic-free sample is used as the base weight for calculating the percentages of the various fractions.

4. Dispersion of the sample. To the oven-dry sample is added 10 ml. of 5 percent sodium hexametaphosphate (Calgon) solution as a dispersing agent, and the sample is transferred to an 8-ounce pyrex glass nursing bottle by means of a funnel, a rubber policeman, and a jet of water. The volume is made to 6 ounces, and the bottle is stoppered and shaken overnight on a horizontal reciprocating shaker with 120 oscillations per minute.
5. Separation of the sands from silt and clay. The dispersed sample is washed on a 300-mesh sieve, the silt and clay passing through the sieve into a liter graduated cylinder. The sieve is held above the cylinder. The sieve clamp is tapped gently with the side of the hand to facilitate the washing procedure. Washing is continued until the volume in the cylinder totals about 800 ml. The sands and some coarse silt remain on the sieve. It is necessary that all particles less than 20μ diameter be washed through the sieve. The sieve is removed from the holder, placed in an aluminum pan, and dried at

110-120° C. While the sands are drying, another sieve is used for the next sample. The material on the sieve is then brushed into an evaporating dish and further dried for about 2 hours. The dish is then placed in a desiccator, the contents to be sieved and weighed when convenient. The silt and clay suspension in the cylinder is made up to 1 liter with distilled water, covered with a watch glass, and set aside until the pipettings are to be made.

6. Pipetting. Pipettings are made for fine silt (20 to 2μ) and clay (< 2μ) particles in order at a 10-cm. depth, the sedimentation time varying according to the temperature. A Lowry 25-ml. automatic pipette with a filling time of about 12 seconds is used. Prior to each pipetting, the material in the sedimentation cylinder is stirred for 6 minutes (8 minutes if the suspension has stood for more than 16 hours). After removal of the stirrer a length of insulating cover is slipped over the sedimentation cylinder and the suspension is stirred for 30 to 60 seconds using a hand stirrer[9] with an up and down motion. The time is noted at completion of the stirring. About 1 minute before the sedimentation is

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[9] This stirrer is made by fastening a circular piece of perforated plexiglass to one end of a rod.

complete, the tip of the 25-ml. pipette is lowered slowly into the suspension to the proper depth by means of a Shaw pipette rack. The pipette is then filled and emptied into a 50-ml. beaker. One rinse from the pipette is added to the aliquot. A vacuum is used to dry the pipette for use on the next sample. The beaker is dried in an oven at 95 to 98° C. and then further dried for about 4 hours at 110° C. The initial drying is done at a lower temperature to prevent spattering of the suspension. The beaker is then cooled in a desiccator and weighed. Ten ml. volume of dispersing agent is placed in a liter cylinder, the volume made to 1,000 ml. and well mixed. An aliquot is taken with the pipette, dried, and weighed to obtain the weight correction referred to in the section on calculations. This weight correction is obtained for each new solution of sodium hexametaphosphate.

Sieving and weighing the sand fractions. The dry sands, including some coarse silt (50-20μ), are weighed and brushed into a nest of sieves. They are shaken for 5 minutes on a shaker having vertical and lateral movements of one-half inch making 500 oscillations per minute. For a different shaker the time of shaking would have to be determined by microscopic study. The summation method of weighing is used. The first sand fraction is weighed, the second fraction added to it, the total weight determined and so on. If the sum of the weights of the fractions is equal to the total weight, it is assumed that no weighing error has been made.

C. Calculations

Pipetted fractions:

$(A - B)\,KD$ = percent of pipetted fraction

where A = weight in grams of pipetted fraction,

B = weight correction for dispersing agent (in grams),

$$K = \frac{1,000}{\text{volume contained by pipette}},$$

$$D = \frac{100}{\text{organic-free oven-dry weight of total sample}}.$$

Coarse silt is obtained by subtracting the sum of the percentages of sand, fine silt, and clay from 100.

Sand fractions:

$$\text{Weight in grams of fraction on sieve} \times \frac{100}{\text{organic-free oven-dry weight of total sample}} = \text{percent of fraction.}$$

II. Bulk density (20)

A. Apparatus

1. a balance
2. paraffin in a container kept at, or a few degrees above, 60° C. into which the soil sample can be dipped
3. thread and labels of known weight

B. Procedure

1. air-dry the clod on which measurements are to be made
2. carefully tie a string with identification tag around the clod
3. weigh it suspended in air
4. dip the clod momentarily in melted paraffin, and allow the excess to drain. When the adhering paraffin solidifies, weigh the clod and paraffin together
5. suspend in water and weigh again
6. determine correct sample weight by finding moisture percent of soil

C. Calculations

wt. of clod + wax - wt. of clod submerged = volume

$$\frac{\text{correct sample wt.}}{\text{volume}} = \text{bulk density}$$

III. Saturated paste pH (80)

A. pH meter with glass electrode

B. Procedure

1. Prepare the saturated soil paste by adding distilled water to a sample of soil while stirring with a spatula. The soil-water mixture is consolidated from time to time during the stirring process by tapping the container on the workbench. At saturation the soil paste glistens as it reflects light, flows slightly when the container is tipped, and the paste slides freely and cleanly off the spatula for all soils but those with a high clay content.
2. After mixing, the sample should be allowed to stand for an hour or more, and then the criteria for saturation should be rechecked. Free water should not collect on the soil surfaces nor should the paste stiffen markedly or lose its glistening appearance on standing. If the paste does stiffen or lose its glisten, remix with more water. Because soils puddle most readily when worked at moisture contents near field capacity, sufficient water should be added immediately to bring the sample nearly to saturation. If the paste is too wet, additional dry soil may be added.
3. Allow paste to stand at least one hour. Insert the

electrodes into the paste and raise and lower repeatedly until a representative pH reading is obtained.

IV. Organic matter (1)

A. Reagents

1. Potassium dichromate, 1N - Dissolve 49.04 grams $K_2Cr_2O_7$ in distilled water and make up to 1 liter. If this solution is carefully prepared, it will be exactly 1N.
2. Ferrous-ammonium-sulfate, 0.4N - Dissolve 159.6 grams $Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$ in distilled water containing 40 ml concentrated H_2SO_4 and make up to 1 liter. Determine normality periodically by titrating against the potassium dichromate solution.
3. O-phenathroline ferrous sulfate complex - 0.025M solution, "Ferroin".
4. Phosphoric acid - 14.6 M (85%)

B. Procedure

1. Pass soil through a 1/2 mm sieve and weigh out 0.5 grams soil into a 500 ml Erlenmeyer flask. The soil is ground avoiding contact with iron or steel.
2. Add 10 ml potassium dichromate and 20 ml concentrated H_2SO_4. Mix rapidly and thoroughly for 1 minute. Let

stand for at least 20 minutes or until cool.

3. Dilute to 100 ml with water.
4. Titrate with 0.4 N ferrous-ammonium-sulfate. Use 6 drops O-phenanthroline indicator.
5. Run a blank simultaneously using same procedure.

C. Calculation

1. ml Fe $(NH_4)_2(SO_4)_2$ used (blank - sample titration) x $\frac{N}{.4}$ x .543 = % OM.

The factor .543 is derived as follows:

$$(.4\ N) \times \frac{12}{4000} \times \frac{1.72}{0.76} \times \frac{100}{0.5} = .543$$

in which 12/4000 is the meq. weight of carbon, 1.72 is the factor used based on the assumption that organic matter is 58% carbon, 0.76 is the percent recovery factor, and 0.5 is the weight of the sample.

V. Cation Exchange Capacity (1)

A. Reagents

1. Ammonium acetate, 1N, neutral - make up the same as in procedure VI.
2. Ethyl alcohol, 95%.
3. Hydrochloric acid, 0.1N
4. Boric acid solution, saturated
5. Standard sulfuric acid, approximately 0.1000N - use

27.7 ml C.P. concentrated H_2SO_4 and make up to 10 liters. Mix well. Standardize against 25 ml of 0.1000N Na_2CO_3 solution made by weighing out 2.6570 grams of oven dry C.P. Na_2CO_3 and making up to 500 ml with distilled water. Use mixed indicator.

6. Mixed indicator - 0.1 gram bromcresol green and 0.02 gram methyl red dissolved in 100 ml ethyl alcohol.

B. Procedure

1. Weigh out 10 grams of soil and place in a shaking bottle with 50 ml of ammonium acetate solution, shake for 30 minutes.
2. Transfer to a Buchner funnel and wash with an excess of 150 to 200 ml of ammonium acetate. Potassium, calcium, magnesium and sodium in this extract may be run on the flame photometer by making filtrate up to a volume of 250 mls and using standards from procedure VI.
3. Wash out the excess ammonium acetate with 150 to 200 ml ethyl alcohol and discard filtrate.
4. Change to a clean filter flask and wash the soil with 250 ml 0.1N HCl to replace the ammonia.
5. Transfer the filtrate from step 4 to an 800 ml

Kjeldahl flask, add 10 grams NaCl, 10 mls concentrated NaOH, and an anti-bumping disc.

6. Attach immediately to the condenser and distill approximately one-third of the solution over into a previously placed 500 ml Erlenmeyer flask containing 50 ml saturated boric acid solution and 1 ml mixed indicator.
7. Lower the Erlenmeyer flask to prevent back-suction of the material and turn off burners.
8. Titrate the NH_3 with 0.1000N H_2SO_4.

C. Calculation

1. ml $H_2SO_4 \times N \times \frac{100}{10}$ = C.E.C. in m.e./100 grams of soil

VI. Exchangeable Bases (1)

A. Reagents

1. Ammonium acetate, 1 N - Add 700 ml of ammonium hydroxide to about 5 liters of distilled water. Then add 580 ml of acetic acid and make up to 10 liters. Shake vigorously. Adjust to pH 7.0 using a glass electrode pH meter.
2. Standard solutions for potassium, calcium and sodium - The following amounts of pure primary

reagents, dissolved in a small amount of distilled water and made up to 1 liter with ammonium acetate, are used for standard solutions of 1000 ppm of the element:

a. Potassium - 1.9100 grams KCl

b. Calcium - 2.4973 grams $CaCO_3$

c. Sodium - 2.5418 grams NaCl

3. Standard solution for magnesium - Dissolve 0.5 grams pure Mg ribbon and 2.4973 gram $CaCO_3$ in 1:1 HCl and evaporate to dryness on a hot plate. Take up residue in 500 ml NH_4OAc, add 125 ml of 1000 ppm K solution, 50 ml of 1000 ppm Na solution, and make up to a liter with NH_4OAc. The magnesium standard solution should contain 500 ppm Mg, 1000 ppm Ca, 125 ppm K, and 50 ppm Na.

B. Procedure

1. Weigh or measure 2 grams of soil into a 50 ml shaking bottle, add 20 ml of the ammonium acetate extractant, and shake for 30 minutes.
2. Filter through Whatman No. 5 filter paper.
3. Determine with the flame photometer using the following wave lengths:

   a. Magnesium - 383 mμ (285.2 mμ if possible)

   b. Calcium - 554 mμ

   c. Sodium - 580 mμ

   d. Potassium - 768 mμ

4. Prepare a curve for each element by running a series of standards.

VII. Exchangeable Acidity (72)

A. Reagents

1. Buffer solution -- Barium chloride (0.5 N), triethanolamine (0.2 N). Dilute 100 ml of commercial trithanolamine (specific gravity 1.126 about 8 N) with 1,000 ml of water and partially neutralize with HCl to adjust to pH 8.1 to 8.2 (this requires approximately 360 ml of 1 N HCl). Make up to 2 liters with water and mix with 2 liters of a solution containing 250 gm. of $BaCl_2 \cdot 2H_2O$. Protect from CO_2 of the air.
2. Replacement solution -- Barium chloride. Dissolve 250 ml of $BaCl_2 \cdot 2H_2O$ in 4 liters of distilled water, add 10 ml of buffer solution, and mix.
3. Standard hydrochloric acid -- 0.100 N; standardize according to accepted procedures.
4. Mixed indicator -- 0.1 gram bromcresol green and

0.02 gram methyl red dissolved in 100 ml ethyl alcohol.

B. Procedure

1. Place 10 gm of soil in a 125 ml Erlenmeyer flask, add 25 ml of buffer solution, and allow the flask to stand for one-half hour, mixing the contents occasionally by swirling.
2. Transfer to a Gooch crucible containing a moist paper disk (Whatman No. 42) and filter into a 250 ml flask. Use an additional 25 ml of buffer solution to aid in the transfer of all the soil to the crucible. The rate of filtration should be such that not less than 30 minutes is required to complete this filtration and leaching.
3. By adding small increments, leach the soil with 100 ml of the replacement solution.
4. To the leachate add 8 drops of mixed indicator. Titrate with 0.100 N HCl. The end point can be chosen as any point during the progressive color change from a bluish green through violet to pink. This end point should be checked against a blank containing 50 ml of buffer solution and 100 ml of replacement solution and titrated to the same end point with the 0.100 N hydrochloric acid. This end point should be reached

when titrating the soil extract. All calculations are made with this blank determination as a reference.

C. Calculation for a 10 gm sample of soil:

$$\frac{[\text{ml. HCl (blank) less } (-) \text{ ml. HCl (sample)}] \times \text{normality of HCl}}{0.100\ \text{N}} =$$

meq. acidity/100 gm. soil at pH 8.2

APPENDIX D: BULK DENSITY DATA

Sample Number	Horizon	Depth (inches)	Bulk Density
		Willamette	
W-1-1	Ap	0-10	1.41
W-1-2	A12	10-18	1.36
W-1-3	A3	18-26	1.44
W-1-4	B1	26-39	1.35
W-1-5	IIB21t	39-52	1.38
W-1-6	IIB22t	52-60	1.32
		Willamette variant	
W-2-1	Ap	0-10	1.48
W-2-2	A3	10-15	1.56
W-2-3	B1	15-21	1.60
W-2-4	B21t	21-37	1.56
W-2-5	IIB22t	37-56	1.55
W-2-6	IIB3t	56-64	1.52
		Carlton-like	
W-3-1	Ap1	0- 3 1/2	1.36
W-3-2	Ap2	3 1/2- 9	1.50
W-3-3	A12	9-15	1.38
W-3-4	A3	15-24	1.50
W-3-5	B1	24-41	1.60
W-3-6	IIB21t	41-52	1.54
W-3-7	IIB22t	52-58	1.52
W-3-8	IIC1	58-62	1.62
W-3-9	IIC2	62-90	1.56
		Woodburn	
W-4-1	Ap1	0- 4 1/2	1.28
W-4-2	Ap2	4 1/2-10	1.38
W-4-3	A3	10-17	1.32
W-4-4	B1	17-22	1.53
W-4-5	B21	22-29	1.46
W-4-6	IIB22t	29-44	1.55
W-4-7	IIB23t	44-62	1.54
W-4-8	IIB3t	62-73	1.57
W-4-9	IIC	73-87	1.47

Sample Number	Horizon	Depth (inches)	Bulk Density
		Willamette	
W-5-1	Ap1	0- 4	1.40
W-5-2	Ap2	4- 9	1.42
W-5-3	A3	9-15	1.42
W-5-4	B1	15-20	1.48
W-5-5	B21	20-32	1.52
W-5-6	IIB22t	32-40	1.56
W-5-7	IIB23t	40-56	1.46
W-5-8	IIC	56-70	1.48
		Willamette variant	
W-6-1	Ap1	0- 4	1.46
W-6-2	Ap2	4- 9 1/2	1.60
W-6-3	A3	9 1/2-15	1.50
W-6-4	B1	15-20	1.51
W-6-5	B21t	20-29	1.54
W-6-6	IIB22t	29-44	1.47
W-6-7	IIB23t	44-59	1.49
W-6-8	IIC	59-78	1.54
		Willamette variant	
W-7-1	Ap1	0- 5	1.38
W-7-2	Ap2	5-10	1.40
W-7-3	A3	10-15	1.58
W-7-4	B1	15-20	1.56
W-7-5	B21	20-30	1.49
W-7-6	IIB22t	30-36	1.36
W-7-7	IIB23t	36-48	1.40
		Willamette	
W-8-1	Ap1	0- 5	1.41
W-8-2	Ap2	5-10	1.30
W-8-3	A3	10-17	1.46
W-8-4	B1	17-28	1.47
W-8-5	IIB21t	28-33	1.38
W-8-6	IIB22t	33-49	1.51
W-8-7	IIB3t	49-60	1.44
W-8-8	IIC	60-74	1.44

Sample Number	Horizon	Depth (inches)	Bulk Density
		Dayton	
D-1-1	Ap1	0- 3	1.36
D-1-2	Ap2	3- 7	1.47
D-1-3	A2	7-14	1.40
D-1-4	IIB2t	14-25	1.84
D-1-5	IIIB3t	25-30	1.61
D-1-6	IIIC	30-41	1.52
		Dayton	
D-2-1	Ap1	0- 4	1.48
D-2-2	Ap2	4- 9	1.24
D-2-3	A2	9-13	1.50
D-2-4	IIB2t	13-24	1.74
D-2-5	IIIB3t	24-34	1.58
D-2-6	IIIC	34-44	1.35