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Sediment Transportation on Steep Terrain, Oregon Coast Range²

The study area upon which this report is based is located in the central part of the foothills of the Oregon Coast Range (Figure 1) near the margin of the Willamette Valley. Topography of this part of the Coast Range gives one the impression of early maturity, with rounded, thoroughly dissected hills and steep-sided, predominantly narrow valleys. Valley flats are not uncommon, however, and occasionally small, flat, upland remnants may be seen. Abrupt, local variation of developmental stages of topography is typical of this tectonically active province.

Rainfall in the general area averages about 65 inches annually (Yearbook of Agriculture, 1941) and is distributed through the year approximately as shown in Figure 2. Mean annual temperature is about 50° F (Johnsgard, 1963).

Native vegetation was predominantly 300- to 600-year-old Douglas-fir (*Pseudotsuga menziesii*). Essentially all of the virgin stands of fir have been logged. Present tree cover on south exposures such as the study area includes scattered bigleaf maple (*Acer macrophyllum*) and Oregon white oak (*Quercus garryana*) with groves of second-growth Douglas-fir. The understory vegetation on south exposures, which is commonly the dominant vegetative cover, is composed of a large variety of tall grasses and shrubs. North exposures are ordinarily covered with dense stands of second-growth Douglas-fir with almost no understory vegetation.

Soils, geomorphic surfaces, and bedrock have been mapped (Balster and Parsons, 1966) in the area between Price Creek and Woods Creek (Figure 1). Particle-size data were obtained for the surface materials on steep, side-valley slopes of two of four adjacent gulches entering Woods Creek Canyon from the north side. These two tributary valleys have been named Oakpark Gulch and Deerslayer Gulch (Figure 3) in accordance with local usage, to facilitate discussion. Observations from various localities in neighboring portions of the Coast Range have aided interpretations.

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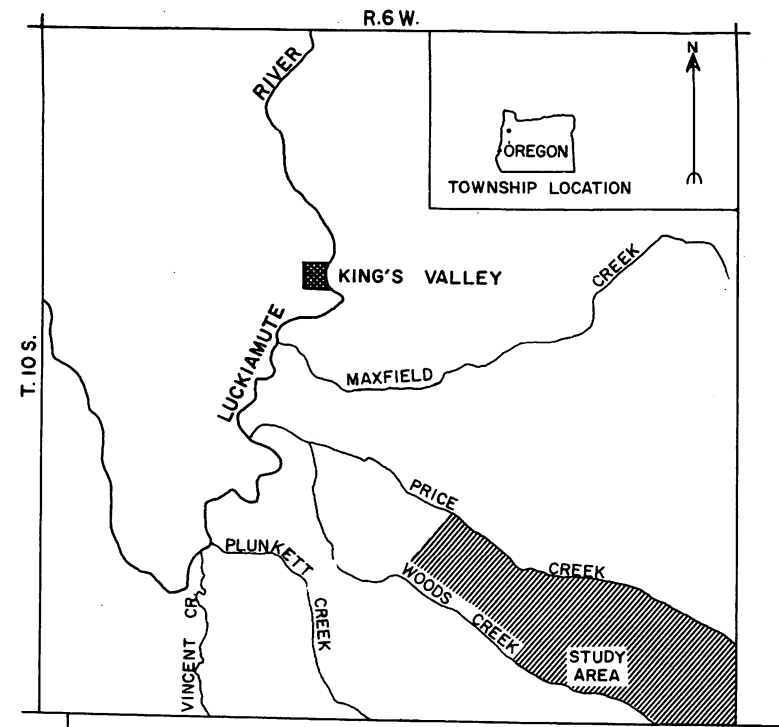


Figure 1. Index map.

Geology of the Area

Woods Creek and Price Creek drainages are underlain by pillow basalts, breccias, and pyroclastic sediments of the Eocene Siletz River Formation³ (Snively and Baldwin, 1948). Complex faulting and gentle folding are characteristic of the area and appear to have controlled the direction of development of Woods Creek and Price Creek canyons. Deerslayer and Oakpark gulches are probably not directly related to geologic structure, but they may be related to fracture patterns in the basalt.

Extent of weathering of the basalts in the area is highly variable. Relatively fresh, hard rock and soft, clayey saprolite represent extremes. Generally, the bedrock is highly fractured and has at least a thin rind of clayey, weathered material surrounding the fragments. Relatively fresh basalt is overlain by only a few feet of rocky soil on the more steeply sloping landforms of the area. Deep, soft saprolite was penetrated by hand-augering to a depth of 20 feet immediately northeast of Deerslayer Gulch on a high remnant of an old erosion surface. Relatively fresh, hard basalt crops out near the bottoms of both Deerslayer and Oakpark gulches (Figure 3).

³Snively and Baldwin (1948) named the unit "Siletz River volcanic series." Because this usage does not agree with the meaning of series as defined by the American Commission on Stratigraphic Nomenclature (1961), the authors use the unit as a formation in accord with present accepted terminology.

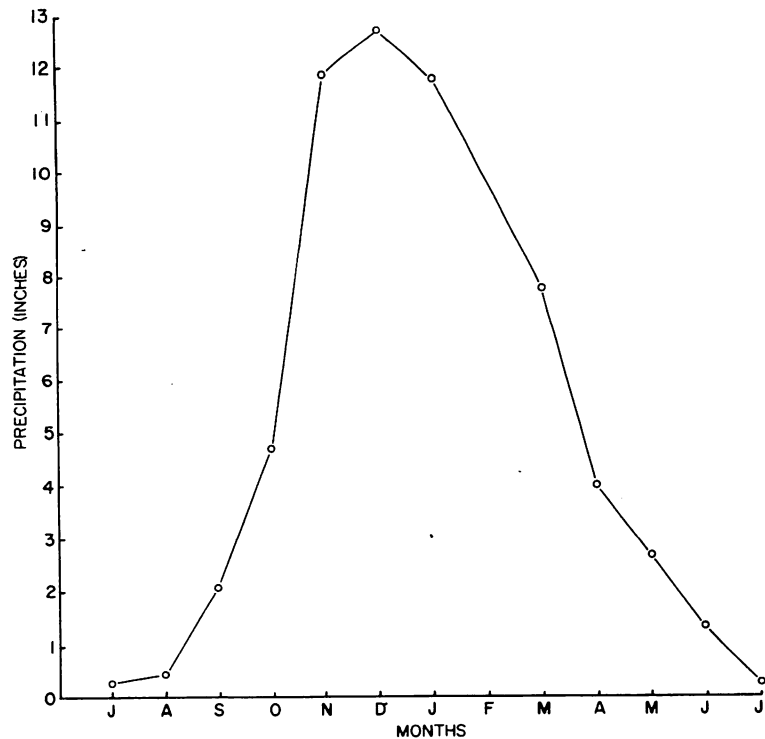


Figure 2. Distribution of rainfall by months.

Sediment Transportation

Woods Creek transports a variety of subrounded fragments, the coarsest of which range from about 15 inches near the headwaters to about 11 inches near the mouth of the canyon. Abundant fine, red sediment, presumably derived from the soil of the surrounding hills, is intricately interstratified with the coarse material on the narrow valley bottom.

Both Deerslayer and Oakpark gulches are floored by coarse, subangular basalt cobbles and boulders up to a foot in maximum dimension near the heads of the valleys. Particle-size of this alluvium decreases very rapidly down the valleys to their junctions with Woods Creek Canyon. Each gulch has a fan composed of poorly sorted, crudely stratified material varying in size from clay to cobbles. The rapid decrease in size of fragments downvalley and the steep gradient of the valley bottoms indicate that these ephemeral streams lack ability to transport their bed load and to cut further downward (Mackin, 1958; Holmes, 1952).

Extremely poor sorting suggests that the fans are the product of earthflow. It is entirely possible that the gulches were cut chiefly by earthflow (Doehring, 1965). Occurrence may have been related to minor catastrophic events such as forest fires and conditions of extraordinary moisture imbibition by mantling material. Exceptional infiltration of water during the winter of 1964-65 was facilitated by several inches of

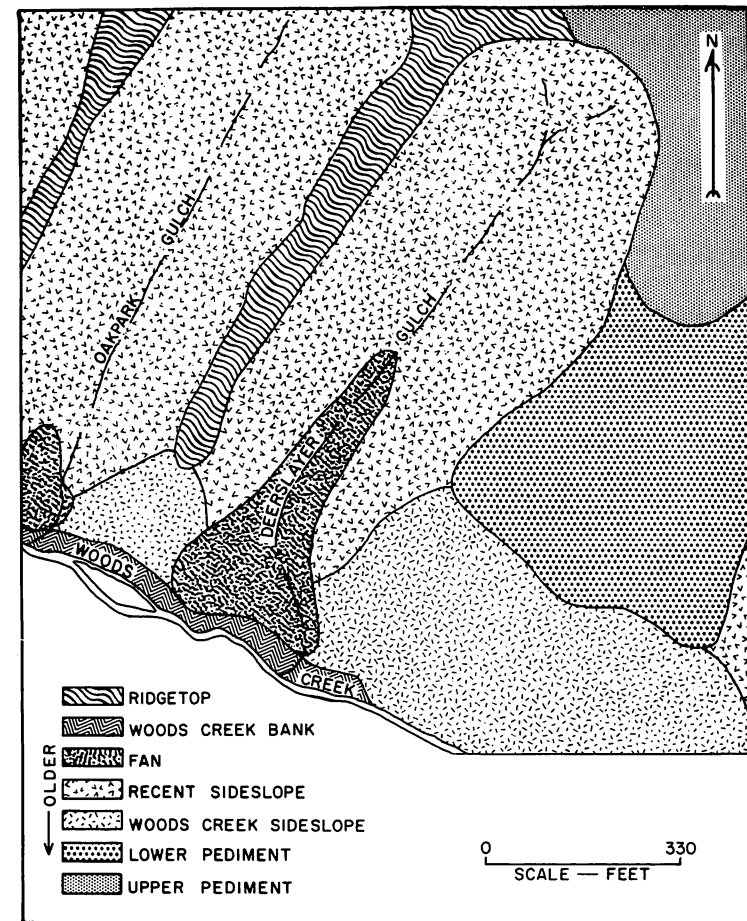


Figure 3. Landforms. The four upper map units are not strictly in age sequence but are morphologically separable.

snow cover that was saturated and subsequently melted by abundant warm rain. Mass movement by sliding and slumping was unusually abundant in the area during that period, and the degree of the "catastrophe" could undoubtedly have been intensified by a coincidental earthquake.

The base of the fan from Deerslayer Gulch where it is exposed in the cutbank of Woods Creek is only about three feet higher than the immediately adjacent modern channel of Woods Creek. Present gravel bars are at the same elevation as the base of the fan. Charcoal taken from the exposure in the cutbank at the base of the Deerslayer Gulch fan gave a maximum age for the fan (Balster and Parsons, 1966) of 9570 ± 510 years B.P. (before present). As the fan was deposited on the valley bottom of Woods Creek, there has been no significant downcutting of Woods Creek channel since that time. From the standpoint of net valley deepening accomplished

Woods Creek channel must be considered to be at equilibrium at this location. It is also noteworthy that the valley bottom of Woods Creek throughout the basaltic terrane is little or no wider than stream width at flood stage. Therefore, lateral cutting has not been appreciable during the dated interval of time.

This lack of vertical or lateral cutting does not indicate a lack of transportation of sediment, coarse or fine, downcanyon at high-water stages. During the winter flood of 1964-65, large quantities of coarse gravel were swept out of the canyon. Abundant fine sediments were also in transit as indicated by the turbidity of the water. Several changes in the course of the channel were caused by complete plugging of old established channels with coarse gravel.

The estimated minimum original volume of the dated fan is about 120 thousand cubic yards. The part of the fan remaining in the mouth of the gulch contains about 80 thousand cubic yards of debris. Thus, approximately 40 thousand cubic yards of material have been transported away from the site of the fan by Woods Creek during the past 9750 ± 510 years.

According to the information at hand, it may be concluded that Woods Creek is transporting sediments out of its canyon at essentially the same rate that material is being made available. In other words, it is a system at equilibrium. Transportation of material into Woods Creek Canyon is accomplished by both mass movement and fluvial processes. Evaluation of the relative importance of each of these is virtually impossible because adequate information on time and sequence of events is lacking. Channel processes of Woods Creek transport material out of the canyon.

The map showing landslides and earthflows best illustrates the occurrence and amount of transportation of materials by mass movement (Figure 4). At least six types of mass movements occur within the area: debris flow, debris avalanche, debris slide, slump, soilfall, and rockfall (Highway Research Board, 1958). Only landslides (debris avalanches and debris slides) and earthflows (debris flow) are of mappable size. During heavy winter storms, debris flow, debris avalanche, and debris slide are most important in the order of listing. Slumps are almost negligible and soilfall occurs only along cutbanks of Woods Creek and Price Creek. Rockfall is rare, but it does occur during the wet season. Conversely, rockfall becomes the predominant method of movement during the summer months, but even then it is small in total volume.

Size Distribution Study

Landforms (Figure 3) of the detailed study area surrounding Deerslayer Gulch may be assigned to three relative age groups. The oldest high pediment⁴ remnant is mantled by deep, red soil with a well-developed, textural B horizon (Parsons and Balster, 1966) and basalt saprolite in excess of 20 feet thick. The younger pediment remnant, and its backslope, is underlain by deep red soil similar to that on the older pediment. Basalt saprolite on this level generally does not exceed eight feet in thickness. The fan, steep valley sides, and narrow ridgetops may be assigned to a single age group, although there is a suggestion that the valley sideslopes of Woods Creek

⁴Pediment is used here as a morphologic term to identify a landform type. Pediment has been defined by Ruhe (1956) as "an erosion surface that lies at the foot of a receded slope, is underlain by rocks or sediments of the upland, is barren or mantled by a layer of alluvium (pedisediment) and displays a longitudinal profile normally concave upward."

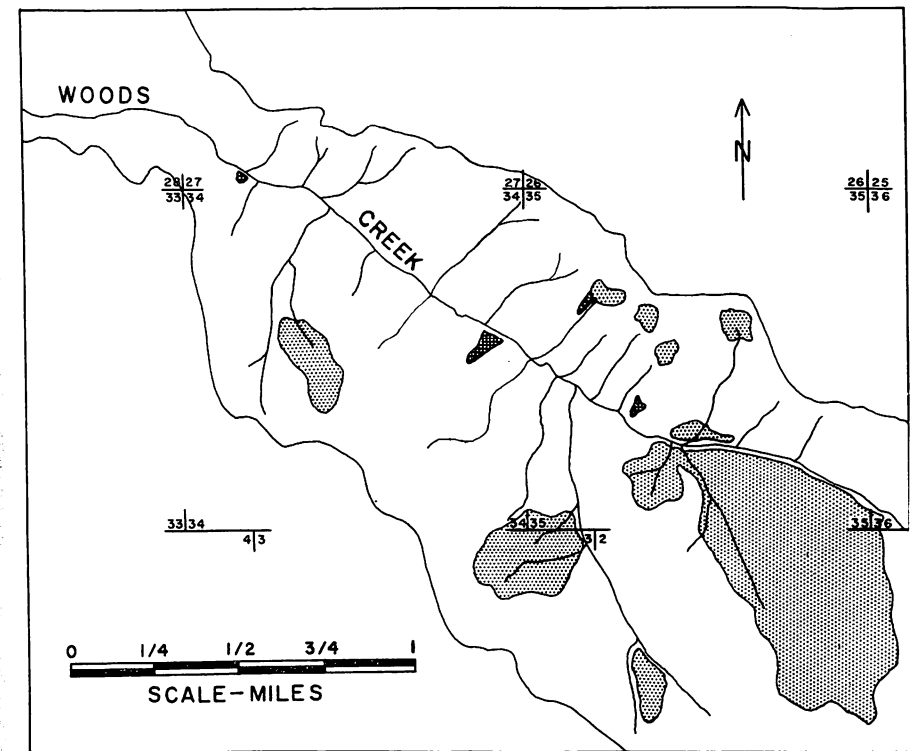


Figure 4. Distribution of large mass-movement features. Light stippled pattern represents old features. Heavy pattern represents movements that have occurred since 1964.

may slightly predate those of Deerslayer and Oakpark gulches. The surfaces of this latter age group are mantled by thin, slightly developed, stony soil. However, soil on the sideslopes of Woods Creek contains more aggregates (peds) than soil along Deerslayer and Oakpark gulches and probably reflects greater time for soil formation.

Air dry samples weighing about 25 pounds each were collected from the upper foot of the sola along transects as shown on the map (Figure 5). The samples were sieved, immediately after collection, through a 1/4-inch mesh screen. The coarse material was then divided into two grades: fragments greater than and less than one inch. Each of these three size grades was weighed to the nearest ounce and the weight recorded.

Within the area of the map (Figure 5), the steep valley sideslopes are essentially planar except for a very small toeslope and a similar small shoulder. The slope gradient (in per cent) shown on the map were measured with an Abney⁵ level to determine if obvious differences in size of material were related to variation of declivities. No relationship is apparent.

Processes of mass wasting, such as creeping and slumping, tend to produce material

⁵Trade names and company names are included for the benefit of the reader and do not imply an endorsement by the U.S. Department of Agriculture.

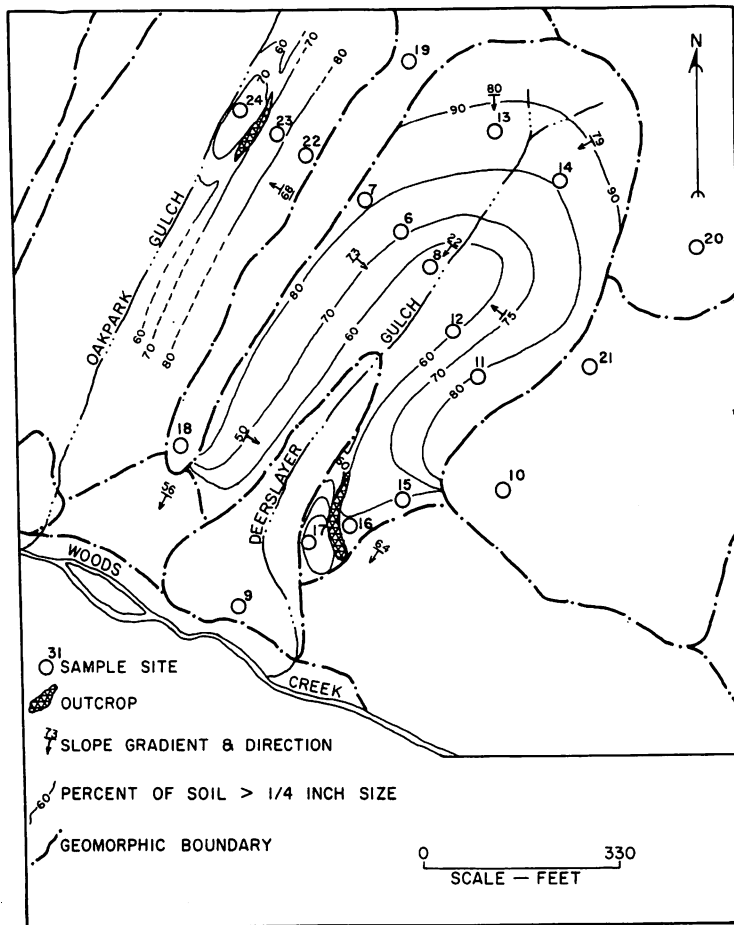


Figure 5. Distribution of the coarse fraction of the soil.

with an assortment of size grades. Transportation by water tends to produce materials with size sorting. The downslope decrease in size of material (Figure 5) seems to be most adequately explained by a combination of transportation of fine particles down the valley walls by water and comminution of fragments by weathering. As should be expected, the areas immediately downslope from outcrops show exceptionally high proportions of coarse material.

Accumulation of assorted material behind logs and stumps is indicative of the mass wasting along these steep valley sideslopes. The predominant process is probably rockfall. "Terraces" on the uphill side and depressions on the downhill side of stumps are much like those described by LaMarche (1964). The rate of downslope movement in the Deerslayer Gulch area is almost certainly increased by activities of sheep and deer in the area.

As the sides of the gulches are devoid of even small gullies, sheetflood and rill erosion are the agents of transportation by water. Minute "terraces" of alluvium are present behind obstructions on the slopes throughout the winter and are almost certainly transient in time. Pedestals of soil several inches high form under the protection of rocks and bark chips.

Evidence of downslope transportation is not obvious on the gentler, older slopes of the area. Although some movement must occur down these slopes, they appear to be relatively stable. Soils on these slopes have deep, strongly structured profiles with low base saturation and clay-textured B horizons with evidence of clay illuviation on ped faces (Parsons and Balster, 1966). Soil development of this nature corroborates the present stability of these surfaces.

Discussion

Observations indicate that Woods Creek is transporting sizable quantities of material out of the canyon. On the other hand, the radiocarbon date from the base of the alluvial fan at the mouth of Deerslayer Gulch indicates that there has been no net downcutting during the past 9570 ± 510 years.

Woods Creek may be considered to be a stream at grade, because it has developed a condition of balance between transportation and erosion (Davis, 1902; Mackin, 1948; Woodford, 1951). A state of equilibrium since deposition of the dated fan is indicated by the lack of downcutting or alluviation. Valley widening by processes of lateral cutting has been unimportant, as the valley bottom is barely wider than the stream during flood stage.

Further general deductions are possible if the Woods Creek drainage is considered to have been an open system (Chorley, 1962; Schumm and Lichty, 1965) at "dynamic equilibrium" (Strahler, 1952; Hack, 1960) since the culmination of the erosion cycle during which the saprolites were produced. Continual change marked by minor catastrophic events should establish an active or dynamic equilibrium. It is of considerable interest that the channel of Woods Creek has suffered so little net change over the dated period of time and has, on the other hand, transported large quantities of material completely out of the system.

Only a minor amount of solid material such as volcanic ash can be considered to have entered the system during the dated interval. Overall, the net energy of Woods Creek drainage system is being decreased (Melton, 1960) by loss of material. The energy expended is being used to reduce the slope gradients in the drainage area and to transport the resulting sediment out of the system.

Most of the transportation of material to Woods Creek channel is either by mass movement or by water erosion down steep slopes. Evidence shows less transportation across gentler slopes at higher elevations. It is suggested, therefore, that reduction of relief is not a major part of present denudation mechanisms.

The only other alternative mechanisms are headward erosion and reduction of slope gradient. Both varieties are active, but should be important in about the proportion of the relative areas of headwall to valley wall in the total drainage network. Reduction in slope gradients seems to be a necessary mechanism in contrast to the concepts of King (1953).

It is most interesting that Woods Creek shows a condition of equilibrium over the relatively short-term dated interval. There can be little doubt, on the other hand, that this equilibrium condition is slowly revised during the long-term progress of the erosion cycle.

Literature Cited

- American Commission on Stratigraphic Nomenclature. 1961. Code of stratigraphic nomenclature. Amer. Assoc. Petroleum Geol. Bull., 45:645-665.
- Balster, C. A., and R. B. Parsons. 1966. A soil-geomorphic study in the Oregon Coast Range. Oregon Agr. Exp. Sta. Tech. Bull. No. 89.
- Chorley, R. J. 1962. Geomorphology and general systems theory. U.S. Geol. Survey Prof. Paper 500-B:1-10.
- Davis, W. M. 1902. Base level, grade and peneplain. Jour. Geol., 10:77-111.
- Doehring, D. O. 1965. (abstract) Fire as a geomorphic agent in the San Gabriel Mountains of southern California. Geol. Soc. Amer. Prog., pp. 45-46.
- Hack, J. T. 1960. Interpretation of erosional topography in humid temperate regions. Amer. Jour. Sci., 258A:80-97.
- Highway Research Board. 1958. Landslides and engineering practice: Highway Research Board Special Report 29, public. 544.
- Holmes, C. D. 1952. Stream competence and the graded stream profile. Amer. Jour. Sci., 250: 899-906.
- Johnsgard, G. A. 1963. Temperature and water balance for Oregon weather stations. Oregon Agr. Exp. Sta. Special Report 150, 127 pp.
- King, L. C. 1953. Canons of landscape evolution. Geol. Soc. Amer. Bull., 64:721-752.
- LaMarche, V. C., Jr. 1964. (abstract) Determination of denudation rates from measurements of root exposure. Geol. Soc. Amer. Program, p. 117.
- Mackin, J. H. 1948. Concept of the graded river. Geol. Soc. Amer. Bull., 59:463-512.
- Melton, M. A. 1960. (abstract) Concept of state of drainage systems. Geol. Soc. Amer. Program, p. 160.
- Parsons, R. B., and C. A. Balster. 1966. Morphology and genesis of six "Red Hill" soils in the Oregon Coast Range. Soil Sci. Soc. Amer. Proc., 30:90-93.
- Ruhe, R. V. 1956. Geomorphic surfaces and the nature of soils. Soil Sci., 82:441-465.
- Schumm, S. A., and R. W. Lichty. 1965. Time, space and causality in geomorphology. Amer. Jour. Sci., 263:110-119.
- Snavely, P. D., and E. M. Baldwin. 1948. Siletz River volcanic series, northwestern Oregon. Amer. Assoc. Petroleum Geol. Bull., 32:806-812.
- Strahler, A. N. 1952. Dynamic basis for geomorphology. Geol. Soc. Amer. Bull., 63:923-938.
- Woodford, A. O. 1951. Stream gradients and Monterey Sea Valley. Geol. Soc. Amer. Bull., 62:799-852.
- Yearbook of Agriculture. 1941. Climate and man. U.S. Dept. of Agr., 1248 pp.

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Comparative Morphology of the Reproductive Tracts of Some of the Pacific Northwest Pulmonates and Its Use in Their Taxonomy

The bases for identifying most pulmonates have been the shell characteristics, namely, the height/diameter ratio and the number of whorls and the radulae formulae. This system has been satisfactory for most gastropods where shell characteristics are distinct and color patterns constant. In recent studies, shell characteristics have not always been considered satisfactory, and consequently other methods have been sought in order to solve the problems encountered.

Mead (1943, 1950) studied the morphology of the genitalia of the pulmonates *Ariolimax* (Moerck) and *Achatimida* and found distinct differences in the genital system between genera and species. As a result, he was able to revise the taxonomy of the west coast slugs of the genus *Ariolimax* (Moerck). Similarly, Abdel-Malek (1954a, 1954b) was able to separate into two distinct subfamilies *Helisoma trivolvis* and *Biomphalaria boissyi*, using the differences found in the histology of the genital organs. Boettger (1934), Webb (1953), and Franzen (1963) used the morphology of the genitalia to separate the genera in the family Succineidae, and Porter (1965) used it to separate two genera within the family Haplotrematidae. Watson (1920), Fretter (1946), Johansson (1956a), and Creek (1951, 1953) also found these structures useful and necessary in the identification of prosobranchs.

Because most of the descriptions of the Pacific Northwest pulmonates are based upon somewhat inadequate shell and radula characteristics, the purpose of this study was to attempt to correlate the genital characters with radula and shell characters for the identification of these organisms.

Materials and Methods

The snails were collected from four stations within a radius of 25 miles from Corvallis, Oregon, at sites which were characterized by an abundant growth of sword ferns and Douglas fir, in a moist habitat. The stations were located at (1) Woods Creek, 8 miles west of Philomath, Oregon; (2) along the banks of the Alsea River, west of the town of Alsea, Oregon; (3) near Burnt Woods, Oregon; and (4) Coffin Butte, north of Corvallis.

The snails were maintained in the laboratory in plastic terraria filled with soil and organic debris from the original habitat. The terraria were kept at approximately 65°F.

The snails were killed by leaving them in an Erlenmeyer flask filled with water for from 18 to 24 hours. By this slow drowning method, the snails were killed while