USDA Report on
WATER and RELATED LAND RESOURCES

MIDDLE WILLAMETTE RIVER BASIN
OREGON

Based on a cooperative Survey by

THE STATE WATER RESOURCES BOARD OF OREGON

and

THE UNITED STATES DEPARTMENT OF AGRICULTURE

Prepared by · · ECONOMIC RESEARCH SERVICE · · FOREST SERVICE · ·
SOIL CONSERVATION SERVICE

JULY 1962

cc: Beattie 10/30/63
Leon Thomas

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Report Prepared by

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INTRODUCTION

This report presents information concerning the water and related land resources of the Middle Willamette River Basin and is the result of a cooperative study by the U. S. Department of Agriculture and the State Water Resources Board of Oregon.

The State Water Resources Board of Oregon is making a survey and investigation of the Middle Willamette River Basin to develop information needed for planning the coordinated development of the area's water resources. The information needed for its study includes the following: (1) the kind and location of desirable water resource developments; (2) the amounts of water required; (3) the physical opportunities for development to meet water needs; and (4) the broad economic aspects of possible development. The State will use this information to formulate and implement plans and programs to secure the most beneficial use and control of the area's water resources. The State's programs are intended, by legislative decree, to be dynamic in nature with provision for changes as new information is available and as the physical or economic situation changes. The current survey is only the beginning of the State's work in this area.

Upon request of the State Water Resources Board, the U. S. Department of Agriculture cooperated in this survey under the provisions of section 6 of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress, as amended).

The broad objectives of the cooperative survey were to gather basic information pertinent to the use and control of water for agriculture in the area, to highlight such major water related problems as erosion, flood prevention, and drainage, and to outline a general program for water and related land resource management to be used as a background for future detailed study and planning. No final solutions are intended, for it is felt that watershed planning must be a dynamic, continuing process requiring further cooperative work by all groups concerned.

This report should be of use to anyone interested in the area's land and water resources. It should be of value in appraisal of present and future use of water for agriculture in relation to other water uses for planning, evaluation, development, and operation of the various agricultural programs of federal, state, and local agencies.

The survey consisted partly of an accumulation and evaluation of previously recorded data, both published and unpublished, much of which was furnished by other cooperating groups. In addition, the USDA Field Party made limited surveys to gather basic information that was not otherwise available on physical characteristics of certain reservoir sites, land and water availability and use, problems and needs for many tributary watersheds, and forest land resources and ownership. These were not detailed surveys; much of the information was obtained through consultation with local, public, and private officials. The basic data used as a foundation for statistical information presented in this report are in the files of the USDA Field Party.

Several agencies and organizations provided helpful assistance in making this survey. The field offices of the Soil Conservation Service furnished some of the basic data concerning reservoir sites and tributary watershed data. Most of the land status information was obtained from County Assessor's records of the counties concerned. Much information on the forest land was furnished by the various field offices of the U. S. Forest Service, the Pacific Northwest Forest and Range Experiment Station, the Bureau of Land Management, the State Forester of Oregon, and the West Coast Lumbermen's Association. Much of the agricultural data were obtained from publications of the U. S. Bureau of the Census. Several of the above-mentioned agencies also provided helpful consultation and comment concerning the preparation of this report. In accordance with the cooperative agreement, the State Water Resources Board developed and furnished information concerning existing water rights, major resources and their use, and other pertinent information in addition to furnishing hearing reports and numerous maps.

USDA REPORT ON WATER AND RELATED LAND RESOURCES

MIDDLE WILLAMETTE RIVER BASIN, OREGON

SUMMARY

General Description of the Basin

The Middle Willamette River Basin encompasses an area of 5,426 square miles, 45 percent of the entire Willamette River Basin and 5.6 percent of the total area of Oregon. The basin is composed of three physiographic provinces, the Coast Range uplift on the west, the Willamette Valley Trough, and the western and high Cascades province on the east. The Coast Range is characterized by irregular ridges, short, steep slopes, and soils formed from weathered igneous and sedimentary rock. The Willamette Valley Trough is a broad alluvial plain interspersed with areas of rolling topography and low hills. Most of the valley soils are derived from alluvial sediments with a limited area of residual soils formed from basalt. The Cascade Range is characterized by steep slopes, sharp ridgetops, and deep canyons with elevations ranging from 1,000 to over 10,000 feet. The soils are formed from igneous rock, including Miocene formations in the western Cascades and more recent formations in the high Cascades.

The basin has a temperate maritime climate with dry, moderately warm summers and wet, mild winters. The average annual precipitation varies from a low of 30 inches in the valley to over 100 inches in the mountains. The average annual frost-free season varies from about 200 days in the valley to less than 30 days at the higher elevations.

Settlement of the basin began in 1830. The earliest agricultural activities were the production of small grains and beef cattle. Lumbering began on a limited scale and expanded with the development of markets and transportation facilities. Population increased from less than 10,000 in 1850 to about 290,000 in 1960. The past economic growth of the basin has been based primarily on agriculture and lumbering. However, in recent years employment in agriculture and lumbering has decreased while employment in wholesale and retail trades and services has increased.

About 76 percent of the basin is in private ownership, and 24 percent is publicly owned. About 61 percent of the basin is forested land; 34 percent is agricultural land; and 5 percent is devoted to other uses.

Forestry

The forest land of the basin may be divided into four distinct zones on the basis of ecology, climate, and other factors. The major uses of forest land in the basin are for the production of crops of commercial timber, for outdoor recreation, and for watershed protection; but uses for wildlife habitat and livestock pasture are also important. The emphasis placed on these uses varies considerably by ownership and zone. About 65 percent of the 2,121,300 acres of forest land is privately

owned. Much of this is managed primarily for timber production. About 35 percent is publicly owned and in many instances is managed to accommodate a balance of several uses. Of the 1,938,000 acres of commercial forest land, 657,150 acres containing 29.3 billion board feet of merchantable timber are administered by either the U. S. Forest Service, the Bureau of Land Management, or the Oregon State Board of Forestry.

Timber harvesting and lumber production reached a peak between 1943 and 1956 and have declined sharply since; but the plywood and wood fibre products industries have continued to expand. Timber harvest from private land has decreased while timber harvest from public land has increased. The wood-using industries require an annual sawtimber supply of 1.8 billion board feet to operate at full capacity. The commercial forest land in the basin has an annual sustained yield of about 1.3 billion board feet under the expected intensity of management. As the old-growth timber is gradually replaced by young stands, the structure of wood-using industries will probably change, and water requirements for wood-using industries will be greater.

The basin's forested areas have many natural attractions that make them desirable for recreation such as lakes, fishing streams, outstanding scenery, a relatively abundant wildlife population and suitable hunting terrain, and thousands of acres of roadless wilderness. Forested areas attract many recreational visitors. For instance, recreational visits to the national forests of the basin totaled 460,400 in 1960, more than triple the visits made in 1956. Areas adjacent to lakes and streams receive most of the visits. Increased recreation use is expected in the future.

The basin's forest land supports a large and varied wildlife population; but grazing of forest land by livestock is important only in the Willamette Valley.

Since about 80 percent of the annual water yield from the basin originates on forest land, management practices on this land have an important influence on quality, quantity, and timing of water yield. Uses of water on forest land includes requirements for plant growth, domestic, recreation, livestock, wildlife, fish life, industrial, and other purposes. The total water requirements are expected to increase greatly as forest land is used more heavily and managed more intensively.

Agriculture

The soils and climatic conditions in the basin are favorable for a diversified agriculture. The land base for agriculture consists of 1,033,300 acres of cropland, 134,000 acres of rangeland, and 285,400 acres of grazed forest land. The major uses of cropland are for the production of small grains, grass seed, pasture, and hay. Although relatively smaller acreages are used for the production of fruits, nuts, vegetables, and other specialty crops, these crops have considerable economic importance. The acreage in hay and small grains has decreased while acreage in vegetables has increased.

The 12,615 farms in the basin average 144 acres in size and represent investments of about $36,790 per farm. Farm numbers are decreasing, and average farm size is increasing. Most farmers own their farms.

Milk cows, beef cattle, sheep, and poultry are the major types of livestock in the basin. Although there have been changes in numbers of the different types of livestock raised, total animal units have remained fairly stable since 1920.

Agricultural income from the sale of crops and livestock in the basin in 1959 is estimated at $98.5 million. Income from the sale of crops accounted for 63 percent of the agricultural income, and livestock accounted for 37 percent. Since 1939, income from the sale of crops has been increasing at a higher rate than income from the sale of livestock.

The major irrigated crops in the basin are pasture, vegetables, hay, and silage. Several other crops are also irrigated. A total of 128,510 acres were irrigated in the basin in 1961. With some exceptions, irrigation is practiced along or near the main stem of the Willamette River and its tributaries. Streamflows are the source of water for 50 percent of the irrigated acreage; ground water is the source for 45 percent; and reservoir and pond storage is the source for 5 percent. Sprinkler irrigation is used on 98 percent of the irrigated land. Irrigated acreage in the basin has more than doubled since 1949. There are adequate land and water resources to irrigate an additional 895,800 acres. However, the degree to which irrigation development occurs will depend primarily on economic factors.

Water Related Problems

Major water related problems in the basin include those of seasonal water supply, irrigation systems, drainage, flooding, sedimentation, and erosion. The total water resources are more than adequate for present and future agricultural needs. The total average annual yield from the basin after current consumptive use withdrawals is about 12 million acre feet. The irrigation water requirement for the 895,800 acres of potentially irrigable land would be about 3,000,000 acre feet. Irrigation development for much of this land would require group action.

About 557,100 acres, or 34 percent of the arable soils in the basin, have problems of excessive wetness. Flood control is often a prerequisite to successful drainage. Flooding occurs in the winter and spring and causes extensive damage. In the forested areas, flood damage occurs in areas where roads are poorly planned and constructed, where logging operations are not adequately planned, where forest fires have destroyed the vegetative cover, and in areas that have been overgrazed. Flood damages in the valley areas range from erosion and sedimentation to losses of crops, property, and life.

Needs and Opportunities for Improved Management of Water and Related Land Resources

Maintenance and improvement of the condition of all tributary watersheds in the basin should be continued. Good watershed management on all forest land is vital to water users and to landowners in downstream areas. Forest land managers and owners need to meet their responsibility for management of all forest resources. They also need additional knowledge about many phases of forestry to enable them to do a better job of watershed management. Small forest landowners particularly need the advice and assistance of trained foresters to help them realize maximum benefits from their land.

The pressure from an increasing population and the accompanying industrial and urban development is exerting an increasing demand on land and water resources of the basin. To meet this demand there is a continuing need for more conservation cropping systems and erosion control practices, improved and increased irrigation water use, and drainage measures.

To assure maximum benefits from irrigation, even the best designed system must be managed carefully to give attention to the amount and frequency of water application. Both should be adapted to the soil, crop, and weather. The technical advisor and farmer are in need of more factual information on water-holding capacities and intake rates of soils to facilitate more efficient use of water.

There are only 8 organized group irrigation projects in operation and three under consideration; more of them are needed for good water management.

About 406,500 acres of land need drainage for maximum production in its present use. Soluble salts are not a problem in this area, so the water drained from wet land can be used for irrigation. Often sufficient drainage for the desired use can be accomplished by removal of surface water, but most of the land and crops require extensive subsurface drainage systems.

Erosion on cultivated land is mainly the result of water action cutting away fields by streambank erosion and washing and leaching away surface soil from unprotected fields by rilling, gullying, and sheet erosion. Erosion from wind action is usually negligible. Stream channel work is most beneficial when a complete unit of stream channel is improved in a single coordinated project rather than by piecemeal work by individual landowners.

There is a great need for better management and development of water resources of the basin to better serve all phases of the economy. Ground water, surface water, and stored water can all be used to advantage to help meet the water requirements of the growing population. The conservation of excessive, often damaging, runoff water in reservoirs for flood protection and subsequent use for irrigation, industry, domestic, recreation, pollution abatement, and fish life has considerable

potential in the Middle Willamette River Basin. There are many potential water storage sites throughout the basin where reservoirs could be developed for multipurpose use.

Opportunities for Watershed Protection and Flood Prevention Projects

The USDA Field Party divided the basin into 57 small watershed areas and made a reconnaissance survey of them. The purpose of this survey was not to make an economic study of feasibility but to delineate by limited observation those watersheds which have problems whose solution appears to be feasible under P. L. 566. A summary report was written for 29 of the watershed areas. Data on physiographic conditions, land use and ownership, water yield and seasonal distribution, and water related problems and needs were evaluated on each watershed area. It was concluded that 12 of the small watershed areas reported on have problems which can be solved under the provisions of P. L. 566. The watersheds with best possibilities are generally those with a high potential for agricultural and/or urban development; with localized flooding and drainage problems; and with water supply needs that cannot be met by individual action. Watersheds with a high proportion of forested land, a large yield of water, and a relatively small acreage to be benefited through water development and control do not have good watershed project possibilities under existing conditions and laws.

GENERAL DESCRIPTION OF THE BASIN

LOCATION AND SIZE

The Middle Willamette River Basin is located in the northern portion of western Oregon and includes the Willamette River and its tributaries from approximately river mile 32.7 to river mile 145.8 (fig. 1). The basin is bounded on the north and south by the Lower Willamette and Upper Willamette Basins, respectively, bounded on the west by the North Coast and Mid Coast Basins, and bounded on the east by the Deschutes Basin. The basin has a total area of about 5,426 square miles, about 45 percent of the entire Willamette River Basin area and about 5.6 percent of the total area of Oregon. The basin includes a major portion of five counties - Benton, Linn, Marion, Polk, and Yamhill 1/ - and a minor portion of five counties - Clackamas, Lane, Lincoln, Tillamook, and Washington.

For the purpose of this report, the Middle Willamette River Basin is divided into three subbasins which are numbered 5 through 7 because this basin is only a part of the entire Willamette Basin. Subbasin 5, the Santiam Subbasin, has an area of 2,440 square miles and includes all of the basin east of the Willamette River and south of the Pudding River-Santiam River divide. Subbasin 6, the Coast Range Subbasin, has an area of 1,794 square miles and includes all of the basin west of the Willamette River. Subbasin 7, the Pudding Subbasin, has an area of 1,192 square miles and includes all of the basin east of the Willamette River and north of the Pudding River-Santiam River divide.

The major watersheds in the Middle Willamette River Basin include the Santiam and Calapooya Rivers in subbasin 5, the Yamhill, Luckiamute, and Marys Rivers in subbasin 6, and the Molalla and Pudding Rivers in subbasin 7.

PHYSICAL ASPECTS

Geology

The structural framework of the Willamette Basin is generally that of a broad synclinal trough, the axis of which roughly parallels the Willamette River and dips to the north. The western flank of the trough is formed by the Coast Range, a broad, faulted, anticlinal uplift. To the east the structure is terminated by great thicknesses of volcanic rock forming the Cascade Range. In relation to its structural framework, the basin is a part of three distinct geologic-topographic prov-

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1/ These counties are often referred to hereafter as the "5 principal counties of the basin". Because they include 89.3 percent of the basin's area and 94.3 percent of its population and because more than two-thirds of each county's area, more than 95 percent of each county's population, and most of each county's industry and agriculture are in the basin, they are used in several instances to illustrate trends in the basin's economic growth. The other five counties have only a minor portion of their area, population, and economy in the basin and are not considered to be representative of the basin.

inces that are elongate in a north-south direction and parallel to the valley axis. These provinces are, from west to east respectively, the Coast Range uplift, the Willamette Valley trough, and the western and high Cascades. The generalized geologic map (fig. 2) illustrates the geologic structure of the basin.

Coast Range Uplift. The Coast Range uplift includes approximately one-sixth of the basin. Here deformation of the earth's crust has bowed the sedimentary beds and underlying volcanic rocks into a broad anticline which has subsequently been dissected to form the rugged foothills and peaks of the Coast Range. The erosional dissection of the structure also provided much of the sediment forming the present valley alluvium. Considerable faulting has occurred in the Coast Range along with related volcanic activity, both of which have formed significant topographic features. Generally the area is underlain by moderately hard sandstone and shales with basalt forming the core of the uplift.

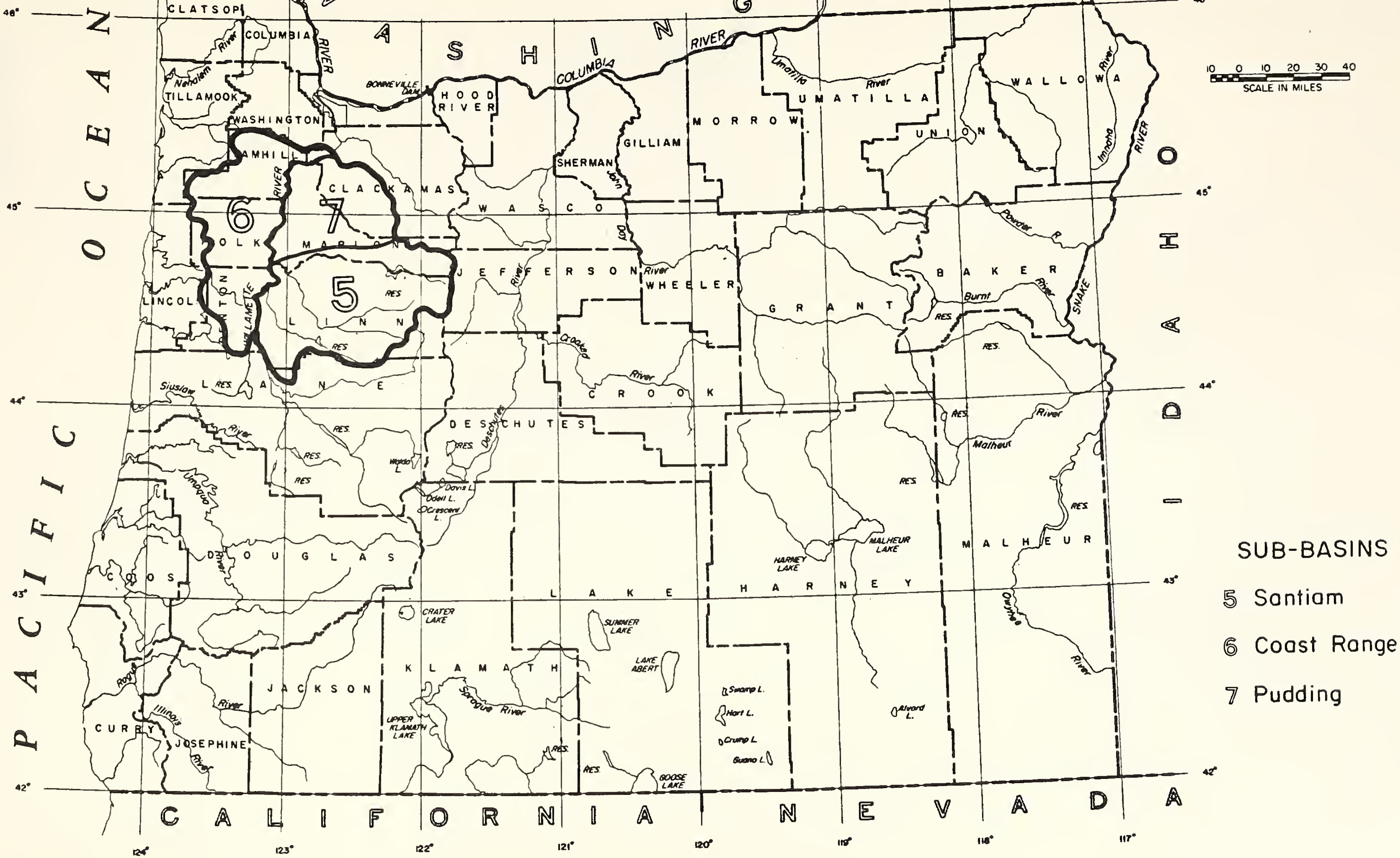
Sedimentary beds of the Mid-Eocene Epoch of the Tyee formation in the south and the Yamhill formation in the north combine to occupy the largest area of this province. A smaller area of sedimentary rock of tuffaceous and marine sandstone of the Spencer and Nestucca formations of the late Eocene Epoch lies along the eastern border. The Siletz River volcanics formation of the early Eocene Epoch crops out in the Yamhill valley and again in the Dallas area and is found most extensively in an area from Camp Adair and Corvallis southwest to beyond Marys Peak. Considerable volcanic activity associated with faulting in the Mid-Miocene Epoch has resulted in intrusive flows of dikes and extrusive flows of basalt.

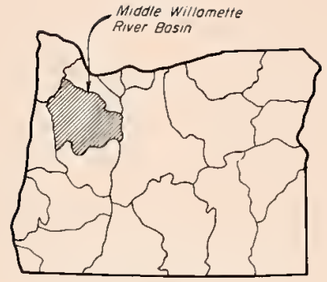
In western Yamhill County, a complex of interbedded breccia, tuff, dark gray volcanic basalt with pillow structure, dark gray tuffaceous shale and siltstone, and thin bedded sandstone outcrops in about 75 percent of the area. About 25 percent of the area is comprised of intrusive rocks which are mainly dark gray, medium to coarse-grained gabbro and diorite with sill and dike structure.

Marine sediments are prominent in western Polk and Benton Counties. About 50 percent of the area is comprised of yellowish-brown tuffaceous sandstone, rythmically bedded with dark siltstone. About 30 percent of Polk County is occupied by breccia, tuff, and dark greenish-gray basalt with pillow structure which contains seams of zeolite and calcite. Similar basalt occupies about 45 percent of western Benton County. Intrusive dark gray medium to coarse-grained gabbro and diorite with dike and sill structure cover about 20 percent of western Polk County and 10 percent of western Benton County.

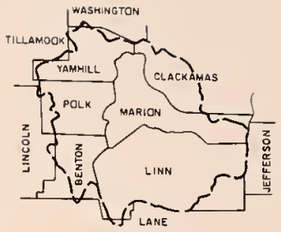
The areas of sedimentary rock are generally maturely dissected and have numerous slumps and slides. Areas of basic igneous rock are often rugged, steep, convex, and less dissected than areas of sedimentary rock because of their greater resistance to weathering. The sills of intrusive rock and extrusive flows of basalt are resistant to erosion and persist in some areas as gently sloping mountain tops such as Marys Peak.

FIGURE 1
LOCATION MAP
MIDDLE WILLAMETTE RIVER BASIN
OREGON
JULY, 1962





RIVER BASIN LOCATION



COUNTY LOCATION

SUBBASINS

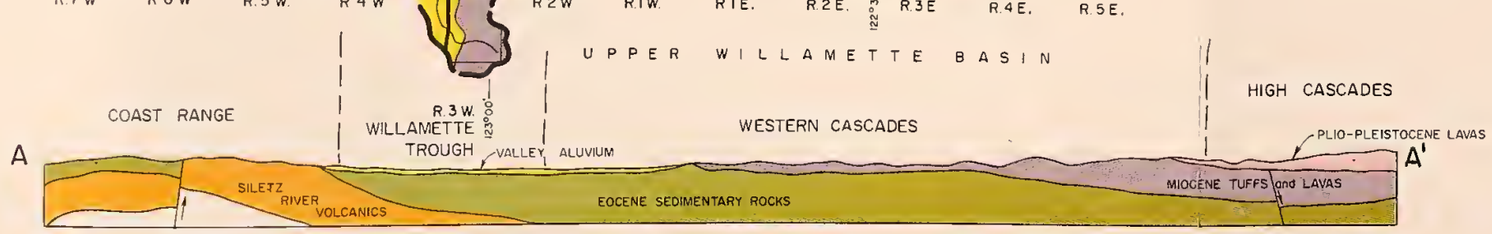
5 SANTIAM

6 COAST RANGE

7 PUDDING

LEGEND

- Eocene Sedimentary Rocks
- Siletz River Volcanics
- Valley Aluvium
- Columbia River Basalt
- Miocene Tuffs and Lavas
- Plio-Pleistocene Lavas
- River Basin Boundary
- National Forest and/or Primitive Area Boundary



GEOLOGIC CROSS SECTION THROUGH SECTION A-A'

FIGURE 2

GENERALIZED GEOLOGIC MAP

MIDDLE WILLAMETTE RIVER BASIN

OREGON

JULY 1962

SCALE IN MILES 5 0 5 10

U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

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Willamette Valley Trough. The Willamette Valley trough comprises the central one-third of the basin and is characterized by a broad alluvial plain broken in the northern portion by several low ranges of hills.

Coincident with the anticlinal upsweep to the west, the formations underlying this area were downfolded forming an elongate basin which has subsequently been filled with sediments from the Coast and Cascade Ranges. Bedrock is not generally exposed in the Willamette Valley; however, through use of valley well logs and surface altitudes to the west, it has been demonstrated that the sedimentary formations exposed along the Coast Range do persist at depth beneath the valley alluvium. These formations probably interfinger with Cascade formations of equivalent age. In the northern portions of the basin, several large areas are covered with erosional remnants of Columbia River basalt which form prominent topographic features such as the Chehalem Mountains and the Salem and Eola Hills.

Western and High Cascades. The eastern half of the basin is in the western and high Cascades province, an area underlain by predominantly volcanic rocks forming the western flank of the Cascade Range. The bedrock formations are basalt and andesite flow rocks and pyroclastic rocks (tuffs, breccias, and agglomerates). These include gently folded lavas and tuffs of the western Cascades of the Miocene Epoch and younger overlying lavas and volanics of the high Cascade peaks of the Plio-Pleistocene Epoch. The latter flows poured out on the eroded surface of the western Cascades to form the present crest of the high Cascades.

Mass movements have been important in sculpturing the landscape in the humid climate of the western Cascades, especially in areas of pyroclastic rocks. Large areas of land have been, and are, undergoing slow mass movement resulting in uneven slopes, slumps, and landflows. The relatively recent Pleistocene glaciers originated in the higher portions of the area and moved down ancient valleys. Upon their recession, the glaciers left behind deepened and widened U-shaped valleys and deposits of glacial debris.

Topography

The principal topographic features of the Middle Willamette River Basin are the Coast Range, the Willamette Valley, and the Cascade Range.

Coast Range. The Coast Range is a low lying mountain barrier between the Willamette Valley and the Pacific Ocean. It is characterized by irregular ridges and short, steep slopes. Summit elevations are generally 1,000 to 3,000 feet with Marys Peak being the highest point at 4,097 feet.

Willamette Valley. The Willamette Valley floor in the Santiam and southern portion of the Coast Range Subbasins is quite smooth, broken only by shallow, meandering stream courses and few buttes. Stringers of nearly level bottom land extend into the Coast Range and Cascade foothills along the major streams. Elevations of the valley floor vary from 150 to 350 feet.

The Willamette Valley in the Pudding and northern Coast Range Subbasins is characterized by relatively level areas interspersed with areas of rolling topography and low hills. Level valley bottoms are found in the Woodburn-Molalla area north and east of Salem, the Newberg area, and near the Willamette River and its major tributaries. Much of the valley in Polk and Yamhill Counties has gently rolling topography. Hilly areas occur south of Silverton and in the vicinity of Salem. Most of the hill summits are below 1,000 feet elevation while the elevation of the valley floor is generally 100 to 300 feet.

Cascade Range. The western Cascade Range within the Middle Willamette River Basin is very rugged. It contains steep slopes, sharp ridgetops, and deep canyons cut by the Molalla, Pudding, Santiam, and Calapooya Rivers and their tributaries. Elevations range from about 1,000 feet in the foothills to 6,000 feet on the highest summits. The high Cascades within the basin lies at 4,000 to 6,000 feet elevation with a few volcanic peaks rising to 8,000 feet or higher. Mt. Jefferson, elevation 10,499 feet, is on the Cascade Crest at the eastern edge of the basin. The high Cascades have been dissected by both stream and glacial action.

Soils

Soil surveys have been made in much of the Willamette Valley, but there is little information concerning the Coast Range and Cascades.

Coast Range. The Coast Range soils in the Middle Willamette River Basin are formed from weathered rock. Variations in soils are closely related to geology and slope. Soils from basalt and gabbro occur on convex, moderate to steep slopes that have resisted dissection. They are characterized by moderately fine texture, moderate depth, high productivity, high water-holding capacity, and a low slump and slide hazard. However, if interbedded tuff or sediments are present, slide hazards are high. Soils from sedimentary rocks tend to occur on convex, smooth to uneven, moderate to steep slopes which are often finely dissected by drainage ways. They are characterized by fine texture, moderate depth, moderately high productivity, moderate water-holding capacity, and a high slump and slide hazard.

Soils near the Coast Range summit are dominantly intergrades between the Yellowish-Brown Lateritic and Reddish-Brown Lateritic great soils groups with inclusions of the Lithosol great soil group. The intergrade soils generally have moderate structure, medium texture, pH below 5, and base saturation about 10 to 20 percent. Soils near the Willamette Valley are dominantly Reddish-Brown Lateritic soils. They have strong structure, fine texture, pH above 5, and base saturation greater than 25 percent. For soils of similar parent rock, soils near the Coast Range summit have higher productivity, steeper slopes, and greater stone content than soils near the Willamette Valley.

Willamette Valley Trough. There are two general groups of soils in the Willamette Valley on the basis of the parent material.

The first group is the residual soils formed from basic igneous rock and tuffaceous sandstone found in the Chehalem, Salem, and Eola Hills. These soils are of the Reddish-Brown Lateritic great soil group and are well drained, moderately fine textured, moderately deep to deep, slightly acid to medium acid, and gently sloping to moderately steep.

The second group is the most extensive and the most important economically. The soil parent material is alluvial sediments of three geologic ages cromprising different formations.

1. The older deposit of gravelly sediments in varying stages of weathering on the higher terraces on the margins of the valley floor.

2. The middle aged deposits of silty material on the main valley floor known as the Willamette Silts. These cover the largest area.

3. The recent sediments of the floodplains adjacent to streams.

Each formation includes soil material that varies in texture from coarse to fine, but medium to fine textured material is most common. The soils in each formation vary in drainage characteristics and form drainage catenas having members ranging from somewhat excessively drained to poorly drained. There are variations in slopes from strongly sloping, convex slopes to level, concave slopes, and in pH values from slightly acid to strongly acid. The soils are classified into the following great soils groups: Brunizem-like, Grey-Brown Podzolic, Planosol, Humic Gley, and Regosol.

The soils formed on the older, gravelly sediments on the higher terraces along the margin of the valley floor are underlain by gravel and have varying amounts of gravel in the entire profile. This group of soils is represented by the Pringle-Santiam-Gilkey drainage catena. These soils are used for production of cereal grains, grass seed, strawberries, pasture, and timber.

The soils formed on the middle aged sediments of the Willamette Silts formation on the main valley floor usually have deep profiles of silty or clayey soil material. There is a minor area of soils having moderately shallow to deep profiles of gravelly soil material. The soils of silty or clayey material constitute the Willamette-Amity-Dayton drainage catena. The Willamette is a Brunizem-like soil with very deep, well-drained, medium to moderately fine textured profile. The moderately well-drained Woodburn is a Grey Brown Podzolic soil with a very deep, moderately fine textured profile. The imperfectly drained Amity is a Grey Brown Podzolic soil with a very deep, fine textured profile. The Concord is a Low Humic Gley soil with a very deep, poorly drained, fine textured profile. The Dayton and Holcomb are Planosol soils with deep, poorly drained, fine textured profiles with a clay pan 12 to 30 inches from the surface. The soils of gravelly material constitute the Sifton-Salem-Clackamas-Courtney drainage

catena. The catena is made up of the well-drained Sifton and Salem, the imperfectly drained Clackamas, and the poorly drained Courtney soils.

The soils formed on sediments of the Willamette Silts formation are adapted to the growth of a wide range of crops such as hay crops, grass seed, row crops, pasture, and cereal grains. In addition, nuts, tree fruits, berries, and alfalfa are produced on the better drained soils.

The soils formed on the recent alluvial floodplain have characteristics that conform closely to the texture of the parent material from which they are developed. These soils vary from no development to weakly developed profiles and are moderately shallow to very deep. They make up the Camas-Chehalis-Wapato drainage catena. The Camas is a Regosol soil with moderately shallow, somewhat excessively drained, moderately coarse textured profiles. Newberg and Chehalis are Regosol soils with very deep, somewhat excessively to well drained, moderately coarse to medium textured profiles. Maytown is a soil with a very deep, moderately well drained, moderately fine textured profile. Wapato and Reed are Low Humic Gley soils with very deep, poorly to very poorly drained, fine textured profiles.

The recent alluvial soils are adapted to the growth of a wide range of crops such as hay crops, grass seed, row crops, pasture, and cereal grains. In addition, nuts, tree fruits, berries, and alfalfa are produced on the better drained soils, and root crops such as carrots, beets, turnips, and potatoes are produced on the soils of moderately coarse to medium texture.

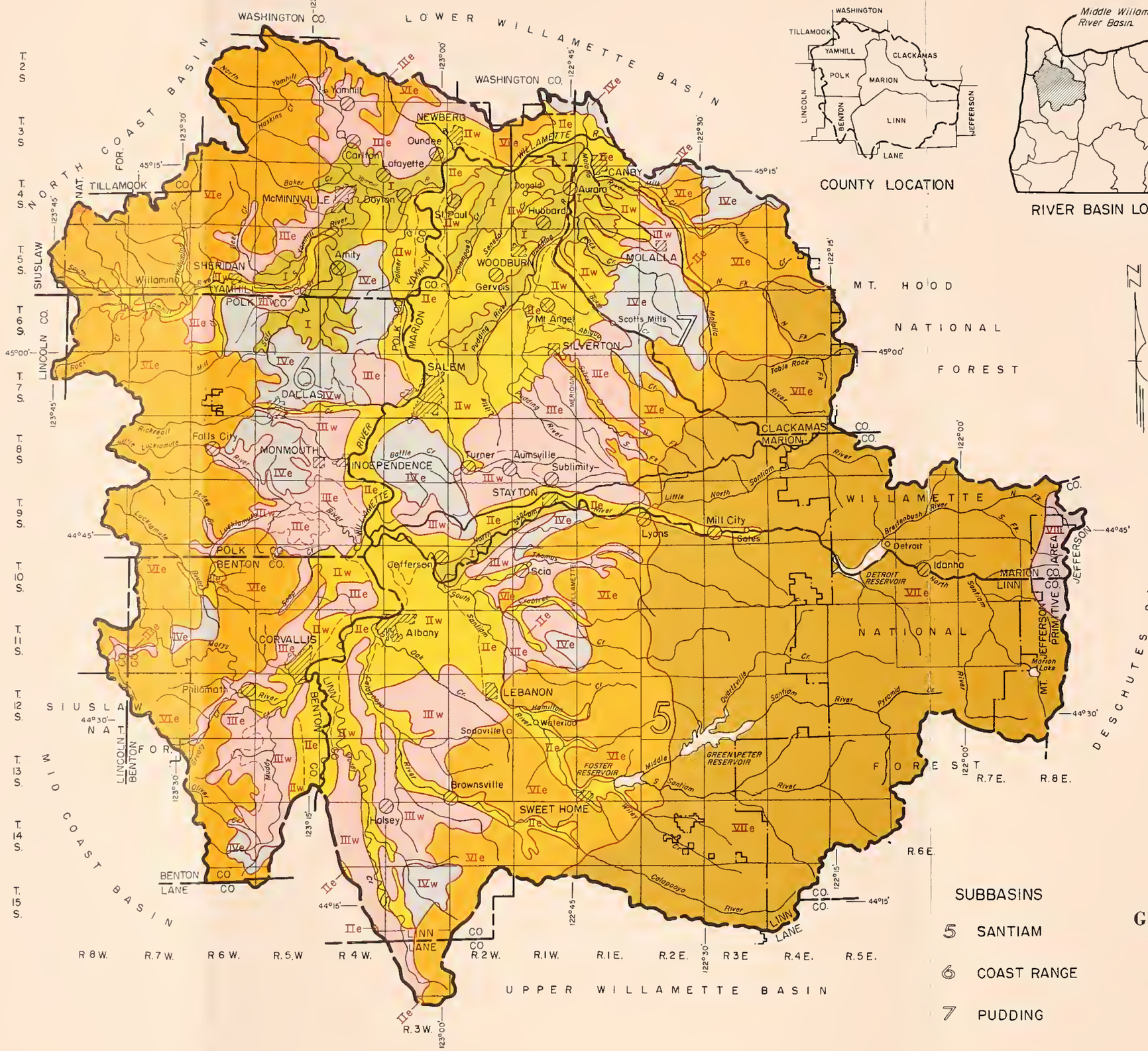
Cascade Range. The soils of the Cascade Mountain slopes within the basin can be placed into three groups on the basis of parent material.

Soils formed from acid igneous and basic igneous material vary in characteristics according to the age of rocks and topography. The soils on steep slopes or from geologically young rocks tend to be medium textured, shallow, and stony. There are minor areas of lava flows that are so young as to be without soil. The soils forming on gentle slopes from older rocks tend to be moderately deep, medium to moderately fine textured, and relatively stone-free.

Soils forming from pyroclastic rocks tend to be fine textured and moderately deep to deep on gentle slopes and moderately fine textured and shallow to moderately deep on steep slopes.

Soils formed from glacial deposits tend to be deep, porous, and stony.

Progressing from the Cascade foothills toward the Cascade Mountain crest, the following groups of soils will be found: Reddish-Brown Lateritics, Yellowish-Brown Lateritics, Brown Podzolics, and Podzols. There may be minor areas of Regosols and Lithosols.



COUNTY LOCATION

RIVER BASIN LOCATION

CLASS I — Soils in Class I have few or no limitations or hazards. They may be used safely for cultivated crops, pasture, range, woodland, or wildlife.

CLASS II — Soils in Class II have few limitations or hazards. Simple conservation practices are needed when cultivated. They are suited to cultivated crops, pasture, range, woodland, or wildlife.

CLASS III — Soils in Class III have more limitations and hazards than those in Class II. They require more difficult or complex conservation practices when cultivated. They are suited to cultivated crops, pasture, range, woodland, or wildlife.

CLASS IV — Soils in Class IV have greater limitations and hazards than Class III. Still more difficult or complex measures are needed when cultivated. They are suited to cultivated crops, pasture, range, woodland, or wildlife.

CLASS VI — Soils in Class VI have severe limitations or hazards that make them generally unsuited for cultivation. They are suited largely to pasture, range, woodland, or wildlife.

CLASS VII — Soils in Class VII have very severe limitations or hazards that make them generally unsuited for cultivation. They are suited to grazing, woodland, or wildlife.

CLASS VIII — Soils and land forms in Class VIII have limitations and hazards that prevent their use for cultivated crops, pasture, range, or woodland. They may be used for recreation, wildlife, or water supply.

SUBCLASSES

- e Erosion
- s Soil
- w Wet or Overflow

SUBBASINS

5 SANTIAM

6 COAST RANGE

7 PUDDING

FIGURE 3

GENERALIZED LAND CAPABILITY CLASSES
MIDDLE WILLAMETTE RIVER BASIN
OREGON

JULY 1962

5 0 5 10
SCALE IN MILES

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE M-3632

7-E-17228-N

Land Capability. The Soil Conservation Service has a practical way of grouping soils called "Land Capability Classification". Soil characteristics such as permeability, water-holding capacity, depth, inherent fertility, texture, structure, wetness, acidity, overflow hazards, slope, and also climatic conditions as they influence use, management, and productivity of land are considered in grouping soils into eight land capability classes. These eight classes are designated by Roman numerals as indicated on the "Generalized Land Capability Map" (fig. 3). The hazards and limitations of use of the groups increase as the class number increases. Class I land has few hazards or limitations, whereas Class VIII land is so limited that it is unfit for safe or economical cultivation and grazing and should be used only for recreation, wildlife habitat, and watershed.

Table 1.--Estimated acreage of land by capability class and subclass, Middle Willamette River Basin, Oreg., 1962

Land capability class	Subbasin 5 Santiam	Subbasin 6 Coast Range	Subbasin 7 Pudding	Total
	Acres	Acres	Acres	Acres
I	31,000	32,100	27,400	90,500
IIe	96,400	35,500	50,000	181,900
IIw	88,600	55,900	58,200	202,700
IIs	48,300	111,300	65,200	224,800
Total II	233,300	202,700	173,400	609,400
IIIe	69,300	112,800	66,600	248,700
IIIw	46,200	74,600	30,100	150,900
IIIs	9,200	6,500	11,900	27,600
Total III	124,700	193,900	108,600	427,200
IVe	138,300	98,200	29,900	266,400
IVw	152,800	26,600	24,100	203,500
IVs	3,900	10,800	2,100	16,800
Total IV	295,000	135,600	56,100	486,700
Total I-IV	684,000	564,300	365,500	1,613,800
VIe	398,100	225,400	188,000	811,500
VIs	...	63,700	12,900	76,600
Total VI	398,100	298,100	200,900	888,100
VIIe	451,400	215,200	186,400	853,000
VIIs	...	68,900	...	68,900
Total VII	451,400	284,100	186,400	921,900
VIII	28,100	10,700	10,100	48,900
Total	1,561,600	1,148,200	762,900	3,472,700

Source: Compiled by USDA, Soil Conservation Service.

Generally speaking, the classification can be broken into two divisions as follows: (1) land in capability classes I through IV is land suited for cultivation and other uses, and (2) land in capability classes V through VIII is best suited for range, forestry, and wildlife because of its own limitations. Land capability classes are sometimes broken into subclasses to indicate the dominating limitation or hazard. The subclasses are "e" for wind or water erosion, "w" for wetness or prolonged frequent inundation from overflow, "s" for soil limitation, and "c" for climatic limitations.

An estimate of the amounts of land in each subbasin has been made for each land capability class and subclass. These data were developed from the Conservation Needs Inventories from those counties within the Middle Willamette River Basin and are summarized in table 1. The general location of the major groups within the Middle Willamette River Basin is shown in figure 3.

Climate

The Middle Willamette River Basin has a temperate maritime climate with dry, moderately warm summers and wet, mild winters. The varying topography produces considerable variation in the climate.

The average annual precipitation is as low as 30 inches in the Willamette Valley but increases rapidly with elevation to 100-140 inches in parts of the Coast Range and Cascade Mountains. About 60 percent of the annual precipitation occurs during the November through February winter storm season while only about 10 percent occurs during the June through September dry season. Below 2,000 feet elevation, most of the precipitation occurs as rain falling at low intensities. Intensity of precipitation and the proportion of precipitation that is snow increases with elevation. The percentage of annual precipitation that occurs as snow increases from about 2 percent on the floor of the Willamette Valley to 50 percent at 5,000 feet elevation and about 75 percent at 7,000 feet. Winter snow accumulations are small in most of the Coast Range but are quite large in much of the Cascades where they are an important source of summer streamflows. Summer precipitation in the basin is limited to occasional light rainstorms and thunderstorms.

The prevailing winds are from the west and northwest during the summer and from the south and southwest during winter storm periods. Wind velocities are moderate, though strong winds sometimes accompany winter storms and short periods of strong easterly or northerly winds may occur at any time of the year. Periods of easterly winds bring cold, clear weather in winter and exceptionally dry weather in summer.

Seasonal temperature variations are small in the Coast Range and Willamette Valley. Winter temperatures below 10 degrees and summer temperatures above 100 degrees are rare. Temperatures in the Cascades are generally cooler and seasonal variations greater than elsewhere in the basin.

The frost-free season in most of the Willamette Valley is from April to October, a period of 180 to 200 days. The frost-free season

decreases with increasing elevation to less than 30 days at the higher elevations in the Cascades.

SETTLEMENT AND HISTORY

Trappers and explorers of British and American fur companies traveled through the Willamette Valley as early as 1812. The first settlers in the Middle Willamette River Basin were retired Hudsons' Bay Company employees who homesteaded the French Prairie area of northwestern Marion County about 1830. Settlers from the eastern and midwestern United States began arriving about 1835, and large immigrations occurred after 1840. The Donation Land Law provided free land to immigrants arriving in Oregon by 1850 and encouraged rapid and widespread homesteading. Most of the Willamette Valley was taken up in donation land claims by 1855.

The earliest agricultural activities in the basin were production of small grains and beef cattle. Rapid increases in production of these commodities followed development of markets in California during the gold rush. Production of sheep, flax, and fruit, particularly apples, began during the 1850's.

Many of the early industrial activities in the basin were connected with the processing of agricultural products. Flour mills, woolen mills, and meat packing and preserving plants were among the earliest industrial establishments. Lumbering began at the time of settlement, but at first the quantity of lumber produced was only sufficient for the needs of the settlers. Export of lumber by ocean freighter began in the 1850's.

Lumber and agricultural products were shipped from the basin by water transportation for many years. Wagon roads were constructed through the Willamette Valley and over the Cascades in the 1860's. Railroads were completed to the east and south into California in the 1870's further encouraging the basin's economic growth.

There were several important changes in the basin's economy between 1870 and 1940. Agriculture became more diversified as land use for wheat and flax production decreased and such crops as hops, mint, and vegetables were introduced. Although the population continued to center in the Willamette Valley, there was gradual settlement of main valleys in the Cascades and Coast Range based on logging, tourist trade, and limited mining and agriculture. Transportation continued to improve as the system of surfaced roads was expanded. The lumber, plywood, and food processing industries continued to expand.

In recent years, the basin's economy has been largely based on diversified agriculture, food processing, logging, and manufacture of lumber and wood products. Other manufacturing, recreation and the tourist trade, and operation of the State Government in the Salem area have also become important sources of income.

POPULATION

The population of the Middle Willamette River Basin was about 290,000 in 1960, or about 53 persons per square mile. About 48 percent of the people live in urban areas including 14 cities and towns with more than 2,500 inhabitants. About 15 percent of the people live on farms, and the remaining 37 percent of the people make up the rural nonfarm population (table 2).

Table 2.--Population distribution, Middle Willamette River Basin, Oreg., 1960

Place of residence	Number of inhabitants			
	Subbasin			
	5 Santiam	6 Coast Range	7 Pudding	Total
	Number	Number	Number	Number
Urban areas	22,150	37,600	80,700	140,450
Rural areas:				
Farm	10,900	14,800	17,800	43,500
Nonfarm	32,750	44,300	29,000	106,050
Total	65,800	96,700	127,500	290,000

Source: U. S. Census of Population.

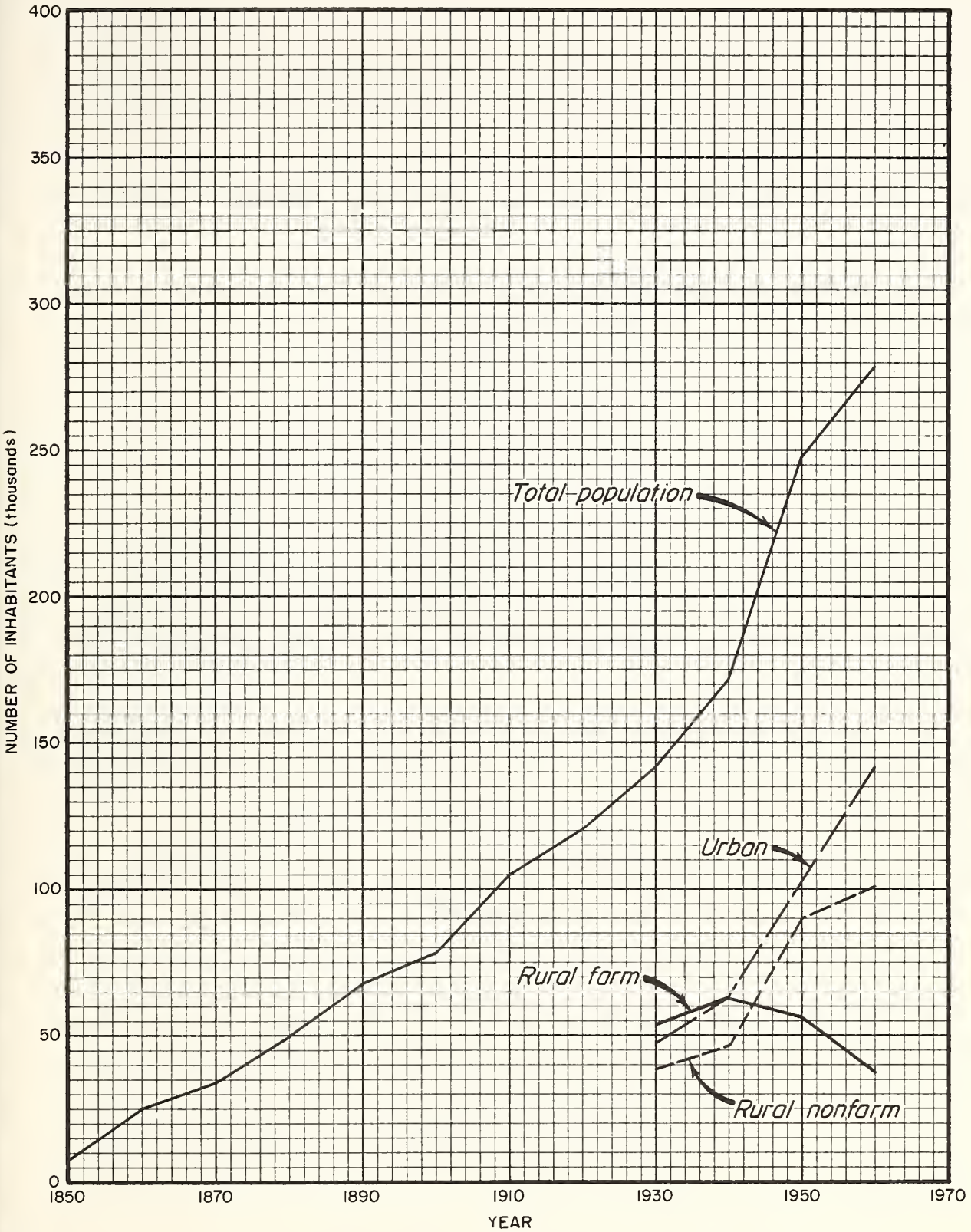
About 44 percent of the population is in the Pudding Subbasin, most populous of the three subbasins. Salem and its adjacent unincorporated suburban fringe contain about 75,000 people, or about 60 percent of the population of the Pudding Subbasin. Woodburn and Silverton, each of which have about 3,100 people, are the only other urban places 1/ in the Pudding Subbasin.

About 33 percent of the population is in the Coast Range Subbasin. Corvallis with a population of 20,669 is the largest city, and McMinnville, Dallas, and Newberg with 7,656, 5,072, and 4,204 people, respectively, are the other urban places in this subbasin.

About 23 percent of the population is in the Santiam Subbasin. The urban places in this subbasin include Albany, Lebanon, and Sweet Home with 12,926, 5,858, and 3,353 people, respectively.

The total population of the basin has increased during each ten year census interval since 1850. Figure 4 shows the population growth for Benton, Linn, Marion, Polk, and Yamhill Counties. The rate of growth has been especially high since 1940, averaging about 3.2 percent per year compared to 2.5 percent for the State of Oregon. The 1960 rural farm population was about 60 percent of the 1940 rural farm population. However, rural nonfarm population more than doubled from 1940 to 1960. Rural nonfarm population growth decreased from 1950 to 1960

1/ Cities and towns with 2,500 or more people are defined as urban places by the U. S. Bureau of the Census.



Source: U. S. Census of Population. *Benton, Linn, Marion, Polk, and Yamhill Counties.*

Figure 4. Population of five principal counties of the Middle Willamette River Basin, Oregon, 1850 – 1960.

because some of the more populous rural areas became urban in nature during that period. Urban population increased by 127 percent between 1940 and 1960.

Population growth has varied among the counties of the basin. Predominantly rural Polk and Yamhill Counties have grown only slightly in population since 1950. Predominantly urban Marion, Linn, and Benton Counties have continued to grow rapidly in population.

EMPLOYMENT AND INDUSTRY

The 1960 Census of Population shows that about 94,000 people are employed in Benton, Linn, Marion, Polk, and Yamhill Counties. This is 34 percent of the population of these 5 counties. Figure 5 shows employment in these counties from 1940 to 1960 by employment group. About 58 percent of those employed work in services and wholesale and retail trades.

About 11 percent of those employed work in agriculture. However, this does not include the large number of seasonal workers employed in growing and harvesting crops during June, July, and August. About 3 percent of those employed work in manufacturing and processing of food and kindred products. However, an average of about 3 times as many workers are employed in food processing during the 6 month period of May through October. This is about 25 percent of the total workers in food processing in the state.

About 12 percent of those employed work in the harvesting and processing of timber. This industry also shows considerable seasonal variation in employment. The remaining 16 percent of those employed work in construction and other manufacturing industries.

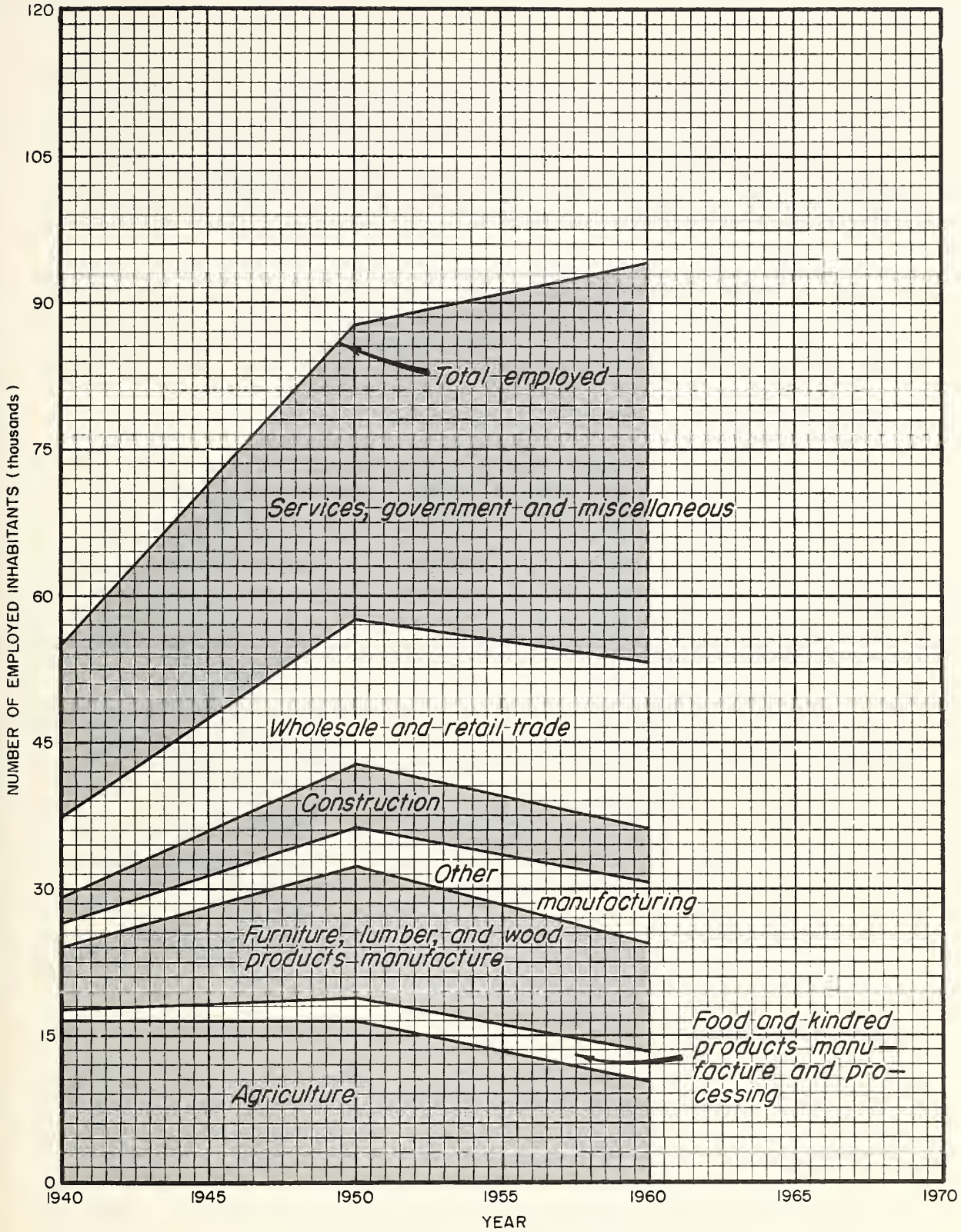
Employment has declined since 1950 in agriculture and lumber, furniture, and wood products manufacture while employment has increased in wholesale and retail trades and services.

The total value added by manufacture in Benton, Linn, Marion, Polk, and Yamhill Counties was $162.6 million in 1958. 1/ An estimated 63 percent of the total value added by manufacture is attributed to wood-using industries including logging. About 17 percent of the total value added is attributed to manufacture and processing of food and kindred products. These values are not necessarily indicative of the manufactured and processed value of wood and agricultural crops grown in the basin because there is considerable movement of these raw materials to and from the basin for manufacture.

POWER

The Middle Willamette River Basin is a power deficient area, and it is expected it will remain one. Its water power is of greatest value in its ability to meet peak loads.

1/ 1958 Census of Manufacturers.



Source: U. S. Census of Population *Benton, Linn, Marion, Polk, and Yamhill Counties.*

Figure 5. Employment of inhabitants of five principal counties of the Middle Willamette River Basin, Oregon, 1940–1960.

Power generation within the basin is integrated with the northwest power pool. The Columbia River, the largest source of power, has its high flows in late spring and early summer while the flow in this basin is high in the winter. In order to provide maximum efficiency, power reservoirs in the Middle Willamette River Basin are regulated to conserve as much of the stored water as possible until the Columbia River system is nearing depletion, which occurs about the first of September.

Power rights and claims amount to 5,300 cubic feet per second compared to 7,300 cubic feet per second in the Upper Willamette River Basin. The majority are in the Santiam Subbasin where they total 4,337 cubic feet per second. The Pudding Subbasin totals 932 cubic feet per second, and the Coast Range Subbasin has only 20 cubic feet per second.

TRANSPORTATION

The Middle Willamette River Basin is served by an excellent road and highway system. The major north-south routes in the basin are Interstate 5, U. S. 99W, and U. S. 99E. The major east-west routes are U. S. 20 and Oregon 22. There is an extensive network of secondary roads in most of the basin. The access road network is still under active development on much of the forested land. Regularly scheduled bus service is available on the major highways and several secondary routes. Regularly scheduled motor freight service is available to most of the incorporated cities of the basin.

The main line of the Southern Pacific Railroad traverses the valley floor from Portland to Eugene furnishing both freight and passenger service. Several branch rail lines furnish freight service to most of the principal cities of the basin.

There are 13 airports in the basin that are classified for public use by the Oregon State Board of Aeronautics. Regular air passenger and freight service is available at Corvallis and Salem.

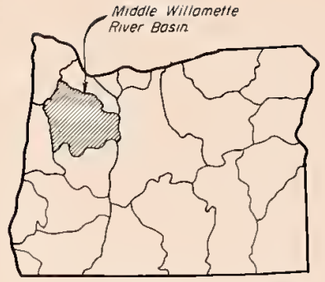
Navigation by shallow-draft vessels is possible on the Willamette River as far upstream as Harrisburg and on a short section of the Yamhill River. The chief waterborne cargo is rafted logs.

LANDOWNERSHIP

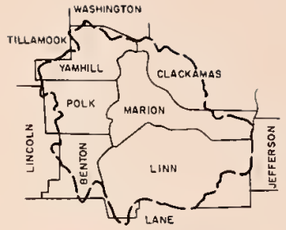
In this report, landownership in the Middle Willamette River Basin is classified as federal, state, county and municipal, and private. Table 3 shows the ownership distribution for each subbasin, and figure 6 shows the general location of the various ownerships.

About 76 percent of the Middle Willamette River Basin is privately owned. Most of the private land is owned by farmers and ranchers. About one-fifth of the private land is owned by a few large timber companies. A majority of the land in each of the three subbasins is privately owned.

About 20 percent of the basin is in federal ownership. About 67 percent of the federal land is in national forests administered by the



RIVER BASIN LOCATION



COUNTY LOCATION

SUBBASINS

5 SANTIAM

6 COAST RANGE

7 PUDDING

LEGEND

- Notional Forest
- Other Federal
- Stote of Oregon
- County and Municipal
- Large Privote
- Small Privote
- Drainage Basin Boundary
- Subbasin Boundary
- Notional Forest and/or Primitive Area Boundary

FIGURE 6

GENERALIZED LAND STATUS

MIDDLE WILLAMETTE RIVER BASIN

OREGON

JULY 1962

SCALE IN MILES 5 0 5 10

U S DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE — M-3632

7-E-17377-N

Table 3.--Land use and ownership, Middle Willamette River Basin, Oreg., 1962

Class of ownership	Land use: Forest	Agriculture	Other	Total
	Acres	Acres	Acres	Acres
5. Santiam Subbasin:				
Federal:				
U. S. Forest Service	430,700	300	20,000	451,000
Bureau of Land Management	93,400	...	1,000	94,400
Corps of Engineers	9,300	...	4,000	13,300
State of Oregon	33,050	...	15,000	48,050
County and municipal	500	...	4,400	4,900
Private	551,650	373,300	25,000	949,950
Subtotal	1,118,600	373,600	69,400	1,561,600
6. Coast Range Subbasin:				
Federal:				
U. S. Forest Service	16,800	...	200	17,000
Bureau of Land Management	72,000	...	200	72,200
Corps of Engineers	...	...	...	...
State of Oregon	20,500	400	14,000	34,900
County and municipal	7,500	...	5,000	12,500
Private	530,200	435,800	45,600	1,011,600
Subtotal	647,000	436,200	65,000	1,148,200
7. Pudding Subbasin:				
Federal:				
U. S. Forest Service	3,000	...	...	3,000
Bureau of Land Management	47,300	...	200	47,500
Corps of Engineers	...	...	...	...
State of Oregon	19,150	2,600	10,000	31,750
County and municipal	200	...	7,000	7,200
Private	286,050	354,900	32,500	673,450
Subtotal	355,700	357,500	49,700	762,900
Total Middle Willamette Basin:				
Federal:				
U. S. Forest Service	450,500	300	20,200	471,000
Bureau of Land Management	212,700	...	1,400	214,100
Corps of Engineers	9,300	...	4,000	13,300
State of Oregon	72,700	3,000	39,000	114,700
County and municipal	8,200	...	16,400	24,600
Private	1,367,900	1,164,000	103,100	2,635,000
Total	2,121,300	1,167,300	184,100	3,472,700

Source: Compiled from data furnished by USDA Field Party survey, U. S. Forest Service, Bureau of Land Management, and County Assessors of counties concerned.

U. S. Forest Service and is mostly in the Santiam Subbasin. About 31 percent of the federal land is administered by the Bureau of Land Management. There are sizable acreages of B. L. M. land intermingled with lands of other ownership in all three subbasins. About 2 percent of the federal ownership is administered by the Corps of Engineers, U. S. Army, and is in the vicinity of the Detroit, Green Peter, and Foster Reservoirs.

About 3 percent of the basin is owned by the State of Oregon. About 46 percent of the State-owned land is administered by the State Board of Forestry; 34 percent is in highway rights-of-way; and 8 percent is in state parks. Other portions of state-owned land are administered by the Oregon State University and the Board of Control. Much of the State-owned land is located in the southeastern part of the Pudding Subbasin, in the northeastern part of the Santiam Subbasin, and in Benton County in the Coast Range Subbasin.

Less than 1 percent of the basin is owned by counties and municipalities and consist of county and city parks, municipal watersheds, and road rights-of-way.

LAND USE

The generalized pattern of land use in the basin is shown in figure 7, and a tabulation of land use by ownership class is presented in table 3.

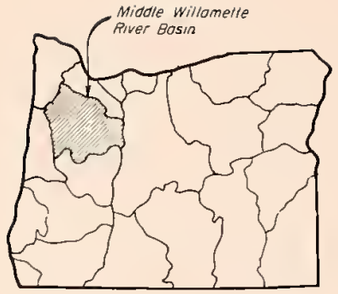
About 61 percent of the basin is forest land. Most of the forest land is in the Cascades and Coast Range. The Santiam Subbasin contains more than half of the basin's forest land. Forest land use is discussed later in this report.

About 34 percent of the basin is agricultural land and is mostly in the Willamette Valley. It is quite evenly divided among the three subbasins. Agricultural land use is discussed later in this report.

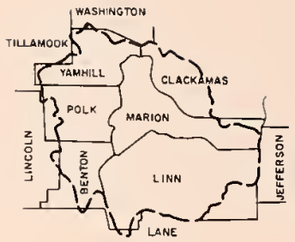
About 5 percent of the basin is used for purposes such as cities, towns, highways, and roads. Also included are bodies of water and nonvegetative areas such as lava flows and areas above timberline in the Cascades.

Forest land is predominant in the Santiam and Coast Range Subbasins. About 72 percent of the Santiam Subbasin and 56 percent of the Coast Range Subbasin is forested. Agricultural land occupies 23 percent of the Santiam Subbasin and 39 percent of the Coast Range Subbasin. About 5 percent of each subbasin is devoted to other uses.

The Pudding Subbasin is nearly evenly divided between forest and agricultural land uses, each occupying about 47 percent of the subbasin. About 6 percent of the Pudding Subbasin is devoted to other uses.



RIVER BASIN LOCATION



COUNTY LOCATION

SUBBASINS

5 SANTIAM

6 COAST RANGE

7 PUDDING

LEGEND

- Douglas Fir Forest
- Upper Slope Forest and Alpine Zone
- 50% - 90% Forest, 10% - 50% Agricultural
- 50% - 85% Agricultural, 15% - 50% Forest
- More Than 85% Cultivated
- River Basin Boundary
- Sub River Basin Boundary
- National Forest or Primitive Area Boundary
- Land Use Boundary

FIGURE 7

GENERALIZED LAND USE

MIDDLE WILLAMETTE RIVER BASIN

OREGON

JULY 1962

5 0 5 10

SCALE IN MILES

U S DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE • PORTLAND, ORE. 1962 M-3632

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CHARACTERISTICS OF FORESTED AREAS

Forest Stands

The forest land of the Middle Willamette River Basin may be divided into four distinct zones on the basis of ecology, climate, and pattern of landownership as follows: the Willamette Valley zone, the principal forest zone, the upper slope forest zone, and the subalpine forest zone.

The Willamette Valley zone generally lies below 1,000 feet elevation and has the driest and warmest climate of any part of the basin. This zone was only partially forested at the time of settlement, and much of the forest land has since been cleared for agricultural, urban, residential, and other uses. Forest land now occupies less than 30 percent of the total area and is generally in blocks of less than 500 acres owned by farmers and ranchers intermingled with agricultural land. There are both hardwood and coniferous stands. The hardwood stands occur on bottom lands subject to flooding and on dry sites. Cottonwoods, Oregon ash, bigleaf maple, and willows are the most common species on bottom lands. Oaks and Pacific madrone are common on dry sites (fig. 8). Coniferous stands occur on a variety of sites. Ponderosa pine and Douglas-fir are the most common coniferous species, probably because of their ability to withstand moderate fires.

The principal forest zone begins at about 500 to 1,000 feet elevation in the Cascades and Coast Range and extends up to 3,000-4,000 feet. It contains a major part of the timber producing land of the basin. The climate is characterized by annual precipitation of 70 to 140 inches, moderate winter snowfall but virtually no snowpack development, and somewhat cooler temperatures than those experienced in the Willamette Valley. More than 90 percent of the land is forested. Coniferous forests of Douglas-fir and lesser amounts of western hemlock, western redcedar, sugar pine, and true firs are predominant (fig. 9). Stands of red alder occur in the Coast Range where fire or logging destroyed the original stand. Other hardwood species such as bigleaf maple and Oregon white oak are scattered through the coniferous stands. Most of the forest land is owned by large timber companies or is in public ownership.

The upper slope forest zone begins at about 3,000 to 4,000 feet elevation and extends upward to 5,000-6,000 feet. Upper slope forests occur in the Coast Range only on the highest peaks, but they cover a large area in the Cascades. The climate of this zone is characterized by annual precipiation of 90 to 140 inches, heavy winter snowfall and significant snowpack development, and cool summer temperatures. About 80 percent of the land is forested; 20 percent of the land consists mainly of nonforested areas of recent volcanic origin, meadows, and lakes. True fir and mountain hemlock stands are predominant, but lodgepole pine stands occur on areas of recent fire or volcanic activity. Most of the land is in national forests.

Figure 8.--This stand of oak, madrone, and Douglas-fir is typical of forested areas on hill land in the Willamette Valley zone. SCS photo. 7-731-2

The subalpine forest zone begins at 5,500 to 6,000 feet elevation in the Cascades and extends to the upper limit of tree growth. The climate is characterized by heavy winter snowfall and an average frost-free season of less than 30 days. The principal tree species, subalpine fir, mountain hemlock, whitebark pine, and Alaska yellow-cedar, occur in scattered stands intermingled with meadows and barren areas. Only a few peaks along the Cascade Crest are above the upper limit of tree growth. Most of the land in this zone is in national forests.

Forest Landownership

About 65 percent of the forest land in the Middle Willamette River Basin, or 1,667,900 acres, is in private ownership (fig. 10). About 44 percent of the private forest land is in 18 individual holdings of more than 5,000 acres each, referred to as "large private" ownerships. Most of the large private holdings are in the principal forest zone in the Cascades and Coast Range.

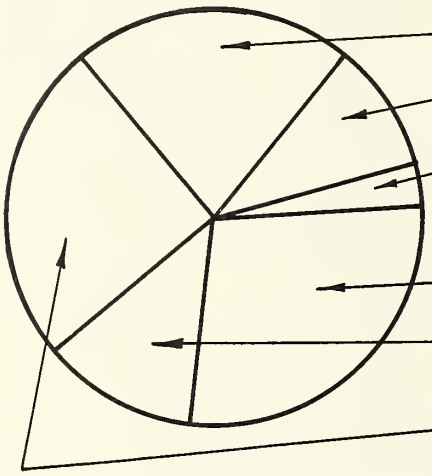
About 18 percent of the private forest land is in about 350 individual ownerships of from 500 to 4,999 acres each, referred to as "medium private" ownerships. About 38 percent of the private forest land is in about 8,800 individual ownerships of 10 to 499 acres each, referred to

Figure 9.--This stand in the Crabtree Creek watershed, subbasin 5, is typical of old-growth Douglas-fir stands in the principal forest zone of the basin. SCS photo. 7-1154-9

as "small private" ownerships. Many of the small private ownerships and some of the medium private ownerships are in the Willamette Valley zone.

About 32 percent of the forest land in the basin, or 672,500 acres, is in federal ownership. Two-thirds of the federal forest land is in the Willamette and Siuslaw National Forests. Most of the headwaters of the North Santiam and South Santiam Rivers are in the Willamette National Forest. The Siuslaw National Forest in the basin includes

Forest landownership, Middle Willamette River Basin, Oreg., 1962



Ownership class	Acres	Percent
Federal:		
National forest	450,500	22
Bureau of Land Management	212,700	10
Corps of Engineers	9,300	...
State of Oregon	72,700	3
County and municipal	8,200	...
Private:		
Over 5,000 acre holdings	600,000	28
500-4,999 acre holdings	247,900	12
10-499 acre holdings	520,000	25
Total	2,121,300	100

Figure 10

small tracts in the Marys Peak area and in the Rickreall Creek and South Yamhill River watersheds.

About one-third of the federal forest land is national land reserve and Oregon and California Railroad Revested Lands administered by the Bureau of Land Management. B. L. M. lands occur in blocks of one to several sections scattered through the Coast Range and the foothills of the Cascades.

The Corps of Engineers, U. S. Army, administers less than 1 percent of the federal forest land; much of this land will be cleared in development of Green Peter Reservoir.

About 3 percent of the forest land in the basin, or 72,700 acres, is owned by the State of Oregon. About 73 percent of the State-owned forest land is administered by the Oregon State Board of Forestry, and 13 percent is in the McDonald State Forest administered by the Oregon State University for educational and research purposes. The rest of the State-owned forest land is in state parks administered by the State Highway Department or is administered by the State Board of Control.

Less than 1 percent of the forest land in the basin, or 8,200 acres, is owned by counties and municipalities and is mainly in the Corvallis and McMinnville municipal watersheds in the Coast Range Subbasin.

Forest Land Use

The major uses of forest land in the Middle Willamette River Basin are for production of crops of commercial timber, for outdoor recreation, and for watershed protection. Other uses for wildlife habitat, production of forage for livestock, and for botanical and ecological study are also important. Most forest land is used for several purposes. Much of the private forest land, especially that in large ownerships, is managed intensively for timber production. Some of the public forest land is used primarily for outdoor recreation, and uses such as livestock grazing and timber harvesting may be excluded; but, most federal and state forest land is managed to accommodate a balance of several uses.

There is considerable variation in the way in which forest land is managed. On many private holdings the only management is that related to the harvesting of mature timber while on other private holdings considerable attention is given to measures that will maximize the continuous production of timber. On public land used intensively for outdoor recreation, such as state parks, management efforts are aimed at providing adequate facilities and a safe and aesthetically pleasing environment.

The national forest land is managed under the "multiple use-sustained yield" concept. As defined by the Multiple Use-Sustained Yield Act of June 1960 (P. L. 86-517), this means the management of forest and related areas in a manner that will conserve the basic land resource itself while at the same time producing high-level sustained yields of water, timber, recreation, wildlife, and forage in the combination that will best meet the needs of the American people. By law, the majority of the Bureau of Land Management lands are devoted to permanent forest production in conformity with the principal of sustained yield for the purpose of providing a permanent source of timber supply, protecting watersheds, regulating streamflow, contributing to economic stability of local communities and industries, and providing recreational facilities. BLM's management program of "Balanced Use" is similar in scope to the Forest Service's "Multiple Use" program.

Recently there has been rapid expansion in the use of forest land for several purposes, particularly timber management and outdoor recreation. The major resources of forest land in the basin--timber, recreation, wildlife, range, and water--are discussed in detail later in this report.

According to the Timber Resources Review, about 1.2 percent of the forest land in a nine county area of northwestern Oregon, which includes the Middle Willamette River Basin, was cleared for other uses in 1952. Conversion of forest land to such uses as suburban development, agriculture, reservoir sites, and road and power line rights-of-way is expected to continue; although such conversion will be viewed more critically as the need to maintain forest lands in a productive condition becomes more apparent to meet the future resource needs of the nation.

Land Class and Cover Type Classification. The U. S. Forest Service uses a land class and cover type system of describing forest land. There are four main land classes which are commercial forest, noncommercial forest, reserved forest, and nonforest.

Commercial forest land is forest land that is (a) producing, or is physically capable of producing, useable crops of wood, (b) economically available, now or prospectively, for timber harvest, and (c) not withdrawn from timber harvest. Publicly owned commercial forest land where timber harvesting is especially modified to protect or enhance recreational or watershed values is called "modified-commercial" forest land. Commercial forest land is further subdivided by cover types.

Table 4.--National forest land, Middle Willamette River Basin, Oreg., 1960

Land class and cover type	Subbasin 5 Santiam	Subbasin 6 Coast Range	Subbasin 7 Pudding	Total
	Acres	Acres	Acres	Acres
Commercial forest land:				
Sawtimber stands:				
Old-growth Douglas-fir	127,000	8,500	1,000	136,500
Other Douglas-fir	100,500	400	500	101,400
Western hemlock	27,000	200	...	27,200
Western redcedar	1,000	...	...	1,000
True fir-mtn. hemlock	31,500	...	...	31,500
Other conifers	3,300	700	400	4,400
Poletimber stands:				
Douglas-fir	22,000	2,000	...	24,000
Western hemlock	1,400	...	...	1,400
True fir-mtn. hemlock	6,500	...	...	6,500
Other conifers	1,800	300	900	3,000
Seedling-sapling stands:				
Douglas-fir	12,000	4,000	...	16,000
True fir-mtn. hemlock	1,000	...	...	1,000
Other conifers	700	...	...	700
Nonstocked forest land	7,300	...	...	7,300
Modified-commercial forest land	32,000	600	...	32,600
Subtotal	375,000	16,700	2,800	394,500
Noncommercial and nonforest land 1/	21,000	300	200	21,500
Reserved forest land 2/	55,000	...	...	55,000
Total	451,000	17,000	3,000	471,000

1/ Outside classified areas.
2/ Includes all land within classified areas.

Source: Compiled from data furnished by U. S. Forest Service.

Noncommercial forest land is forest land that is physically incapable of producing useable crops of wood because of adverse site conditions, or is so physically inaccessible as to be economically unavailable for timber harvesting within the foreseeable future.

Table 5.--Land administered by Bureau of Land Management, Middle Willamette River Basin, Oreg., 1961

Land class and cover type	Subbasin 5 Santiam	Subbasin 6 Coast Range	Subbasin 7 Pudding	Total
	Acres	Acres	Acres	Acres
Commercial forest land:				
Coniferous stands:				
Younger than 80 years...	40,550	49,700	31,800	122,050
80-160 years.....	21,000	3,100	3,650	27,750
Older than 160 years....	25,500	13,850	7,300	46,650
Hardwood stands.....	2,200	3,100	2,000	7,300
Nonstocked forest land....	2,750	2,150	1,450	6,350
Noncommercial forest land...	2,400	300	1,300	4,000
Total.....	94,400	72,200	47,500	214,100

Source: Compiled from data furnished by Bureau of Land Management.

Reserved forest land is forest land, either productive or nonproductive with regard to timber growth potential, that is withdrawn from timber harvest through statute, ordinance, or administrative order.

Table 6.--Land administered by Oregon State Board of Forestry, Middle Willamette River Basin, Oreg., 1962

Land class and cover type	Subbasin 5 Santiam	Subbasin 6 Coast Range	Subbasin 7 Pudding	Total
	Acres	Acres	Acres	Acres
Commercial forest land:				
Coniferous stands:				
Younger than 90 years...	26,400	5,400	9,000	40,800
Older than 90 years.....	3,900	2,000	800	6,700
Hardwood stands.....	200	2,500	50	2,750
Nonstocked forest land....	1,800	400	100	2,300
Noncommercial forest land...	300	...	...	300
Total.....	32,600	10,300	9,950	52,850

Source: Compiled from data furnished by Oregon State Board of Forestry.

Nonforest land includes all land that is not at least 10 percent stocked with trees (except for nonstocked cutover forest land) such as cultivated land, pasture, cities and towns, lakes, and streams.

A land class and cover type classification for land administered by the U. S. Forest Service, Bureau of Land Management, and Oregon State Board of Forestry is shown in tables 4, 5, and 6. The available resource data for other forest land is obsolete. Forest surveys of all counties in the basin have recently been completed by the Pacific Northwest Forest and Range Experiment Station, but the results of these surveys are not yet available.

Protection of Forest Resources

Protection from Fire. Protection of the forest resources of the Middle Willamette River Basin from wildfire is shared by the Federal Government, the State of Oregon, and several rural fire districts. Generally, the U. S. Forest Service protects land within the national forests; the State of Oregon protects land outside the national forests but within the principal forest areas; and the rural fire districts protect land within the Willamette Valley. About 4 percent of the basin containing about 45,000 acres of forest land, largely in the Willamette Valley, lacks organized fire protection.

The chief causes of wildfire in the basin are lightning, carelessness of forest users, and debris burning. Lightning fires are most common in the Cascades particularly in the North Santiam watershed. Fires caused by forest users are most common in heavily used recreation areas and along major highways. The area around Detroit Reservoir and along the main roads in the North Santiam watershed have had an especially high frequency of forest user fires. Wildfires caused by escaped debris burning and land clearing fires are most common in the Willamette Valley where autumn burning of agricultural land is practiced.

Past fire prevention efforts have produced a great reduction in man-caused fires. Additional preventative measures would probably further reduce the frequency of man-caused fires. For instance, many fires around Detroit Reservoir result from warming and picnic fires built outside established campgrounds and spread through debris and drift on the margins of the reservoir. Providing adequate picnicking facilities and periodic cleanup of drift around the reservoir would probably result in a sizable reduction in fire occurrence.

Fire protection forces have been and are adequate to control average fire situations. However, they sometimes are not adequate to control fire situations resulting from severe lightning storms or extreme burning conditions. The fire protection agencies need to increase their capacity to mobilize for rapid fire suppression under emergency conditions.

Protection from Insect, Disease, and Animal Damage. Protection of the forests of the Middle Willamette River Basin from insect, disease, and animal damage is primarily a responsibility of the individual landowners and managers. However, many owners cooperate in com-

batting forest pest problems. Their cooperative efforts are coordinated by the Pacific Northwest Forest Pest Action Council, an organization of public and private officials. The U. S. Forest Service makes forest insect and disease detection surveys and provides funds for pest control on all forest land under the Cooperative Pest Control Act. The State of Oregon and private landowners share in financing pest control projects on private land.

Important forest insect pests in the basin include the balsam wooly aphid, the spruce budworm, and the Douglas-fir bark bettle, all of which have reached epidemic numbers in the past. Insect pest populations are presently of an endemic nature, killing an occasional weakened tree. Total losses to insects are, however, quite large. Control of forest insects lies primarily in keeping forest stands in a vigorous condition, promptly disposing of logging slash and windthrown or fire killed timber that provide a breeding place for insects, and promptly eradicating epidemic outbreaks of insect populations.

There are several important diseases of forest trees in the basin. The Douglas-fir root rot (Poria weirii) causes windthrow losses in mature stands and kills young trees. White pine blister rust attacks Western white pine and sugar pine. Several fungous rots cause decay in forest trees.

Several species of small animals feed on tree seed and seedlings and must be controlled if they threaten establishment of forest stands. Deer and bear also damage young stands.

TIMBER

The Resource

There are an estimated 1,938,000 acres of commercial forest land in the Middle Willamette River Basin (table 7). Timber volumes for federal lands administered by the U. S. Forest Service and Bureau of Land Management are shown in tables 8 and 9. Commercial forest land administered by the Oregon State Board of Forestry has an estimated sawtimber stand of 300 million board feet. 1/

The most productive timber-producing sites in the basin are in the Coast Range and at elevations of 1,500 to 3,000 feet in the Cascades. In these areas of heavy precipitation and moderate temperatures, the site index for Douglas-fir averages from 130 to 170. The site index is a term meaning the average height of dominant and codominant Douglas-fir at age 100 years. The site quality decreases with increasing elevation and steepening terrain in the Cascades. For instance, the national forest commercial forest land in the Santiam Subbasin has an average site index of 120. About 4,000 feet elevation in the Cascades, the site index rarely exceeds 100.

1/ Timber volumes used in this report are in terms of log scale, Scribner rule, in trees 11 inches D. B. H. and larger.

Table 7.--Commercial forest land by ownership and subbasin, Middle Willamette River Basin, Oreg., 1962

Class of ownership	Subbasin 5 Santiam	Subbasin 6 Coast Range	Subbasin 7 Pudding	Total
	Acres	Acres	Acres	Acres
Federal:				
National forest	375,000	16,700	2,800	394,500
Bureau of Land Management	92,000	71,900	46,200	210,100
Corps of Engineers	3,200	...	...	3,200
State of Oregon	32,300	10,300	9,950	52,550
County and municipal	...	2,680	...	2,680
Private	541,000	495,000	266,000	1,302,000
Total	1,043,500	596,580	324,950	1,965,030

Source: USDA report tables 4, 5, and 6 and data furnished by Pacific Northwest Forest and Range Experiment Station.

Table 8.--National forest timber volume 1/, Middle Willamette River Basin, Oreg., 1960

Species	Subbasin 5 Santiam	Subbasin 6 Coast Range	Subbasin 7 Pudding	Total
	MM bd.ft.	MM bd.ft.	MM bd.ft.	MM bd.ft.
Douglas-fir	9,400	560	60	10,020
Sugar pine and West white pine	310	...	10	320
Western and mtn. hemlock	3,250	20	10	3,280
Western redcedar	450	10	10	470
Incense-cedar and Alaska yellow-cedar	5	...	...	5
True firs and Englemann spruce	1,550	10	10	1,570
Lodgepole pine	20	...	...	20
Hardwoods	15	...	...	15
Total	15,000	600	100	15,700

1/ Includes volume in all stands on commercial forest land.

Source: Estimated from U. S. Forest Service timber resource inventory data.

Table 9.--Timber volume by species 1/, land administered by Bureau of Land Management, Middle Willamette River Basin, Oreg., 1961

Species	Subbasin 5 Santiam	Subbasin 6 Coast Range	Subbasin 7 Pudding	Total
	MM bd.ft.	MM bd.ft.	MM bd.ft.	MM bd.ft.
Douglas-fir	2,750	6,490	910	10,150
Sugar and Western white pine	25	5	...	30
Western and mtn. hemlock	960	1,390	290	2,640
Western redcedar	75	90	10	175
True firs	80	100	170	350
Hardwood	2/	2/	2/	2/
Total	3,890	8,075	1,380	13,345

1/ Includes volume in all stands on commercial forest land.
2/ No estimate available.

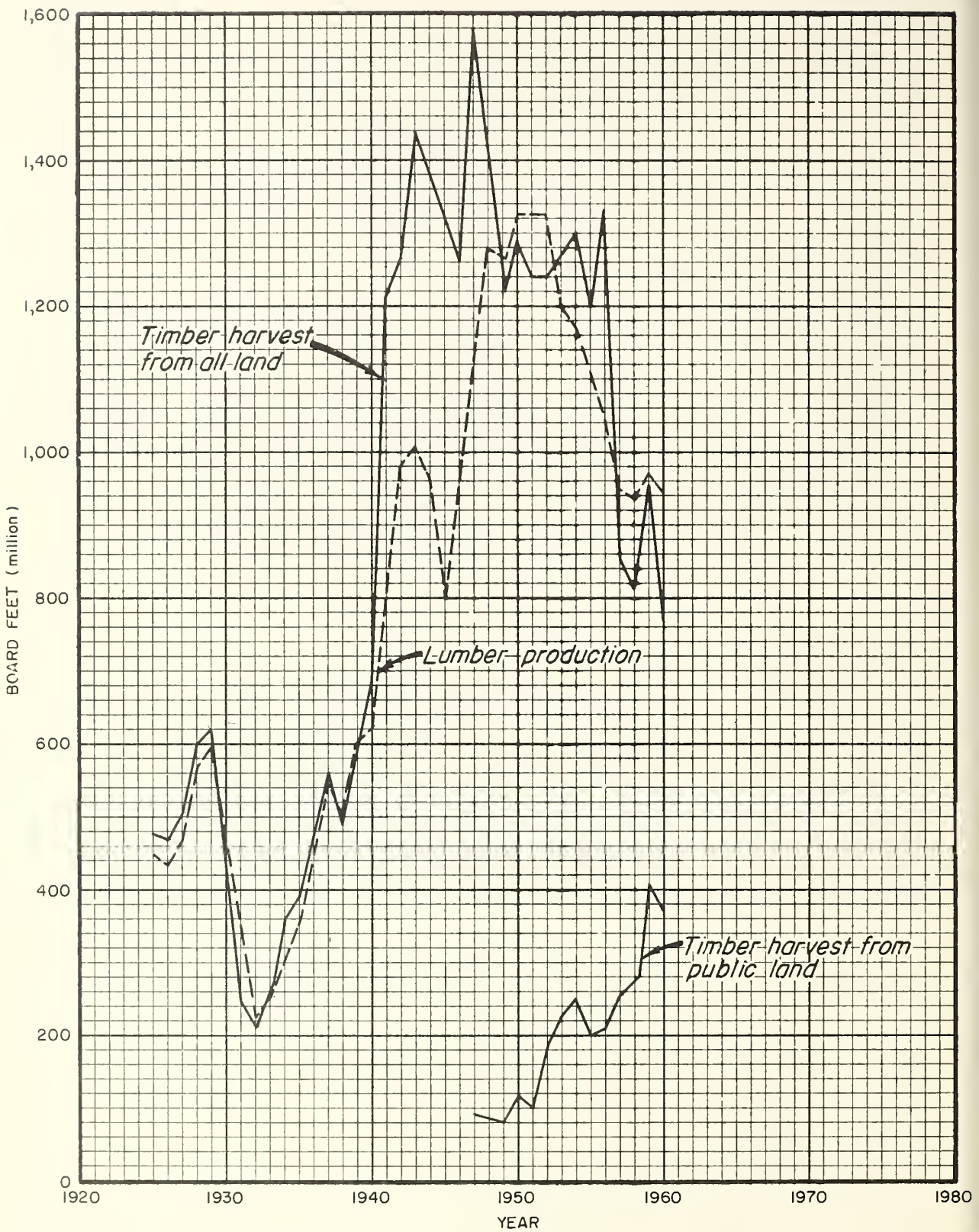
Source: Estimated from Bureau of Land Management timber inventory data.

Logging and Wood-Using Industries

Logging and sawmilling began in the Middle Willamette River Basin at the time of settlement, and timber harvest had increased to about 500 million board feet annually by the 1920's. Timber harvesting and lumber production reached their peaks between 1943 and 1956 and have declined abruptly recently (fig. 11). Manufacturing industries that utilize wood residue have been rapidly expanded since 1945. Timber harvested in the basin is supplemented by timber imported from other areas, primarily the North Coast and Middle Coast Basins. Some timber harvested from the Middle Willamette River Basin is exported to other areas for manufacture.

Timber harvested from publicly-owned land is steadily increasing in importance in the basin. There was little demand for public timber until 1950 because of an abundance of accessible, high quality private timber. As private timber has become less plentiful, the demand for public timber has steadily increased. For instance, the timber harvest from public land in Benton, Linn, Marion, Polk, and Yamhill Counties has increased from 9 percent of the total timber harvest in 1950 to 48 percent in 1960.

Tables 10 and 11 show the number and the installed capacity of wood-using industrial establishments in the Middle Willamette River Basin in 1959. The wood-using industries of the basin require large quantities of raw material. It is estimated that sawmills and veneer and plywood plants require an annual sawtimber supply of 1.8 billion board feet to operate at full capacity. The pulp and paper industry used about 0.1 billion board feet of logs in 1960 in addition to using large quantities of wood residue from sawmill and plywood manufacture.



Sources: U. S. Forest Service and West Coast Lumbermen's Assn.

Figure 11. Timber harvest and lumber production from Benton, Linn, Marion, Polk, and Yamhill counties, Middle Willamette River Basin, Oregon, 1925 – 1960.

Table 10.--Wood-using industrial establishments, Middle Willamette River Basin, Oreg., 1959

Product	Subbasin 5 Santiam	Subbasin 6 Coast Range	Subbasin 7 Pudding	Total
	Number	Number	Number	Number
Primary products:				
Lumber	53	70	42	165
Plywood, veneer	15	14	1	30
Shingles	4	4	1	9
Remanufactured products	7	8	9	24
Wood residue products:				
Pulp and paper	2	2	1	5
Hardboard, particle board, etc.	7	2	...	9

Table 11.--Installed production capacity of certain wood-using industries, Middle Willamette River Basin, Oreg., 1959

Product	Subbasin 5 Santiam	Subbasin 6 Coast Range	Subbasin 7 Pudding	Total
Lumber, M bd. ft./8 hr. shift	1,650	1,800	1,000	4,450 1/
Plywood and veneer, million sq. ft./mo. 3/	80	54	6	140 2/
Hardboard, particle board, etc., million sq. ft./mo. 3/	6	1	...	7
Wood pulp, tons/24 hrs.	330	180	150	660
Paper, tons/24 hrs.	330	10	150	490

1/ Production capacity information available for only 100 of the 165 sawmills in the basin. The other 65 sawmills are small and operate intermittantly, and their total production is probably less than 10 percent of the basin total.

2/ No estimate available for 4 veneer plants.

3/ Three-eighth inch basis.

Sources: Handbook and Directory of the Forest Industries, Miller-Freeman Publications, Inc., Portland, Oreg., 1960. Crow's Buyer's and Seller's Guide of the Western Lumber and Plywood Industries, C. C. Crow Publications, Inc., Portland, Oreg., 1960. Lockwood's Directory of the Paper and Allied Trades, Lockwood Trade Journal Co., Inc., New York, 1960.

The logging and wood-using industries are important to the economy of the area. About 12 percent of the employed people in Benton, Linn, Marion, Polk, and Yamhill Counties in 1958 were engaged in lumber, furniture, wood products, and pulp and paper manufacture. The 1958 payroll for the above industries was an estimated $53 million. The stumpage value of timber harvested in the above counties in 1958 was an estimated $20 million. The value added by manufacture in 1958 in the above counties was $83 million for the lumber and wood products industries and about $18 million for the pulp and paper industries.

Sawmills and plywood plants produce large quantities of wood residue that can be used for wood fibre product manufacture. In 1953, wood residue production in Benton, Linn, Marion, Polk, and Yamhill Counties was an estimated 1.7 million tons of which 8 percent was used for wood fibre product manufacture; 40 percent was used for fuel; and 52 percent was not used. Since 1953, lumber production and, hence, residue production has decreased to about 60 percent of what it was in 1953 while the volume of wood residues used by the pulp industry has increased to 4 times what it was in 1953. A large volume of residue, particularly sawdust, shavings, and bark, is still not used for anything other than fuel. Use of such material for product manufacture could be an important contribution to the economy of the area. Better wood utilization for wood fibre products depends on a number of factors not all of which are within the control of a single producer or industry. They include the following:

1. Suitability of available wood for known products. Not all of the unused wood is suitable for presently-known fibre products.

2. Markets for wood fibre products. Plant capacity for some products is already overexpanded nationally.

3. Relative costs of raw material, labor, transportation of finished product, etc. compared to costs in other areas.

4. Relative cost of disposal of effluent.

5. Availability of sufficient quantities of pure water.

Harvesting and Regeneration Methods

Clearcutting in areas of 20 acres or more is the most widespread harvesting practice in the old-growth timber stands of the Middle Willamette River Basin. This method is well suited to the harvesting of old-growth Douglas-fir stands on steep topography. Other methods, such as shelterwood or unit area selection, may be more suitable for young-stands and upper slope true fir-mountain hemlock stands. Cable harvesting methods are best suited to steep terrain and usually result in less soil disturbance than tractor skidding, but tractor skidding is also used mostly in areas of moderate terrain or in stands where the volume harvested per acre is not large (fig. 12). Logs are generally hauled to the mill by truck, though rail and water transportation are also used.

Figure 12.--This 40 acre clearcut on BLM land in the Middle Santiam River watershed, subbasin 5, is being logged by cable methods. Note the small amount of soil disturbance. Adjacent stand of mature trees will provide a seed source for regeneration. SCS photo. 7-1154-8

The large volume of cull logs and slash left on cutover areas after logging operations have been completed is usually disposed of by broadcast burning or spot burning of heavy accumulations of slash during the moderate fire danger period in early fall. Broadcast slash burning, if properly employed, reduces the fire hazard and may encourage natural regeneration if the slash fires are of moderate intensity. Slash disposal practiced by the federal agencies under terms of timber sale contracts is normally done in accordance with a previously determined slash disposal plan for the area involved. Opinions vary among foresters and landowners as to the desirability of broadcast slash burning as related to fire protection, regeneration, and watershed protection. Unburned old-growth slash is a serious fire hazard for which the landowner is responsible under state law. Thus, it appears that slash burning will continue to be a widespread practice so long as old-growth timber is being harvested or until increased utilization practices reduce the slash remaining after logging to a negligible amount.

Much of the forest land in the basin has site conditions favorable to rapid regeneration of cutover areas, and natural regeneration is

often adequate provided cutting areas are small enough that there is a nearby seed source (fig. 13). Planting of nursery-raised seedlings and direct seeding are common methods of supplementing natural regeneration. Deficient summer moisture conditions, competition from sod-building grasses, grazing of domestic and wild animals, and destruction of seed by small rodents are common regeneration problems in the Willamette Valley. Competition from alder and brush species is the most serious problem in the Coast Range. Regeneration problems in the Cascades occur on some dry southerly exposures, on pummice soils, and on areas where deer browsing and rodent damage to seedlings are excessive.

Figure 13.--This 20 year old Douglas-fir stand with trees averaging 30 to 40 feet tall developed from a natural seed source. SCS photo.
7-1177-7

Young timber stands need intensive cultural treatment to maximize the quality and quantity of wood growth. It is particularly important to thin young stands to remove dead, dying, and diseased trees and to give desirable trees more growing space. Public and private owners have been doing limited amounts of thinning recently in stands older than 50 years on gentle terrain. However, little thinning has been done in stands younger than 50 years or stands on terrain too steep

for skidding with horses or small tractors. Improved markets for small logs and development of equipment and techniques for thinning on steep terrain would help to improve the economic possibility for thinnings. Second growth management research, such as that being carried on by the Pacific Northwest Forest and Range Experiment Station in cooperation with the Bureau of Land Management and industrial forest owners, will play a vital role in the development of young-growth forest management in Oregon.

Harvesting and regeneration practices vary somewhat with ownership. The public and largest private ownerships that are managed by trained foresters are among the best managed lands. Generally, the commercial forest land that is most poorly managed from the standpoint of production of timber crops is land in private ownerships of less than 5,000 acres.

Sustained Yield Potential

Old-growth timber is still the predominant raw material for wood-using industries of the Middle Willamette River Basin, but second-growth timber is increasing in importance. The commercial old-growth timber will probably be completely harvested in about 90 years. Therefore, the potential sustained timber growth of the basin's forest land is of great importance in determining how much raw material will be available in the future for the wood-using industries of the basin.

The long term sustained yield of the basin's forest land will depend upon several factors including the following:

1. The site quality of forest land.

2. Promptness and adequacy of regeneration on cutover land.

3. Adequacy of protection from fire, insects, diseases, and animal damage.

4. Cultural treatment applied to the young stands.

5. Maintenance of optimum stocking and growth throughout the life of the stand.

6. The age at which final harvest is made.

7. Availability of markets for wood that is not presently merchantable.

8. The amount of forest land that is converted to and from other uses.

Public Lands. The timber resources of federal and state commercial forest land have been inventoried within the past 5 years. The volume of timber that could be harvested annually within the ensuing 10 years without impairment of the productivity of these lands was determined

from the inventory data. This volume is known as the allowable annual cut. Allowable cuts are established for blocks of land whose boundaries do not necessarily coincide with river basin and subbasin boundaries. The administrative policy of the public agencies is to offer for sale each year a timber volume equal to the allowable cut assuring a continuous, uniform harvest of timber from public land. The timber resources are reinventoried at approximately 10-year intervals, and allowable cuts are recalculated for the ensuing 10-year period considering such factors as improvement in wood utilization, rapidity of regeneration of cutover land, and changes in management techniques and policies. The present allowable cuts for federal and state forest land in the basin are shown in table 12.

Table 12.--Comparison between estimated allowable annual cut and actual timber harvest, federal and state owned forest land, Middle Willamette River Basin, Oreg., 1961

Ownership class	Allowable annual cut 1/				Average annual harvest 1956-60
	Subbasin				
	5 Santiam	6 Coast Range	7 Pudding	Total	
	MM bd.ft.	MM bd.ft.	MM bd.ft.	MM bd.ft.	MM bd.ft.
National forest	143	6	1	150	150
Bureau of Land Management 2/	60	37	23	120	118
State of Oregon 3/	8	4	1	13	13
Total	211	47	25	283	281

1/ Includes portions of several management units (working circles) each of which has an established allowable annual cut. Therefore, this data may or may not reflect the actual allowable cut for a given subbasin.

2/ Includes allowable cut recalculations made during 1961. The previous allowable cut was about 110 MM board feet.

3/ Land administered by Oregon State Board of Forestry.

Source: Estimated from data furnished by U. S. Forest Service, Bureau of Land Management, and Oregon State Board of Forestry.

Management of the timber resource on a large portion of the publicly owned commercial forest land is still quite extensive. For instance, a lack of access roads and rugged terrain prevent salvage of much of the mortality from fire, insects, and diseases. Much of the land is stocked with decadent old-growth timber. While the old-growth stands contain most of the area's timber volume, they are growing very slowly and are highly susceptible to insect and disease attack. A long term timber management objective, however, is to harvest these stands at a rate that will result in sustained timber harvest until the young stands reach maturity. It is also important to establish a

balanced stand age structure--that is, to have the timber producing areas about equally divided among stands of each age class up to the established rotation age.

The long term sustained yield will be largely determined by the growth rate realized in the balanced stand age structure of the future under intensive management. Sustained yield can be roughly estimated on the basis of site quality and land area. For instance, the national forest land located at high elevations in the mountainous areas of rugged topography and shallow soil will probably have the lowest sustained yield per acre while lands administered by the Bureau of Land Management and the Oregon State Board of Forestry are of better site quality, so their sustained yield will tend to be higher. The potential sustained yield for publicly owned commercial forest land is shown in table 13.

Table 13.--Estimated ultimate annual sustained yield of timber from commercial forest land, by ownership, Middle Willamette River Basin, Oreg.

Ownership class	Subbasin 5 Santiam	Subbasin 6 Coast Range	Subbasin 7 Pudding	Total
	Millions of board feet			
National forest	160	14	1	175
Bureau of Land Management	65	60	35	160
Corps of Engineers	...	...	...	...
State of Oregon 1/	15	10	5	30
County and municipal	...	2	...	2
Private	336	405	174	915
Total	576	491	215	1,282

1/ Land administered by Oregon State Board of Forestry only.

Source: Estimated from site index and acreage data furnished by U. S. Forest Service, Bureau of Land Management, and State of Oregon. Average rotation age was set at the point of culmination of mean annual increment. Stocking was assumed to be 75 to 80 percent of normal, and it was estimated that thinnings would be harvested from 30 to 50 percent of the acreage. Yield data is from table 4, USDA Tech. Bul. 201.

Private Land. Little is known of the overall condition of privately owned commercial forest land in the basin because the most recent available data was collected in the 1940's. Since then, several important changes have occurred which affect the ultimate sustained yield of private land.

A large volume of private sawtimber has continued to be harvested, although the harvest has decreased recently apparently because many small holdings are completely logged out. Most of the private timber

harvest is believed to be coming from large holdings; some of these are being well managed.

Another important change has been a greatly increased interest in tree farming among private owners. Cutover land that would have been abandoned 20 years ago is being reforested and managed for timber production. The extent of forest conservation practices is unknown, but they are being adopted by an increasing number of owners, largely through educational efforts of both public agencies and private groups.

A third factor affecting the sustained yield of private land has been an increased market for small logs and for hardwood species. Much of the private land is near the wood processing centers in the Willamette Valley, so there is an increasingly good economic possibility for intensive management of young stands.

It is not possible to make an accurate estimate of the ultimate sustained yield of timber from private forest land because of a lack of recent data. However, a rough estimate based on acreage and site quality is presented in table 13. This estimate implies that the basin cannot supply enough timber on a sustained basis to meet the requirements of the present wood-using industries. However, the wood-using industries may continue to be able to fill the gap between supply and mill capacity by importing logs from other basins.

There is a distinct possibility of a timber shortage during the next 60 years while the large acreage of cutover private land is growing a new crop of timber. It is unlikely that public and conservatively managed private forest land can supply enough timber to meet the industry's requirements during this period. Thereafter, the basin's timber supply should be near sustained yield levels.

As the old-growth timber of the basin is gradually replaced by young stands, the structure of wood-using industries will probably change. There will probably be sawmills and plywood plants of smaller capacity designed to efficiently use small logs. Probably more plant facilities will be developed to use waste wood for wood fibre products. Although no specific estimates can be made, the wood-using industries will probably need several times their present industrial water requirements.

RECREATION

Pattern of Use

Outdoor recreation has been an important part of the lives of Willamette Valley residents for many years. Hunting and fishing are a part of the pioneering heritage. Recently, increased urbanization of the valley has caused more people to seek the out-of-doors to "get away from it all" through camping, picnicking, wilderness travel, sightseeing, and related activities. Better and faster transportation, higher family incomes, and increased leisure time have enabled people to spend more time and money on recreation and to travel farther for rec-

reation. All of these factors have brought about a rapid increase in the use of forest land for recreation.

The basin's forested areas have many natural attractions that make them desirable for recreation. These include lakes, fishing streams, outstanding scenery, a relatively abundant wildlife population and suitable hunting terrain, and thousands of acres of roadless wilderness.

It is no coincidence that most of the public outdoor recreational facilities in the basin are adjacent to lakes or streams. The Willamette River is used for a wide variety of recreational activities such as boating, swimming, fishing, and water skiing, but pollution has tended to limit its attractiveness. Silver Falls State Park has several waterfalls as its outstanding feature. Detroit Lake, developed as a multipurpose reservoir by the Corps of Engineers, has in less than 10 years become the most heavily used outdoor recreational area in the basin. The lakes and streams in the headwaters of the Santiam River watershed are visited by many fishermen, campers, and sightseers.

The many miles of forest roads are an important factor in encouraging increased recreational use of forest land. Completion of the forest road systems will permit development of recreational facilities in many areas that are now inaccessible, providing some relief for accessible areas that are now overused.

It is important to manage the natural attractiveness of forest land for recreational use. On public forest land and some private forest land, recreational zones have been established around potential and developed recreational sites and lakes, streams, and routes of travel used for recreation. Commercial activities are modified in the recreational zones to preserve a suitable environment for recreation, and timber management is carried on with the objective of producing a healthy forest cover that is aesthetically pleasing.

It is also important to preserve some areas in a near-natural condition for recreation or for scientific study and observation. The 86,700 acre Mt. Jefferson Primitive Area is one of the tracts classified by the U. S. Forest Service primarily for wilderness recreation. It contains several alpine lakes and spectacular alpine scenery including Mt. Jefferson, the second highest peak in Oregon. About 55,000 acres of the Mt. Jefferson Primitive Area are in the Middle Willamette River Basin. The portion of the primitive area in the basin received an estimated 7,800 recreational visits in 1960. Much of the use has been concentrated in a few areas. Between Breitenbush Lake and Jefferson Park, heavy recreational travel has caused erosion of the Oregon Skyline Trail, and grazing of recreational visitors' horses and pack animals has seriously depleted the vegetative cover in many of the alpine meadows. The Mt. Jefferson Primitive Area is now being studied for reclassification to permanent wilderness status.

Trends in Use

The most comprehensive statistics of recreational use for the basin are those for the national forests presented in tables 14 and 15. These show that recreational visits to the national forests of the basin totaled 460,400 in 1960, more than triple the recreational visits made in 1956.

A large part of the increased use of national forest land may be attributed to the North Santiam watershed. The national forest area in the North Santiam watershed received about 80,000 recreational visits in 1956. In 1960, the same area received about 390,000 visits. Meanwhile, recreational use of the rest of the basin's national forest land increased from 45,000 visits in 1956 to 70,000 visits in 1960. In the North Santiam watershed, the largest increases in recreational use were in camping, which increased from about 10,000 visits to about 85,000 visits; picnicking, which increased from about 15,000 visits to about 75,000 visits; fishing, which increased from about 16,000 visits to about 145,000 visits; and boating, which increased from about 1,000 visits to about 27,000 visits.

Much of the increased recreational use of the North Santiam watershed may be attributed to Detroit Reservoir, but there has also been greatly increased use of the streams and natural lakes of the area.

National forest land in the South Santiam watershed has several small attractive lakes and appealing high mountain scenery. Some areas are not accessible for recreational use because of a lack of access roads and trails and because of a lack of rights-of-way across private land. However, camp and picnic areas and fishing streams receive moderate use. Completion of Corps of Engineers' flood control reservoirs in the South Santiam watershed will probably result in greatly increased recreational use both inside and outside the national forest.

The Marys Peak area on the Siuslaw National Forest is also an important recreational attraction. It received about 30,000 recreational visits in 1960, a 25 percent increase over the estimated use in 1956. Most recreational visits to Marys Peak are for picnicking and sightseeing.

National forest recreational use is expected to increase by about 7 times in the next 40 years. Increases in recreational use of other land will probably be at least as great. The basin attracts recreational visitors from other parts of Oregon and from other states. Outdoor recreation is an important factor in the basin's economy as well as being vital to the well-being of the people of the area. As the Willamette Valley and the rest of Oregon become more heavily populated, forested areas that are available for recreation will become increasingly important.

Table 14.--Recreational use of the national forests by primary purpose of visit, Middle Willamette River Basin, Oreg., 1956-1960

Purpose of visit	Year				
	1956	1957	1958	1959	1960
	Visits	Visits	Visits	Visits	Visits
Camping	13,400	54,500	54,200	75,000	93,400
Picnicking	33,200	110,800	78,000	89,000	103,400
Swimming	1,000	2,500	5,500	8,000	10,000
Winter sports	1,200	1,300	1,400	1,500	1,500
Hunting	3,200	3,600	3,800	5,700	7,700
Fishing	26,200	35,500	41,600	124,000	156,700
Hiking and riding	6,800	7,200	6,800	6,200	8,600
Boating	1,000	14,800	16,000	23,000	27,600
Organization camping	1,500	1,500	1,500	2,200	1,400
Wilderness travel	3,000	3,500	4,500	7,000	7,800
General enjoyment and sightseeing	28,700	37,500	35,000	32,600	34,400
Other	5,800	7,200	7,500	7,300	7,900
Total	125,000	279,900	255,800	381,500	460,400

Source: Estimated from data furnished by U. S. Forest Service.

Table 15.--Recreational use of the national forests by subbasin, Middle Willamette River Basin, Oreg., 1956-1960

Subbasin	Year				
	1956	1957	1958	1959	1960
	Visits	Visits	Visits	Visits	Visits
5. Santiam	100,400	253,000	226,200	351,100	429,900
6. Coast Range	24,600	26,900	29,600	30,400	30,500
7. Pudding	...	...	...	...	...
Total	125,000	279,900	255,800	381,500	460,400

Source: Estimated from data furnished by U. S. Forest Service.

Public Recreational Facilities

The developed public recreational facilities of the Middle Willamette River Basin consist of national forest and Bureau of Land Management recreational areas, state parks, county parks, and parks maintained by industrial timberland owners.

The national forest facilities include 25 forest camps with a total of 293 family units (a family unit consists of a fireplace, table, and cleared campsite). The largest campgrounds include Marys Peak with 34 family units, Humbug and Breitenbush in the Breitenbush River area with 27 and 37 family units, respectively, and House Rock and Trout Creek in the South Santaim watershed with 22 and 24 family units, respectively.

The Forest Service has recognized recreation as being important on much of the national forest land in the basin. In addition to 55,000 acres in the Mt. Jefferson Primitive Area, about 40,000 acres of national forest land are in recreational zones around streams, lakes, and areas of high recreational value.

The Forest Service allows occupancy of certain tracts of land by individuals or groups for recreational purposes under authority of annual or term land use permits. There are 6 summer home areas in the basin containing 91 homesites which may be occupied by private individuals. Four organization camps have been developed by groups such as the Boy Scouts of America, church groups, and sportsmen's organizations. Four public service sites provide commercial public facilities such as resorts and boat landings. Such facilities are developed where there is a demonstrated public need that cannot be satisfied on private land. In addition, Detroit Lake State Park is on national forest land and operated under permit to the State of Oregon.

The Bureau of Land Management has 2 developed camp and picnic areas in the basin with 48 family units. They are presently constructing 2 additional sites and have 8 others in various stages of planning along with 2 cooperative county park projects. National land reserve lands administered by the B. L. M. are available for lease by the state or counties for parks. The B. L. M. has set aside sizable areas of land for recreational purposes.

There are 10 state parks in the basin totalling about 9,230 acres including Silver Falls, the largest Oregon state park. All of the state parks have picnicking facilities, and 5 have facilities for overnight camping. There is also one picnic area maintained by the Oregon State Game Commission.

There are 17 county parks in the basin intended mostly for day use. Yamhill County maintains 4 boat ramps along the Willamette River.

Four parks are maintained by industrial timberland owners. Private landowners, particularly the large industrial owners, are tending to allow more public recreational use of their land because of a more responsible public attitude toward fire prevention and the need for increased public recognition of private forest management.

All of the public agencies mentioned above plan to provide increased facilities as needed to meet the future demand. For example, it is estimated that the Forest Service has about four times as many sites available for campground development as are presently in use. The Bureau of Land Management has set aside several sites for future camp and picnic area development and will probably provide recreational facilities adjacent to the Corps of Engineers' planned multipurpose reservoirs in the South Santiam watershed. The State of Oregon has a large acreage of land that could be developed for recreational use. Several of the county park departments plan expansion of their facilities. Private landowners are also likely to provide additional public recreational facilities in the future.

Unfortunately, many of the present and planned recreational facilities are far from the valley centers of population. There is a great need for public recreational development along the Willamette River and at other locations within the Willamette Valley to serve people who cannot or do not desire to travel long distances for outdoor recreation. City and county governments and local public service and private organizations can best provide recreational facilities in the Willamette Valley.

WILDLIFE

The wildlife and sports fishery resources of the Middle Willamette River Basin are managed by the Oregon State Game Commission. The commercial fishery is managed by the Fish Commission of Oregon. The wildlife habitat is controlled by the individual landowners and the public land management agencies. Habitat conditions have a marked influence upon the size of wildlife populations.

Big Game

The most numerous big game species in the basin is the Columbian black-tailed deer. The deer population has increased steadily, for logging has created a more favorable habitat in many areas. Hunting pressure is variable depending upon accessibility. The basin, with 5.6 percent of the area of the State of Oregon, had about 14 percent of the deer hunters and about 12 percent of the deer harvest in 1959. The total harvest of about 16,000 deer included about 7,500 anterless deer and 8,500 bucks. Though the success ratio (percentage of hunters successful) was lower than the average for the state, the harvest per square mile, 2.2 deer, was somewhat higher than the statewide average.

Appreciable numbers of mule deer have their summer range along the Cascade crest at the eastern boundary of the basin. Their winter range is in the Deschutes Basin.

About 75 elk have their range in the Breitenbush River watershed. There is also a small elk population in the eastern Coast Range. The annual elk harvest is insignificant.

A relatively stable black bear population occurs throughout the basin. Bear is now classified as a game species in the national forests along the Cascades.

Conflicts between big game management and other resource uses have been widespread. There has been deer damage to tree seedlings on cutover land and to farm crops. Control of deer damage is being attempted through special hunting seasons, issuance of permits for hunting anterless deer, by providing alternate sources of food for deer, and through treatment of seedlings with animal repellants.

Hunting pressure will probably continue to increase in the future. Although some private forest land is closed to hunting, most commercial timber companies realize the need for adequate harvest of big game and

open their land to hunting accordingly. With improved access to both public and private land, the basin can support a considerable increase in hunting pressure.

Small Game

There are several game bird species in the Willamette Valley including ring-necked pheasants, valley quail, bobwhite quail, mourning doves, and band-tailed pigeons. Game birds have continued to thrive in the valley largely because of the cover provided by the scattered areas of forest land, hedgerows, and idle farm land. Game farm raised pheasants are liberated by the Game Commission to supplement natural breeding stock. The population of most game bird species has been stable in recent years despite strong hunting pressure. Distribution of suitable water supplies is a limiting factor to game bird population increases.

The most common game bird species in the forested mountain areas are band-tailed pigeons, blue grouse, ruffed grouse, and mountain quail. Hunting pressure is light in most of the mountain areas, and some game bird populations may be increasing. Most game bird populations have cyclic fluctuations.

Migratory waterfowl are abundant in the Willamette Valley during migration periods, and small numbers of some species nest in the basin.

Silver gray squirrels are common in nut-producing sections of Polk and Yamhill Counties. There is no closed season or bag limit for this species, which does considerable damage to commercial walnut and filbert crops. Other species of squirrel are common in forested areas. Cottontail and snowshoe rabbits are fairly common in most of the basin.

Furbearers

Many species of furbearers including beaver, racoon, gray fox, red fox, marten, mink, muskrat, otter, skunk, and weasel are represented in the basin. Beaver, racoon, and mink are common along streams in the Willamette Valley. Pollution of some streams has created unfavorable habitat conditions for furbearers, and it is reported that pollution of the Willamette River has forced migration of beaver to smaller streams and ditches where they are in conflict with the use of adjacent land. Although not abundant, all of the furbearing species mentioned above are found in the forested areas of the Cascades and Coast Range.

Low market values for pelts have kept trapping pressure light. During the 1959-60 season, 149 trappers (16 percent of the state total) took 4,730 pelts (8.5 percent of the state total) in the 5 principal counties of the basin. The harvest included 2,350 beaver (22 percent of the beaver taken in the state), 1,270 muskrat, and 590 racoon. The market value of the harvest was an estimated $34,500, about 17 percent of the state total, or $231 per trapper.

Predators

The most common predatory speices in the basin are coyote and bobcat. Neither species is abundant. During the 1959-60 season, federal hunters took 970 predatory or nuisance animals including 160 coyote, 110 bobcat, and 800 of other species in Benton, Linn, Marion, Polk, and Yamhill Counties. Bounties were paid by the Game Commission for an additional 120 bobcat and 2 cougar. Cougar are relatively rare in the basin.

Anadromous Fish

Spring chinook and silver salmon, cutthroat trout, and steelhead trout migrate into the basin annually to spawn. Chinook salmon move into the tributaries from March to May and remain in deep holes until the early autumn spawning period. Silver salmon move upstream in October and spawn until January. Steelhead trout migrate upstream to the tributaries in early spring and spawn immediately.

The Fish Commission estimates about 40 percent of the Willamette River spring chinook salmon run originates in the Middle Willamette River Basin. Spring chinook runs occur in the Santiam, Molalla, and Calapooya Rivers. The Fish Commission operates hatcheries on the North Santiam River and the Middle Santiam River for the propogation of spring chinook salmon. The North Santiam hatchery somewhat compensates for natural spawning lost through construction of Detroit Dam.

There are small silver salmon runs in the Molalla, Santiam, Calapooya, and Luckiamute Rivers. The total annual run is estimated to be 5,000 adult fish.

Anadromous fish spawned in the basin are an important part of the commercial and sports fishery on the Willamette and Columbia Rivers and contribute to ocean commercial and sports fisheries from Alaska to California.

Conditions unfavorable to anadromous fish such as pollution, high water temperatures, and physical obstructions to migration are widespread in the basin. Pollution levels are high enough in the lower part of the Willamette River during low flow periods to delay or prevent upstream migration. Water temperatures have been increased by removal of shading vegetation along streams and reduction in natural flows through upstream water consumption. Physical obstructions include dams, log jams, and natural barriers.

Native Fish

The 1,050 miles of fishable streams, 1,414 acres of natural lakes, and 3,720 acres of reservoirs in the Middle Willamette River Basin contain nearly all of the game fish species found in Oregon. The lowland streams and reservoirs contain warm water fish such as large-mouth and small-mouth bass, white and black crappie, bullhead catfish, and bluegill. Streams and lakes in the mountains with cool water temperatures

contain several species of trout. Trash fish occur in the lower reaches of the major streams and in the reservoirs and may interfere with the sports fishery.

There has been a rapid increase in fishing pressure on most lakes and streams. For example, 134,000 anglers at Detroit Lake took 228,000 trout in 1960, far more than the angler use experienced in 1956. Many lakes and streams in the Cascades are heavily fished. The Game Commission supplements natural stocking with hatchery-raised fish in Detroit Reservoir and several lakes and streams.

Native fish populations have been difficult to maintain in several streams because of siltation, pollution, high water temperatures, and physical barriers to fish movement. High water temperatures have encouraged the spread of trash fish and made some streams totally unsuitable for trout during summer low flow periods.

RANGE

Most of the livestock grazing on forest land in the Middle Willamette River Basin is on areas in and near the Willamette Valley. Many of the forest stands are on gentle terrain, are relatively free of undergrowth, and have a ground cover of palatable forage plants.

There is a small amount of permitted grazing on national forest land in the upper slope forest zone, in the Cascades where there are small wet meadows and open timber stands. The present grazing use totals 280 animal-unit months by cattle. At one time, sheep grazed large portions of the upper slope and subalpine zones and severely depleted the ground cover. Sheep grazing was gradually eliminated through administrative controls and changing economic conditions, and the range has gradually recovered. Changing economic and social conditions have required greater emphasis on recreational and watershed values of the mountain areas and less emphasis on value for grazing.

WATER

Water Yield

It is estimated that about 80 percent of the annual water yield from the Middle Willamette River Basin comes from forest land. Forest land is, therefore, vitally important in controlling quality and timing of water yield. At low elevations, forest cover helps maintain soil conditions that encourage infiltration of precipitation. Trees, brush, and organic litter protect the soil from the eroding action of rainfall. More water percolates into ground water storage for later gradual release instead of rapidly running off over the surface. At high elevations, forest cover helps to prolong melting of winter snowpacks, which provide much of the late spring and summer flows in streams rising in the Cascades. Trees provide shade along rivers and streams helping to maintain water temperatures suitable for fish life.

Several cities and towns in the basin depend upon surface water flows for municipal supplies. If the watersheds of the streams used

as a source of municipal water supplies are adequately protected, there will be a continuous yield of a maximum quantity of pure water requiring limited treatment. However, if municipalities or other public agencies do not own or control the use of lands in municipal watersheds, there may be activities that result in unstable water flows, sediment laden water requiring expensive treatment, and insufficient flows during summer months.

Future population growth and expansion of industry and agriculture in the basin will depend upon a sufficient quantity of pure water. Planned extensive development of reservoir storage to provide for future water needs requires soil stability in tributary watersheds to prevent excessive sedimentation of reservoirs. Protection of the watershed values of forest land in the basin will help to insure an adequate supply of pure water to meet future needs.

As we have seen, forest land is also used for timber production, recreation, wildlife habitat, and livestock grazing. Activities connected with each of these uses can impair watershed values of forest land. However, by limiting the intensity of use and by following specific watershed protection practices in development and use of other forest resources, important benefits can be realized from all forest resources while maintaining the basic soil and watershed values. The city of Corvallis municipal watershed provides an example in the basin of how watershed values can be protected while other forest resources are used. This watershed provides over a billion gallons of water per year as a large part of the municipal water supplies for Corvallis and is also used for timber production, recreation, and wildlife habitat.

There are many management practices that can help enhance the watershed value of forest land and can be instituted without diminishing its value for other uses. These practices include the following:

1. Protection of soil mantle over the entire watershed to prevent soil erosion. This can be best accomplished by maintaining the vegetative cover over the soil. When the vegetative cover is removed, as by fire or logging, it should be restored as promptly and completely as possible. Large disturbed areas such as roads and landings should be provided with adequate drainage. Timber harvesting methods should be used that will result in a minimum of soil disturbance. Big game and livestock use should be kept below levels that result in an excessive depletion of vegetative cover and soil compaction.

2. Protection of streambanks and channels from disturbance during logging and road construction. Roads should be so located, designed, and constructed that sidecast material, slash, and debris are kept out of streams. Timber harvesting should be planned so that perennial streams are not disturbed by skidding and landing operations. Logging debris should be removed from streams.

3. Prevention of stream pollution. Adequate sanitation facilities should be provided at recreational areas and public cooperation enlisted to prevent pollution. Buffer strips should be left between recreational developments and lakes and streams.

These are examples of the many individual good practices that cumulatively add up to good watershed management.

There are areas of steep and unstable terrain in the Cascades and Coast Range that are subject to slippage and sliding. Areas underlain by pyroclastic rocks (tuffs and breccias) are particularly hazardous from the standpoint of both slumps and slides. Large areas of land can be set into motion, or accelerated if already moving, by road construction and timber harvesting activities. Various steep slopes associated with recent stream incision or glaciated side slopes also have relatively high slide and surface erosion hazards. Some special considerations that can be given in these areas include careful analysis of road position in relation to critical soils stability and use of skyline-type logging equipment to limit soil disturbance. Some forest land with extremely high slide and surface erosion hazards should be excluded from timber harvesting until harvesting methods have been devised that will adequately protect the site.

Water Requirements on Forest Land

There are many kinds of water requirements, both consumptive and nonconsumptive, on forest land in the Middle Willamette River Basin. Few quantitative estimates can be made of these requirements. Estimates of certain consumptive water requirements on national forest land in the basin are presented in table 16 as a sample of water use on forest land. While the estimated consumptive requirements are small, it is essential that they be considered in planning the development and use of water resources of the basin.

The largest single use of water in forested areas is for plant growth. This consumptive use is known as the evapo-transpiration process and is seldom measured.

Domestic. Domestic water uses with relation to forestry include the following:

1. Water used at forest administrative stations of both public agencies and private companies. Some stations are located in sizable towns and are served by municipal supplies.

2. Water used for domestic purposes at public recreational areas and at recreational facilities such as summer home areas, organizational camps, and resorts that are under special-use permit.

3. Water required for domestic use by other forest users including loggers, road builders, stockmen, and local residents while working or living in forested areas.

Table 16.--Estimated national forest water consumption, Middle Willamette River Basin, Oreg., 1960 and 2000

Use	Subbasin 5 Santiam		6 Coast Range		7 Pudding		Total	
	1960	2000	1960	2000	1960	2000	1960	2000
	Millions of gallons per year							
Domestic:								
U. S. Forest Service administrative stations 1/	6.3	9.5	...	...	...	...	6.3	9.5
Public recreational areas	7.4	18.0	0.3	1.8	...	0.1	7.7	19.9
Summer home areas, organization camps, and resorts under special-use permit	4.2	17.0	...	...	...	...	4.2	17.0
Other areas under special-use permit	0.5	0.6	...	...	...	0.1	0.5	0.7
Other national forest users	0.2	0.3	0.1	0.1	...	...	0.3	0.4
Livestock	0.1	0.1	...	...	...	...	0.1	0.1
Wildlife	35.4	52.0	1.4	1.6	0.3	0.4	37.1	54.0
Industrial:								
Road construction and maintenance	4.6	4.1	...	...	...	...	4.6	4.1
Log transportation and storage 2/	0.8	0.8	0.1	0.1	...	0.1	0.9	1.0
Fire control	0.1	0.1	...	...	...	...	0.1	0.1
Total	59.6	102.5	1.9	3.6	0.3	0.7	61.8	106.8
Totals converted to acre feet	183	314	6	11	1	2	190	327

1/ Does not include water obtained from municipal supplies.
2/ Includes transportation of national forest timber and includes log storage areas or water supplies under national forest special-use permit.

Source: Data provided by U. S. Forest Service. Projections are based on national forest development anticipated by local forest officials, assuming daily per capita water consumption will remain about the same as at present.

Water requirements for all of these purposes are expected to increase greatly as forest areas are used more heavily and managed more intensively.

Livestock. Water requirements for livestock in forested areas include the following:

1. Water actually consumed by livestock.

2. Water stored in ponds and storage tanks (plus evaporation and seepage losses) to provide for needs of livestock.

As the value of forest land for wildlife, timber, and recreation increases, the use of forest land by livestock and water requirements for livestock on forest land will probably decrease.

Recreation. Recreational water uses in forested areas include the following:

1. Water consumed by recreational visitors to forest land. This is primarily a domestic water requirement.

2. Water in lakes and streams that is used for recreational purposes such as fishing, boating, swimming, and aesthetic enjoyment. This is a consumptive water use only to the extent that water is consumed through evaporation from surface of bodies of water. Water levels in lakes and streams need to be maintained at a level that makes them aestheticly attractive during the season of recreational use.

Water requirements for recreation are expected to continue to increase rapidly as recreational use of forested areas increases.

Wildlife. Water requirements for wildlife on forest land include the following:

1. Water actually consumed by wildlife on forest land.

2. Water required as environment for wildlife such as waterfowl and certain furbearers. There is some water consumption through evaporation from lakes and streams. Fairly uniform water levels must be maintained for some species, and water must be kept free of pollution.

Water requirements for wildlife are expected to increase significantly in the future, primarily due to expected increases in deer population.

Fish Life. Water requirements for fish life include the water in lakes and streams that is a necessary environment for fish. There are certain water quality requirements as to temperature, oxygen content, and freedom from pollution and turbidity that must be met if fish and the aquatic plants and animals they feed on are to thrive. An important part of maintaining water quality is the maintenance of adequate streamflows and lake levels. When water quantities are low, especially during summer months, the water temperature is likely to rise, oxygen levels drop, and pollution increases because wastes are not carried away promptly. All fish species have certain special requirements during the spawning season. Stream levels must be sufficient and stream

channels open so that fish can travel to the spawning areas. Water and streambed conditions in the spawning areas must be suitable for each species.

Industrial. Water requirements for forest industries on forest land include the following:

1. Water for construction and maintenance of forest access roads.

2. Water for operation of timber harvesting equipment.

3. Water for storage and transportation of logs.

Water requirements for road construction and maintenance will probably decrease as the primary access road system is completed and as dust palliative materials other than water become more widely used for road maintenance. Water requirements for timber harvesting and log storage and transportation will probably increase as harvesting of second-growth timber increases in importance. Large quantities of small logs will be harvested as thinnings, and log sizes will be smaller in final harvest cuts. Operation will, thus, be less efficient and will require more water per unit of log production.

Fire Control. Variable quantities of water are required for control of forest fires and slash disposal fires. Water must also be stored in ponds and storage tanks so that it is readily available when needed. The amount of water required for this purpose is not expected to change greatly in the future.

AGRICULTURE IN THE BASIN

GENERAL

Agriculture in the Middle Willamette River Basin is highly diversified. The fertile soils in the broad valleys and the temperate climatic conditions are favorable for production of many agricultural products. The close proximity of farms to population centers and markets enables farmers to compete favorably with other agricultural areas in the Northwest.

Although agriculture as practiced in the basin is diversified, farmers within certain areas tend to specialize in the type of products grown. Grass seed, hay, and small grains are produced on the benchlands and rolling foothills. Vegetables and other intensive crops are produced on the fertile bottom soils where irrigation water is available. Dairy and poultry products are raised throughout the basin, but farms producing these products are most numerous near the population centers and markets. Beef cattle, sheep, and goats are most numerous in the rangeland areas on the fringe of the valleys.

Agricultural Data

Data on land use, irrigation, drainage, flooding, and erosion are needed to analyze the present and potential use of land and water for agriculture. Published data are available on some of these items on a county basis, but more detailed information on small watersheds was desired to facilitate future planning and comparison of potential projects. The USDA Field Party made a reconnaissance survey of 57 small watershed areas in the Middle Willamette River Basin to supplement published data and to obtain more detailed information for each subbasin. The location of the watershed areas is shown on a map (fig. 30), and information for each watershed is shown in tables 17A through 17D.

Information in these tables was estimated by local personnel of the Soil Conservation Service, the County Extension Service, and the Agricultural Stabilization and Conservation Service. Although the information is of a reconnaissance nature, published data such as the U. S. Census of Agriculture were used as a cross check on several items. Data from this survey are used throughout much of this report.

Agricultural Land Use

The land base for agriculture consists of 134,000 acres of rangeland, 285,400 acres of grazed forest land, and 1,033,300 acres of cropland (table 18).

Rangeland and grazed forest land constitute about 12 percent of the basin area, or 419,400 acres. Rangeland is defined as noncropland pasture, and grazed forest land is defined as land grazed by livestock that is at least 10 percent stocked with trees. Most of the rangeland and grazed forest land is in a belt between the valley cropland and the higher elevation forested lands. Much of the rangeland is cutover for-

est land that has been seeded to grass. The grazed forest land consists of areas which support a cover of brush or timber that is usually of poor quality.

About 30 percent of the basin area, or 1,033,350 acres, is cropland. The major uses of cropland are for the production of small grains and grass seed (table 18). About 27 percent of the cropland in the basin is in small grain, and 21 percent is in grass for seed. The wet falls, mild winters, and dry summers are ideal for growing and harvesting of these crops. About 43 percent of the small grains is barley; 24 percent is oats; and 33 percent is other small grains. The major grasses raised for seed in the basin are Bentgrass, Fescue and Ryegrass.

Cropland pasture, hay, and silage crops are also grown extensively in the basin. About 14 percent of the cropland is used for pasture and about 10 percent for hay and silage production. These two crops

Figure 14.--Productive cropland pasture in the Pudding Subbasin. SCS photo. 7-954-7

Table 17A.--Reconnaissance data on tributary areas studied, Santiam, Subbasin 5, Middle Willamette River Basin, Oreg., 1962

	Unit	Little North Santiam A	Lower North Santiam B	Mainstem Santiam C	Millersburg-Dever D	Bear Branch E	Sucker Slough F	Thomas Creek G	Upper North Santiam H	Crabtree Creek I	South Santiam J	Albany Flats K	Oak Creek L	Calapooya River M	Willamette River N	East Muddy Creek O	Walton Slough P	Lake Creek Q	Hamilton Creek R	McDowell Creek S	Middle Santiam T	Upper South Santiam U	Total Subbasin 5
Number of farms	Number	10	670	130	70	50	25	160	50	125	235	160	195	475	125	195	160	80	110	15	...	120	3,160
LAND USE:																							
Forest land grazed	Acres	2,500	5,080	1,400	1,000	640	400	8,000	5,430	11,500	5,200	1,000	4,560	15,000	1,500	1,600	11,000	2,000	5,000	2,700	...	5,000	90,510
Forest land not grazed	do.	69,630	6,840	600	400	420	100	48,840	308,630	64,300	13,960	...	2,000	91,000	2,000	33,400	3,000	2,000	16,200	10,270	182,460	172,000	1,028,050
Cropland	do.	1,260	30,210	15,230	9,890	6,570	6,090	17,000	1,370	18,000	33,920	15,520	13,000	57,600	5,890	51,090	19,500	9,790	4,000	1,820	50	3,310	321,110
Rangeland	do.	90	5,400	1,100	...	1,500	1,000	7,000	2,400	2,500	8,000	800	2,000	5,200	1,200	6,400	1,000	1,000	3,000	800	150	2,000	52,540
Other	do.	130	4,340	740	400	100	200	2,000	21,300	1,500	5,150	12,000	1,000	10,000	1,300	4,700	1,180	1,000	100	200	1,050	1,000	69,390
Total watershed area	do.	73,610	51,870	19,070	11,690	9,230	7,790	82,840	339,130	97,800	66,230	29,320	22,560	178,800	11,890	97,190	35,680	15,790	28,300	15,790	183,710	183,310	1,561,600
Cropland use:																							
Dryland	Acres	1,060	15,000	9,200	7,890	6,070	5,790	15,000	1,170	15,900	31,620	15,020	12,000	52,600	4,390	48,190	18,300	9,290	3,600	1,700	20	3,100	276,910
Irrigated	do.	200	15,210	6,030	2,000	500	300	2,000	200	2,100	2,300	500	1,000	5,000	1,500	2,900	1,200	500	400	120	30	210	44,200
Total	do.	1,260	30,210	15,230	9,890	6,570	6,090	17,000	1,370	18,000	33,920	15,520	13,000	57,600	5,890	51,090	19,500	9,790	4,000	1,820	50	3,310	321,110
Potential cropland	Acres	2,500	4,700	1,000	...	1,600	...	2,500	2,000	10,000	1,700	200	2,000	10,000	2,000	5,000	2,000	2,000	4,000	100	...	1,000	54,300
IRRIGATION:																							
Water source:																							
Direct stream diversion	Acres	...	...	1,700	...	...	...	...	...	1,500	...	...	...	...	...	500	...	...	...	...	...	150	3,850
Pumped from streams	do.	100	6,960	2,600	1,200	400	100	...	150	450	850	...	...	2,300	350	1,000	100	250	350	120	30	60	17,370
Pumped from wells	do.	50	8,250	1,730	800	100	200	1,820	...	100	1,450	500	900	2,400	1,000	1,400	1,100	250	...	...	...	...	22,050
Other	do.	50	...	...	...	...	...	180	50	50	...	...	100	300	150	...	...	...	50	...	...	...	930
Total	do.	200	15,210	6,030	2,000	500	300	2,000	200	2,100	2,300	500	1,000	5,000	1,500	2,900	1,200	500	400	120	30	210	44,200
Water shortage	Acres	...	...	...	100	...	50	...	...	200	...	100	100	100	100	...	...	50	...	...	...	...	800
Method of application:																							
Sprinkling	Acres	200	15,210	6,030	2,000	500	300	2,000	200	900	2,300	500	1,000	5,000	1,500	2,400	1,120	500	400	120	30	210	42,420
Flooding	do.	...	...	...	...	...	...	...	...	1,200	...	...	...	...	...	500	80	...	...	...	...	...	1,780
Total	do.	200	15,210	6,030	2,000	500	300	2,000	200	2,100	2,300	500	1,000	5,000	1,500	2,900	1,200	500	400	120	30	210	44,200
Potentially irrigable land:																							
Water source:																							
Natural flows and ground water	Acres	2,500	11,000	8,200	7,800	...	...	1,000	3,000	2,000	3,000	...	2,400	10,000	3,600	40,000	1,000	4,000	200	300	...	1,800	101,800
Other	do.	...	8,000	2,000	...	6,000	5,000	16,000	...	22,000	28,000	14,000	10,600	50,000	400	10,000	14,000	5,000	4,800	700	...	200	196,700
Total	do.	2,500	19,000	10,200	7,800	6,000	5,000	17,000	3,000	24,000	31,000	14,000	13,000	60,000	4,000	50,000	15,000	9,000	5,000	1,000	...	2,000	298,500
STORAGE:																							
Existing:																							
Ponds	Number	4	5	4	4	4	4	21	4	6	12	11	4	15	6	8	...	5	2	2	...	4	125
Reservoirs	do.	1	1	...	...	...	...	4	1	...	...	...	3	...	4	1	1	...	...	...	...	...	16
Possible reservoir sites studied	Number	...	...	...	...	1	1	2	...	3	2	...	1	3	...	1	1	...	1	1	...	1	18
DRAINAGE:																							
Arable land needing drainage	Acres	...	6,000	7,000	7,000	2,000	5,000	13,000	1,000	16,000	13,000	18,000	7,000	30,000	1,000	40,000	9,000	5,000	2,000	500	...	1,000	183,500
Needs:																							
Improved surface drainage	Acres	...	2,000	5,500	...	...	...	1,200	...	2,000	...	...	3,000	20,000	750	20,000	5,000	3,000	1,800	...	...	...	64,250
Subsurface drainage:																							
Open drains	do.	...	1,000	3,500	...	...	...	...	...	...	...	...	2,000	5,000	300	5,000	2,000	1,000	...	...	...	600	20,400
Closed drains	do.	...	5,000	3,500	7,000	2,000	5,000	13,000	1,000	16,000	13,000	18,000	2,000	5,000	700	15,000	2,000	1,000	2,000	500	...	400	112,100
Flooded areas	Acres	20	2,100	2,700	600	700	400	1,000	...	4,000	11,000	2,600	850	16,000	3,000	2,500	1,500	1,400	100	...	...	50	50,520

Source: Based on a survey by the U. S. Department of Agriculture Field Party. Estimates provided by local personnel of the Soil Conservation Service and County Extension Service.

Table 17B.--Reconnaissance data on tributary areas studied, Coast Range, Subbasin 6, Middle Willamette River Basin, Oreg., 1962

Item	Unit	North Yamhill River	Chehalem Creek	Willamette River							Total Willamette River	Hawn Creek	Panther Creek	Baker Creek	Deer Creek	Willamina Creek	Cosper Creek	Agency Creek	Upper Yamhill	South River	South Yamhill	Palmer Creek	Ash Swale	Salt Creek	Mill Creek	Mud Slough	Rickreall Creek	Ash Creek	Little Luckiamute	Luckiamute River	Soap Creek	Marys River	Muddy Creek	Total Subbasin
				Wilsonville	Mainstem Yamhill	Spring Valley	West Salem	Independence	Benton County	Bowers Slough																							
		A	B	C1	C2	C3	C4	C5	C6	C7	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	6
Number of farms	Number	405	150	260	425	200	250	50	250	35	1,470	45	80	90	130	220	10	55	65	225	150	160	160	100	30	100	40	30	145	50	160	215	4,285
LAND USE:																																	
Forest land grazed	Acres	17,550	6,220	3,200	4,000	3,020	1,080	1,150	4,900	1,100	18,450	1,200	1,700	1,600	8,710	2,000	1,000	500	4,530	8,150	1,800	2,630	4,010	1,020	1,380	2,060	2,300	3,130	8,890	4,960	11,000	10,000	124,790
Forest land not grazed	do.	36,600	7,120	3,040	6,600	2,500	3,130	390	3,600	7,000	26,260	...	12,610	8,380	12,510	45,860	2,930	12,460	55,380	2,160	1,900	400	4,100	27,140	...	21,790	1,000	40,030	78,440	12,160	78,000	35,000	522,230
Cropland	do.	19,320	9,380	12,470	30,120	6,580	7,030	12,050	19,600	5,700	93,550	6,740	3,000	4,580	11,550	3,190	2,000	1,500	5,220	38,330	14,370	19,810	21,580	5,090	15,790	14,390	14,300	5,260	18,870	13,820	13,780	26,500	381,920
Rangeland	do.	2,000	2,400	1,530	3,000	660	480	...	650	1,370	7,690	300	1,000	2,000	1,340	480	360	2,000	800	4,550	2,610	3,310	2,880	...	1,980	...	2,200	2,630	5,000	1,460	5,300	1,980	54,270
Other	do.	3,080	1,200	1,390	4,600	400	3,910	810	10,110	2,100	23,320	400	200	300	640	700	80	200	1,720	7,460	700	790	740	680	590	2,880	2,200	1,590	2,700	1,320	5,000	6,500	64,990
Total watershed area	do.	78,550	26,320	21,630	48,320	13,160	15,630	14,400	38,860	17,270	169,270	8,640	18,510	16,860	34,750	52,230	6,370	16,660	67,650	60,650	21,380	26,940	33,310	33,930	19,740	41,120	22,000	52,640	113,900	33,720	113,080	79,980	1,148,200
Cropland use:																																	
Dryland	Acres	18,160	9,200	11,950	25,200	6,280	5,730	6,200	15,300	5,400	76,060	6,440	2,730	4,100	10,830	2,640	2,000	1,480	5,020	35,850	11,300	19,750	20,980	4,930	15,720	13,790	14,250	4,960	17,950	13,700	12,700	24,900	349,440
Irrigated	do.	1,160	180	520	4,920	300	1,300	5,850	4,300	300	17,490	300	270	480	720	550	...	20	200	2,480	3,070	60	600	160	70	600	50	300	920	120	1,080	1,600	32,480
Total	do.	19,320	9,380	12,470	30,120	6,580	7,030	12,050	19,600	5,700	93,550	6,740	3,000	4,580	11,550	3,190	2,000	1,500	5,220	38,330	14,370	19,810	21,580	5,090	15,790	14,390	14,300	5,260	18,870	13,820	13,780	26,500	381,920
Potential cropland	Acres	...	...	750	1,200	1,000	...	...	4,000	500	7,450	100	...	200	...	...	...	150	...	...	200	500	1,000	500	...	500	500	500	1,500	3,500	2,000	3,000	21,600
IRRIGATION:																																	
Water source:																																	
Direct stream diversion	Acres	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	120	...	...	...	120
Pumped from streams	do.	1,160	45	250	3,050	230	50	1,500	1,000	50	6,130	180	250	280	720	550	...	20	200	2,220	2,560	10	350	160	...	600	50	300	800	120	1,020	1,550	19,275
Pumped from wells	do.	...	75	200	1,820	70	1,200	4,350	3,300	150	11,090	60	15	180	...	...	...	...	...	80	500	...	...	...	...	...	...	...	...	...	60	50	12,110
Other	do.	...	60	70	50	...	50	...	...	100	270	60	5	20	...	...	...	...	...	180	10	50	250	...	70	...	...	...	...	...	...	...	975
Total	do.	1,160	180	520	4,920	300	1,300	5,850	4,300	300	17,490	300	270	480	720	550	...	20	200	2,480	3,070	60	600	160	70	600	50	300	920	120	1,080	1,600	32,480
Water shortage	Acres	100	50	...	...	...	...	...	...	...	...	50	50	500	...	...	...	...	50	100	100	20	100	600	20	100	...	50	50	50	700	300	1,500
Method of application:																																	
Sprinkling	Acres	1,160	175	520	4,920	300	1,300	5,850	4,300	300	17,490	300	270	475	720	550	...	20	200	2,480	3,070	60	600	160	70	500	50	300	800	120	1,080	1,600	32,250
Flooding	do.	...	5	...	...	...	...	...	...	...	...	...	...	5	...	...	...	...	...	...	...	...	...	...	...	100	...	...	120	...	...	...	230
Total	do.	1,160	180	520	4,920	300	1,300	5,850	4,300	300	17,490	300	270	480	720	550	...	20	200	2,480	3,070	60	600	160	70	600	50	300	920	120	1,080	1,600	32,480
Potentially irrigable land:																																	
Water source:																																	
Natural flows and ground water	Acres	1,000	200	3,000	23,000	3,500	1,000	6,000	7,000	2,300	45,800	200	50	100	1,250	500	100	100	...	250	1,000	50	100	...	...	...	7,500	...	...	...	500	1,000	59,700
Other	do.	14,000	7,300	8,000	...	1,500	3,000	...	12,000	2,700	27,200	5,300	2,450	3,400	6,200	1,000	1,220	1,400	4,500	34,780	11,500	17,450	17,900	4,000	13,000	13,000	4,500	4,000	17,000	12,000	9,500	24,000	256,600
Total	do.	15,000	7,500	11,000	23,000	5,000	4,000	6,000	19,000	5,000	73,000	5,500	2,500	3,500	7,450	1,500	1,320	1,500	4,500	35,030	12,500	17,500	18,000	4,000	13,000	13,000	12,000	4,000	17,000	12,000	10,000	25,000	316,300
STORAGE:																																	
Existing:																																	
Ponds	Number	6	7	...	6	6	7	...	...	10	29	5	4	2	3	3	...	...	3	14	6	4	8	...	2	...	2	6	36	2	20	25	187
Reservoirs	do.	3	5	...	3	3	4	...	...	1	11	1	...	2	...	...	...	...	...	5	1	...	5	...	1	1	1	...	7	...	12	2	57
Possible reservoir sites studied	Number	5	...	1	...	1	...	...	...	...	2	...	1	2	6	4	1	1	1	3	1	2	2	...	...	1	2	...	7	2	4	4	51
DRAINAGE:																																	
Arable land needing drainage	Acres	9,000	5,000	1,000	7,000	3,000	300	1,000	5,000	700	18,000	2,000	2,000	3,000	4,000	2,000	...	2,000	2,000	15,000	4,000	6,000	6,000	2,000	9,000	2,000	4,000	3,000	7,000	5,000	1,000	10,000	123,000
Needs:																																	
Improved surface drainage	Acres	200	3,000	1,000	3,000	...	...	...	5,000	600	9,600	100	100	400	1,600	100	...	300	...	1,000	700	...	...	...	...	...	...	...	100	1,000	500	6,000	24,700
Subsurface drainage:																																	
Open drains	do.	300	2,000	...	500	...	...	...	1,000	300	1,800	100	150	600	200	100	...	300	500	700	150	...	2,000	500	1,000	...	500	...	400	2,000	700	2,000	16,000
Closed drains	do.	8,700	3,000	1,000	6,500	3,000	300	1,000	4,000	400	16,200	1,900	1,850	2,400	3,800	1,900	...	1,700	1,500	14,300	3,850	6,000	4,000	1,500	8,000	2,000	3,500	3,000	6,600	3,000	300	8,000	107,000
Flooded areas	Acres	800	2,000	700	7,000	...	1,300	7,000	9,500	500	26,000	30	150	200	960	400	180	400	40	2,500	580	400	600	...	900	700	...	1,500	6,000	500	1,800	5,000	51,640

Source: Based on a survey by the U. S. Department of Agriculture Field Party. Estimates provided by local personnel of the Soil Conservation Service and County Extension Service.

Table 17C.--Reconnaissance data on tributary areas studied, Pudding, Subbasin 7, Middle Willamette River Basin, Oreg., 1962

Item	Unit	Willamette River: Canby A1	Willamette River: Butteville A2	Willamette River: North Salem A3	Willamette River: South Salem A4	Total Willamette River A	Champoeg Creek B	Lower Pudding River C	Rock Creek D	Bear Creek E	Gribble Creek F	Molalla River G	Milk Creek H	Upper Pudding River: Butte Creek I1	Zollner Creek I2	Abiqua Creek I3	Silver Creek I4	Drift Creek I5	Beaver Creek I6	Pudding River I7	Total Upper Pudding River I	Little Pudding River J	Mill Creek K	Beaver Creek L	Total Subbasin 7
Number of farms	Number	60	105	250	250	665	150	250	480	180	160	350	585	260	90	110	110	100	30	500	1,200	200	700	250	5,170
LAND USE:																									
Forest land grazed	Acres	200	1,000	2,030	4,130	7,360	550	1,800	7,000	1,100	600	1,120	23,000	5,710	1,000	1,760	4,900	1,000	200	3,000	17,570	1,000	7,000	2,050	70,150
Forest land not grazed	Do.	160	1,500	3,850	5,840	11,350	4,300	5,000	5,800	1,220	500	131,810	22,460	23,630	3,200	36,000	18,000	7,500	300	5,140	93,770	1,500	5,000	2,800	285,510
Cropland	Do.	2,200	6,600	27,300	14,000	50,100	22,520	24,060	21,870	8,810	8,280	15,170	15,330	12,010	5,160	13,000	3,670	5,820	3,930	34,910	78,500	31,740	40,400	13,540	330,320
Rangeland	Do.	180	720	...	3,260	4,160	1,050	1,850	4,000	1,050	650	1,340	3,000	1,640	420	1,330	410	770	420	3,550	8,540	...	600	950	27,190
Other	Do.	580	770	8,350	1,000	10,700	1,260	2,600	2,010	900	560	1,220	2,000	1,220	180	420	8,100	1,100	130	3,600	14,750	2,000	11,130	600	49,730
Total watershed area	Do.	3,320	10,590	41,530	28,230	83,670	29,680	35,310	40,680	13,080	10,590	150,660	65,790	44,210	9,960	52,510	35,080	16,190	4,980	50,200	213,130	36,240	64,130	19,940	762,900
Cropland use:																									
Dryland	Acres	1,400	5,750	21,300	10,350	38,800	18,520	20,560	21,070	8,460	7,780	12,600	13,480	10,160	4,270	10,890	3,370	5,210	3,730	31,410	69,040	26,740	28,500	12,940	278,490
Irrigated	Do.	800	850	6,000	3,650	11,300	4,000	3,500	800	350	500	2,570	1,850	1,850	890	2,110	300	610	200	3,500	9,460	5,000	11,900	600	51,830
Total	Do.	2,200	6,600	27,300	14,000	50,100	22,520	24,060	21,870	8,810	8,280	15,170	15,330	12,010	5,160	13,000	3,670	5,820	3,930	34,910	78,500	31,740	40,400	13,540	330,320
Potential cropland	Acres	150	850	1,700	1,000	3,700	1,800	1,530	3,100	800	650	500	4,300	1,700	1,000	8,000	1,000	1,000	200	2,000	14,900	1,000	1,000	950	34,230
IRRIGATION:																									
Water source:																									
Direct stream diversion	Acres	...	...	...	...	...	...	...	...	...	...	...	...	...	...	990	...	...	...	...	990	...	6,300	20	7,310
Pumped from streams	Do.	350	375	2,000	1,750	4,475	400	500	500	100	250	1,500	1,000	1,080	100	220	150	310	100	500	2,460	2,000	3,000	80	16,265
Pumped from wells	Do.	450	475	4,000	1,800	6,725	3,600	2,800	200	150	150	745	550	500	590	600	100	150	...	2,500	4,440	2,500	1,800	350	24,010
Other	Do.	...	...	...	100	100	...	200	100	100	100	325	300	270	200	300	50	150	100	500	1,570	500	800	150	4,245
Total	Do.	800	850	6,000	3,650	11,300	4,000	3,500	800	350	500	2,570	1,850	1,850	890	2,110	300	610	200	3,500	9,460	5,000	11,900	600	51,830
Water shortage	Acres	...	...	...	...	...	100	...	100	50	250	600	400	400	100	600	20	30	20	100	1,270	300	400	200	3,670
Method of application:																									
Sprinkling	Acres	800	850	6,000	3,650	11,300	4,000	3,500	800	350	500	2,570	1,850	1,850	890	2,110	300	610	200	3,500	9,460	5,000	11,400	580	51,310
Flooding	Do.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	500	20	520
Total	Do.	800	850	6,000	3,650	11,300	4,000	3,500	800	350	500	2,570	1,850	1,850	890	2,110	300	610	200	3,500	9,460	5,000	11,900	600	51,830
Potentially irrigable land:																									
Water source:																									
Natural flows and ground water	Acres	1,100	4,650	20,000	8,000	33,800	3,000	1,250	4,850	1,200	2,000	2,500	1,200	800	...	...	...	...	600	...	1,400	2,000	20,000	500	73,700
Other	Do.	...	1,350	3,000	3,000	7,300	16,000	18,750	15,150	7,000	4,000	10,000	16,300	9,900	5,200	18,000	4,000	3,500	2,400	30,000	73,000	18,000	9,000	12,800	207,300
Total	Do.	1,100	6,000	23,000	11,000	41,100	19,000	20,000	20,000	8,200	6,000	12,500	17,500	10,700	5,200	18,000	4,000	3,500	3,000	30,000	74,400	20,000	29,000	13,300	281,000
STORAGE:																									
Existing:																									
Ponds	Number	...	...	...	9	9	...	3	21	...	...	...	...	12	2	41	20	10	5	...	90	4	20	8	155
Reservoirs	Do.	...	...	...	1	1	...	...	8	...	...	...	...	1	2	9	3	4	2	...	21	1	1	...	32
Possible reservoir sites studied	Number	...	...	...	...	...	...	...	3	2	...	1	3	3	1	1	3	4	2	3	17	1	6	...	33
DRAINAGE:																									
Arable land needing drainage	Acres	400	2,500	7,000	4,000	13,900	9,000	9,000	7,000	3,000	2,000	1,500	8,000	4,000	5,000	5,000	1,000	800	800	11,000	27,600	6,000	10,000	3,000	100,000
Needs:																									
Improved surface drainage	Acres	200	2,000	6,800	4,000	13,000	7,000	7,000	...	...	...	...	1,100	4,000	...	3,000	1,000	800	800	...	9,600	2,000	5,000	1,000	45,700
Subsurface drainage:																									
Open drains	Do.	...	1,400	3,000	2,000	6,400	2,000	2,000	1,000	700	500	...	...	1,000	...	2,000	100	100	500	...	3,700	1,000	4,000	1,000	22,300
Closed drains	Do.	400	1,100	4,000	2,000	7,500	7,000	7,000	6,000	2,300	1,500	1,500	8,000	3,000	5,000	3,000	900	700	300	11,000	23,900	5,000	6,000	2,000	77,700
Flooded areas	Acres	150	200	2,000	4,500	6,850	300	600	1,750	20	100	2,000	2,750	1,050	...	500	...	80	...	250	1,880	3,000	8,000	1,000	28,250

Source: Based on a survey by the U. S. Department of Agriculture Field Party. Estimates provided by local personnel of the Soil Conservation Service and County Extension Service.

Table 17D.--Summary of reconnaissance data on tributary streams studied, Middle Willamette River Basin, Oreg., 1962

Item	Unit	Subbasin 5 Santiam	Subbasin 6 Coast Range	Subbasin 7 Pudding	Total
Number of farms	Number	3,160	4,285	5,170	12,615
LAND USE:					
Forest land grazed	Acres	90,510	124,790	70,150	285,450
Forest land not grazed	do.	1,028,050	522,230	285,510	1,835,790
Cropland	do.	321,110	381,920	330,320	1,033,350
Rangeland	do.	52,540	54,270	27,190	134,000
Other	do.	69,390	64,990	49,730	184,110
Total watershed area	do.	1,561,600	1,148,200	762,900	3,472,700
Cropland use:					
Dryland	Acres	276,910	349,440	278,490	904,840
Irrigated	do.	44,200	32,480	51,830	128,510
Total	do.	321,110	381,920	330,320	1,033,350
Potential cropland	Acres	54,300	21,600	34,230	110,130
IRRIGATION:					
Water source:					
Direct stream diversion	Acres	3,850	120	7,310	11,280
Pumped from streams	do.	17,370	19,275	16,265	52,910
Pumped from wells	do.	22,050	12,110	24,010	58,170
Other	do.	930	975	4,245	6,150
Total	do.	44,200	32,480	51,830	128,510
Water shortage	Acres	800	1,500	3,670	5,970
Method of application:					
Sprinkling	Acres	42,420	32,250	51,310	125,980
Flooding	do.	1,780	230	520	2,530
Total	do.	44,200	32,480	51,830	128,510
Potentially irrigable land:					
Water source:					
Natural flows and ground water	Acres	101,800	59,700	73,700	235,200
Other	do.	196,700	256,600	207,300	660,600
Total	do.	298,500	316,300	281,000	895,800
STORAGE:					
Existing:					
Ponds	Number	125	187	155	467
Reservoirs	do.	16	57	32	105
Possible reservoir sites	Number	67	250	93	410
DRAINAGE:					
Arable land needing drainage	Acres	183,500	123,000	100,000	406,500
Needs:					
Improved surface drainage	Acres	64,250	24,700	45,700	134,650
Subsurface drainage:					
Open drains	do.	20,400	16,000	22,300	58,700
Closed drains	do.	112,100	107,000	77,700	296,800
Flooded areas	Acres	50,520	...	28,250	78,770

Source: Based on a survey by the U. S. Department of Agriculture Field Party. Estimates provided by local personnel of the Soil Conservation Service and County Extension Service.

Table 18.--Agricultural land use, Middle Willamette River Basin, Oreg., 1961

Agricultural land use	Subbasin 5 Santiam	Subbasin 6 Coast Range	Subbasin 7 Pudding	Total
	Acres	Acres	Acres	Acres
Grazing land:				
Forest land	90,500	124,800	70,100	285,400
Rangeland	52,500	54,300	27,200	134,000
Total grazing land	143,000	179,100	97,300	419,400
Cropland:				
Small grain	52,960	137,350	89,330	279,640
Grass seed	130,930	37,040	44,800	212,770
Pasture	40,540	54,380	50,460	145,380
Hay and silage	26,620	37,480	38,960	103,060
All fruits, nuts, and vines	6,910	26,530	20,560	54,000
Vegetable crops	11,550	8,570	12,690	32,810
Field corn	4,970	3,210	12,620	20,800
Clover seed	2,080	10,480	7,980	20,540
Mint	5,730	1,140	3,200	10,070
Hops	30	580	3,460	4,070
Other crops	4,850	28,120	5,180	38,150
Cropland harvested or pastured	287,170	344,880	289,240	921,290
Cropland not harvested or pastured	33,940	37,040	41,080	112,060
Total cropland	321,110	381,920	330,320	1,033,350

Source: Compiled from the USDA Field Party survey and the U. S. Census of Agriculture.

provide the major feed base for the dairy and livestock farms. Grasses, oats and vetch, clover, and alfalfa are the chief forage crops harvested for hay and silage. Because of drying problems, early spring growth is often stored as silage, and subsequent growth is stored as hay. Hay land is also often used for pasture.

Fruits, nuts, and vine crops occupy about 5 percent of the cropland. This includes all tree fruits, nuts, small berries, and vineyards. The percentages of cropland in other crops includes vegetables, 3 percent; mint, 1 percent; hops, less than 1 percent; and all other crops, 4 percent. Figure 15 shows one of the more intensive uses of cropland.

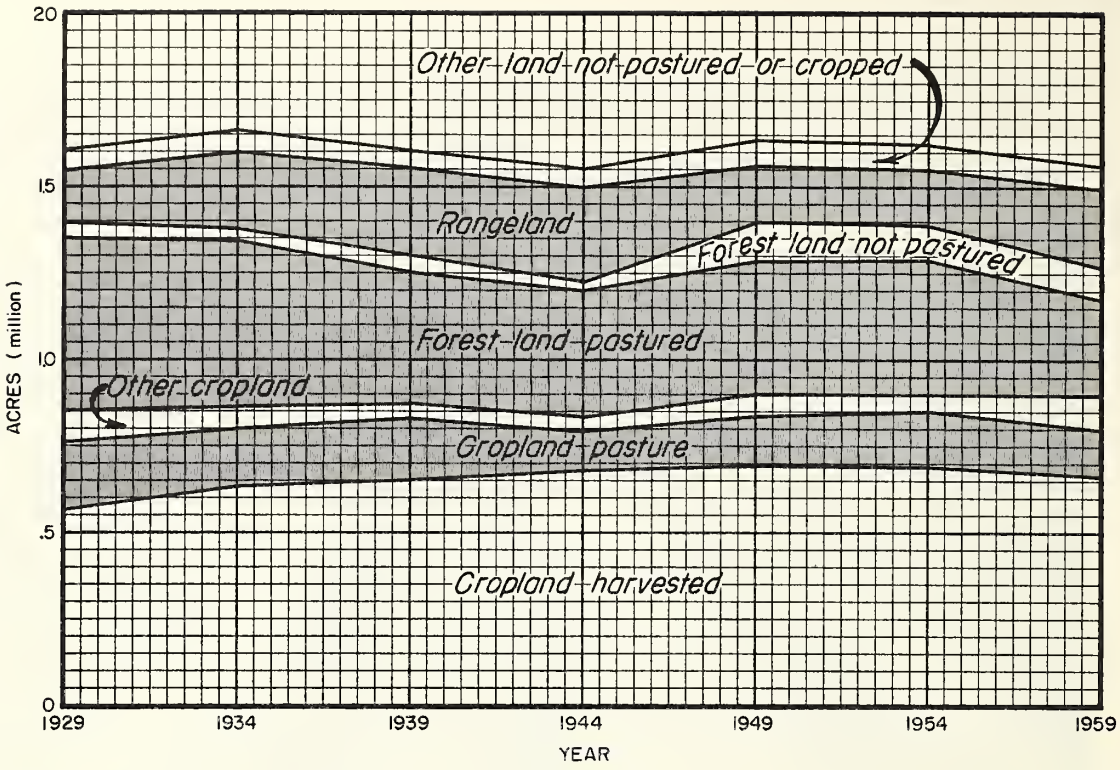
Trends in farmland use for the five principal counties in the basin are shown in figure 16. Total acreage in farms has decreased by about 80,000 acres since 1929. Cropland acreage, however, has increased by about 46,000 acres despite the shift of a considerable amount of cropland to other uses such as subdivisions and roads. Clearing and

Figure 15.--Pole beans, one of the most important vegetable crops in the basin. SCS photo.
7-521-5

development of new cropland has exceeded the acquisition of cropland for other purposes. Grazed forest land has decreased significantly while non-grazed forest land has increased. This reflects an increase in the value of wood products, which has made farm forests a more competitive crop. Cropland pasture has decreased while rangeland has remained fairly stable.

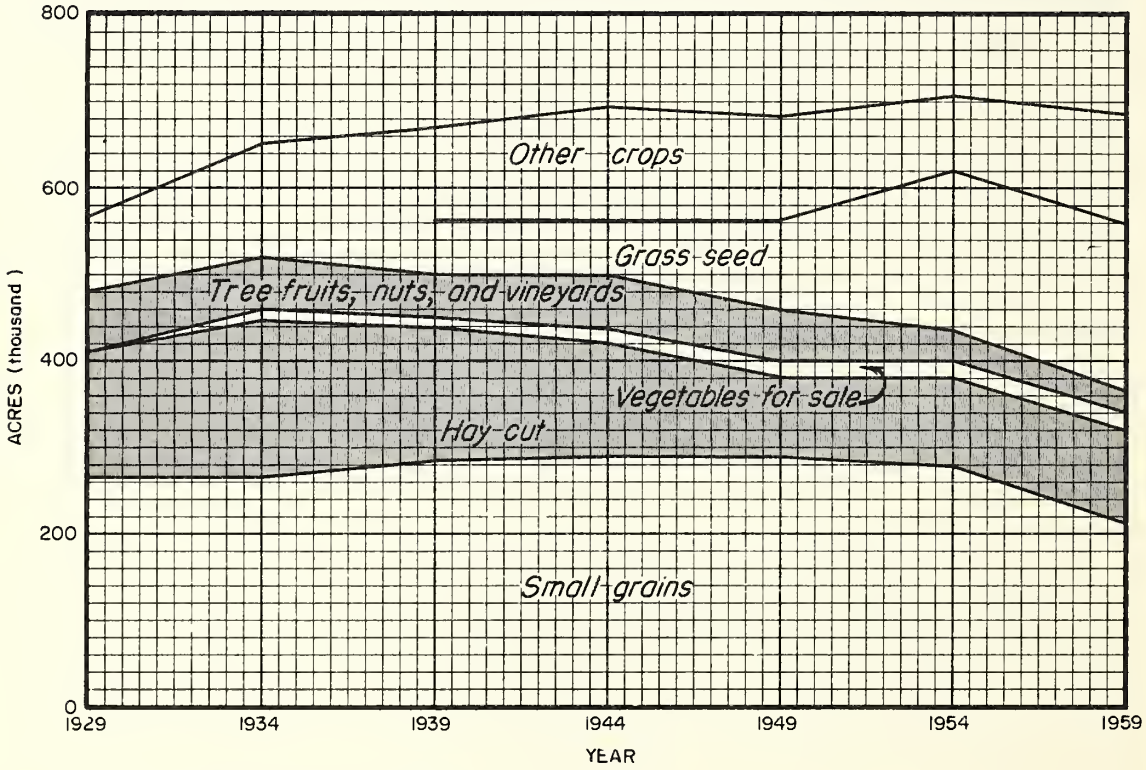
Trends in harvested cropland use are shown in figure 17. Acreage in small grains increased from 1929 to 1944 but has decreased sharply since 1954. The acreage from which hay was harvested has been decreasing since 1934. The acreage in tree fruits, nuts, and vineyards has also been decreasing.

The acreage in vegetable crops has increased consistently since 1929. The acreage in grass seed increased sharply from 1939 to 1954. Although other crops have remained at about 80,000 acres since 1939, several changes have occurred. Flax, once a major crop in the basin, has virtually disappeared. The acreage in hops has also decreased. These crops have been replaced by other specialty crops such as vegetable seeds and peppermint.



Source: U. S. Census of Agriculture data for Benton, Linn, Marion, Polk, and Yamhill Counties

Figure 16. Farmland use for five principal counties in the Middle Willamette River Basin, Oregon, 1929 – 1959.



Source: U. S. Census of Agriculture data for Benton, Linn, Marion, Polk, and Yamhill Counties.

Figure 17. Harvested cropland use for five principal counties in the Middle Willamette River Basin, Oregon, 1929–1959.

CHARACTERISTICS OF AGRICULTURE

Number and Size of Farms

There are 12,615 farms in the basin. Census data indicate that approximately 53 percent are commercial farms; 34 percent are part-time farms; and 13 percent are part-retirement farms. 1/ There are 5,170 farms in the Pudding Subbasin, 4,285 farms in the Coast Range Subbasin, and 3,160 farms in the Santiam Subbasin.

Farms in the basin average about 144 acres with 82 acres of cropland. However, most farms are smaller than average. Table 19 shows the distribution of farms by size group for the five principal counties in the basin. Note that almost half the farms are less than 50 acres in size and three-fourths are less than 139 acres. Most of these farms are either part-time operations or else intensive vegetable, fruit, or specialty farms. Most of the beef, sheep, grain, and grass farms contain over 140 acres; although comparatively few in number, they increase the numerical average size for all farms. Also, some farmers own sizable tracts of commercial forest land which are included in the census figures as farmland.

Table 19.--Percentage distribution of farms by size, five principal counties in the Middle Willamette River Basin, Oreg., 1959

Size of farm	Percentage distribution of farms
	Percent
Under 50 acres	45
50 to 139 acres	25
140 to 259 acres	14
260 or more acres	16
Total	100

Source: U. S. Census of Agriculture data for Benton, Linn, Marion, Polk, and Yamhill Counties.

Agriculture in the basin, as in the Nation, is undergoing changes. Adoption of improved technology has resulted in greater production per unit of input and has been influential in the trend toward specialization. Greater efficiencies attained through technology have been a factor in the enlargement of farm operation units. Figure 18 shows a

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1/ Commercial farms include all farms with a value of sales amounting to $2,500 or more. Part-time farms include farms with a value of sales of farm products of $50 to $2,499 and operators under 65 years of age who either worked off the farm 100 days or more or had other income from nonfarm sources that was greater than the total value of farm products sold. Farms with a value of sales of farm products of $50 to $2,499 were classified as part-retirement if the farm operator was 65 years old or over.

Figure 18.--Mechanical stringer in a bean field.
SCS photo. 7-786-6

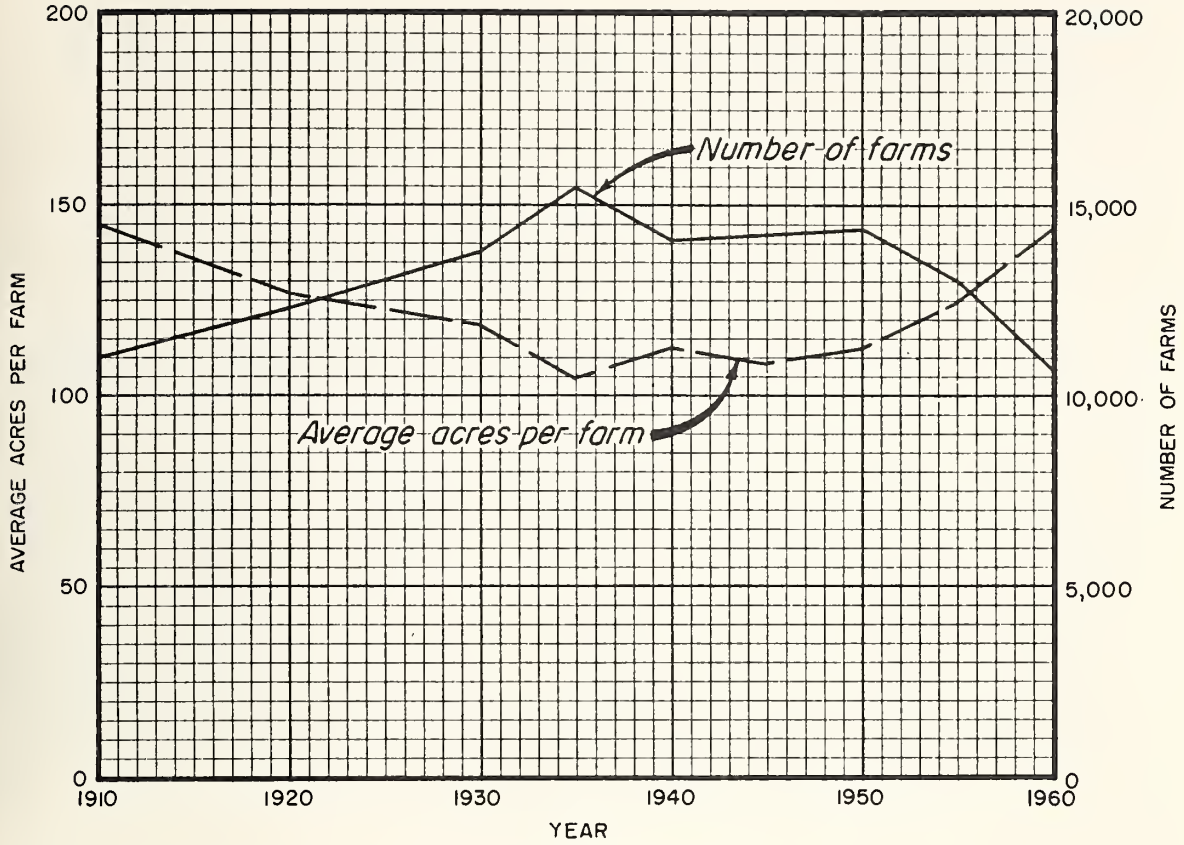
labor-saving device which permits the expansion of bean acreage.

Figure 19 shows the trend in number of farms and average farm size in the basin. Since 1935, farm numbers have decreased while average farm size has increased. At the same time, the average value of land and buildings has increased from $6,760 to $36,790 per farm and from $63 to $255 per acre.

Contrary to the trend toward fewer farms is the trend toward greater reliance on off-farm work by the farmers who remained on their farms. The percentage of farmers working 100 days or more off their farms increased from 26 percent in 1940 to 43 percent in 1959. The fact that farm families are engaged in other activities besides farming is further reflected by 1959 census data which show that 50 percent of the farm families had other income which exceeded the value of farm products sold.

Tenure

Most of the farmers in the basin own their farms. Census data show that in 1959, 74 percent of the farmers were full owners; 19 percent were part owners; and 7 percent were tenants.



Source: Census of Agriculture data for Benton, Linn, Marion, Polk, and Yamhill Counties.

Figure 19. Number of farms and average acreage per farm for five principal counties in the Middle Willamette River Basin, Oregon, 1910–1960.

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Livestock and Poultry

The estimated numbers of livestock and poultry in the Middle Willamette River Basin are shown in table 20. Milk cows, other cattle, hogs, pigs, horses, broilers, and chickens are most numerous in the Pudding Subbasin. Sheep, lambs, goats, and kids are most numerous in the Coast Range Subbasin, where rangeland and grazed forest land acreage is highest. Turkeys are produced predominantly in the Pudding and Coast Range Subbasins. Other poultry such as ducks and geese are also raised in the basin.

Changes in livestock numbers since 1910 are shown in figure 20. Number of milk cows has decreased significantly since 1945, consistent with a national trend. The decline in consumption of dairy products per capita and the rapid rise in milk production per cow are two of the most important factors contributing to this decrease. Adjustments to these conditions have been achieved through a reduction of milk cows and a reduction of dairy farms. In 1944, there were 55,080 milk cows

and 2,240 dairy farms in the five principal counties in the basin. By 1959, milk cow numbers had dropped to 32,079, and the number of dairy farms had decreased to 774.

Table 20.--Livestock numbers, Middle Willamette River Basin, Oreg., 1959

Type of livestock	Subbasin 5 Santiam	Subbasin 6 Coast Range	Subbasin 7 Pudding	Total
	Number	Number	Number	Number
Milk cows	10,300	12,800	13,900	37,000
All other cattle	26,200	31,800	40,600	98,600
Sheep and lambs	62,300	86,500	66,200	215,000
Goats and kids	3,600	4,800	3,000	11,400
Hogs and pigs	13,700	14,000	41,600	69,300
Horses and mules	1,600	1,800	2,700	6,100
Turkeys raised	74,000	470,000	451,000	995,000
Broilers raised	736,000	968,000	2,232,000	3,936,000
Chickens on hand	178,000	294,000	545,000	1,017,000

Source: Compiled from data from the USDA Field Party survey and the U. S. Census of Agriculture.

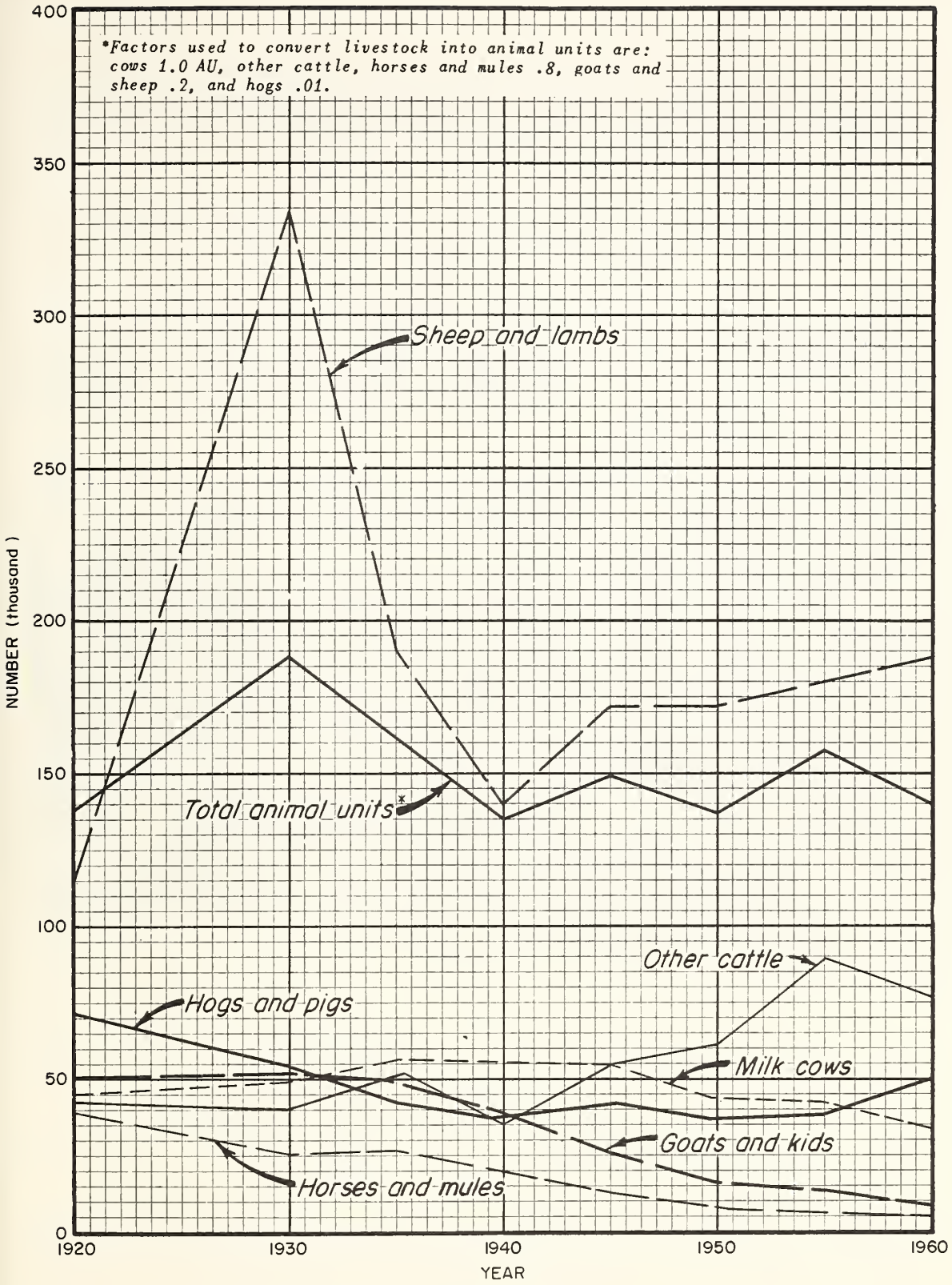
Sheep and lamb numbers trebled from 1920 to 1930 and then dropped precipitously from 1930 to 1940. Since 1940, there has been a gradual increase. Number of cattle other than milk cows remained fairly stable from 1920 to 1940 but has increased in most years since 1940. Goats, used in the past for removing brush, have become less numerous in recent years. Horses, no longer needed for power, are also decreasing in number. Number of hogs decreased in the 1920's and 1930's, remained fairly stable until 1955, and have been increasing since then.

The net effect of changes in livestock numbers since 1920 is shown in terms of animal units (fig. 20). Animal units have remained at about the 150,000 level since 1920.

Agricultural Income

Agriculture contributes to the economy of the basin in two ways--it provides income not only to farmers, but also to the workers employed for harvesting and processing the agricultural products. Income from the sale of crops and livestock in the basin in 1959 is estimated at about $98.5 million (table 21). In addition, over $2 million was derived from the sale of forest products from land operated by farmers.

Income from the sale of crops accounted for 63 percent of the agricultural income and livestock accounted for 37 percent. Field crops such as small grains, grass seed, hops, peppermint, and hay were the largest single source of income and accounted for 35 percent of the agricultural income. Fruits and nuts were second in importance account-



Source: U. S. Census of Agriculture data for Benton, Linn, Marion, Polk, and Yamhill Counties.

Figure 20. Livestock numbers for five principal counties in the Middle Willamette River Basin, Oregon, 1920–1960.

ing for 16 percent of the income followed by poultry products, 12 percent; dairy products, 11 percent; vegetables, 9 percent; cattle and calves, 7 percent; other livestock and livestock products, 7 percent; and horticultural specialties, 3 percent.

Table 21.--Estimated income from crops and livestock, Middle Willamette River Basin, Oreg., 1959

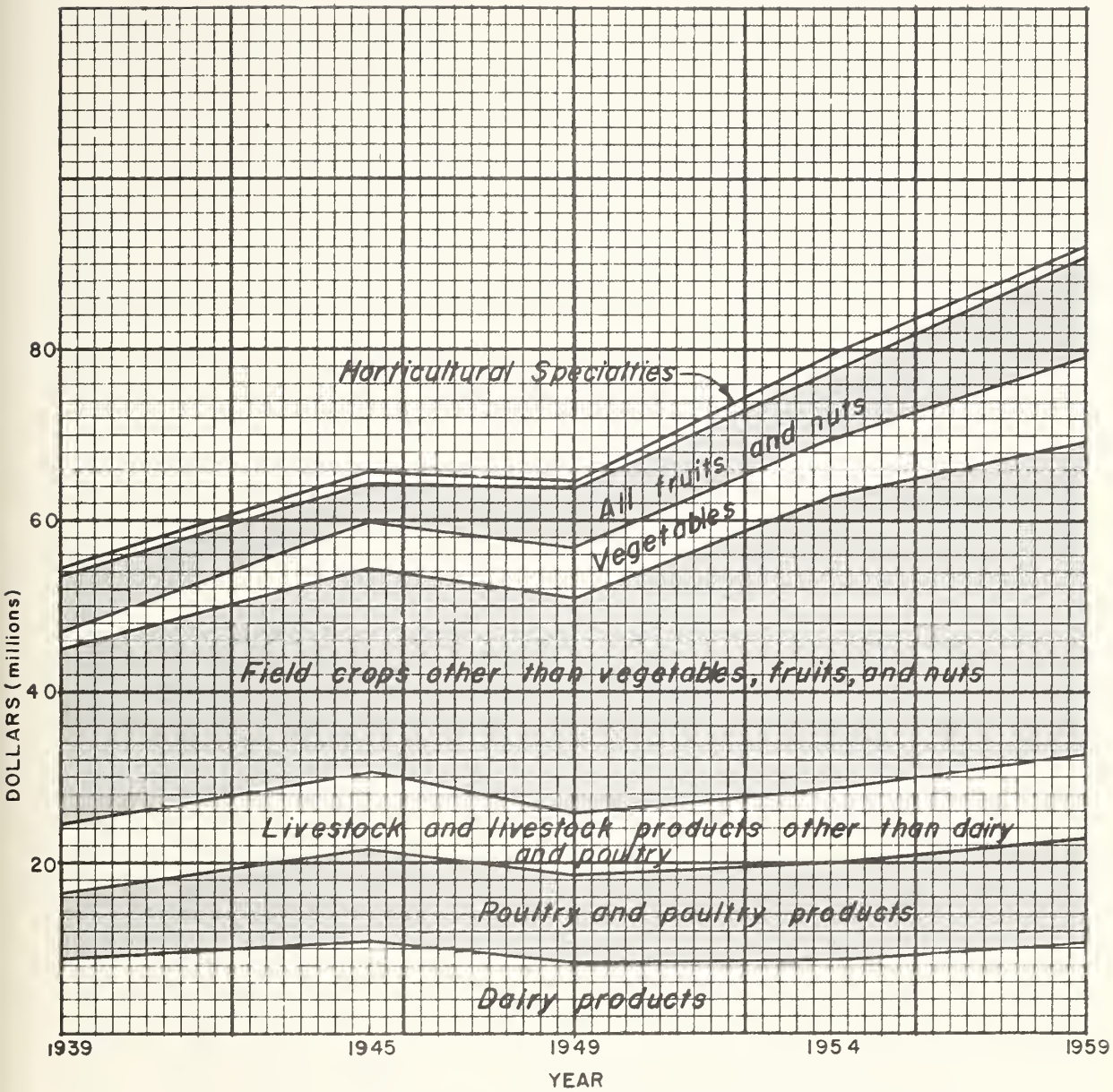
Commodity sold	Subbasin 5 Santiam	Subbasin 6 Coast Range	Subbasin 7 Pudding	Total
	Thousand dollars	Thousand dollars	Thousand dollars	Thousand dollars
Livestock:				
Dairy products	3,040	4,400	3,620	11,060
Poultry products	1,540	4,160	6,420	12,120
Cattle and calves	2,070	2,050	2,680	6,800
Other livestock products	1,620	2,020	2,930	6,570
Total livestock	8,270	12,630	15,650	36,550
Crops:				
Field crops 1/	13,050	10,360	11,010	34,420
All fruits and nuts	1,290	5,770	8,240	15,300
Vegetables	3,060	2,640	3,280	8,980
Horticultural specialties	310	540	2,400	3,250
Total crops	17,710	19,310	24,930	61,950
Total crops and livestock	25,980	31,940	40,580	98,500

1/ Other than vegetables, fruits, and nuts.

About 41 percent of the agricultural income in the basin was received by farmers in the Pudding Subbasin, 33 percent by farmers in the Coast Range Subbasin, and 26 percent by farmers in the Santiam Subbasin.

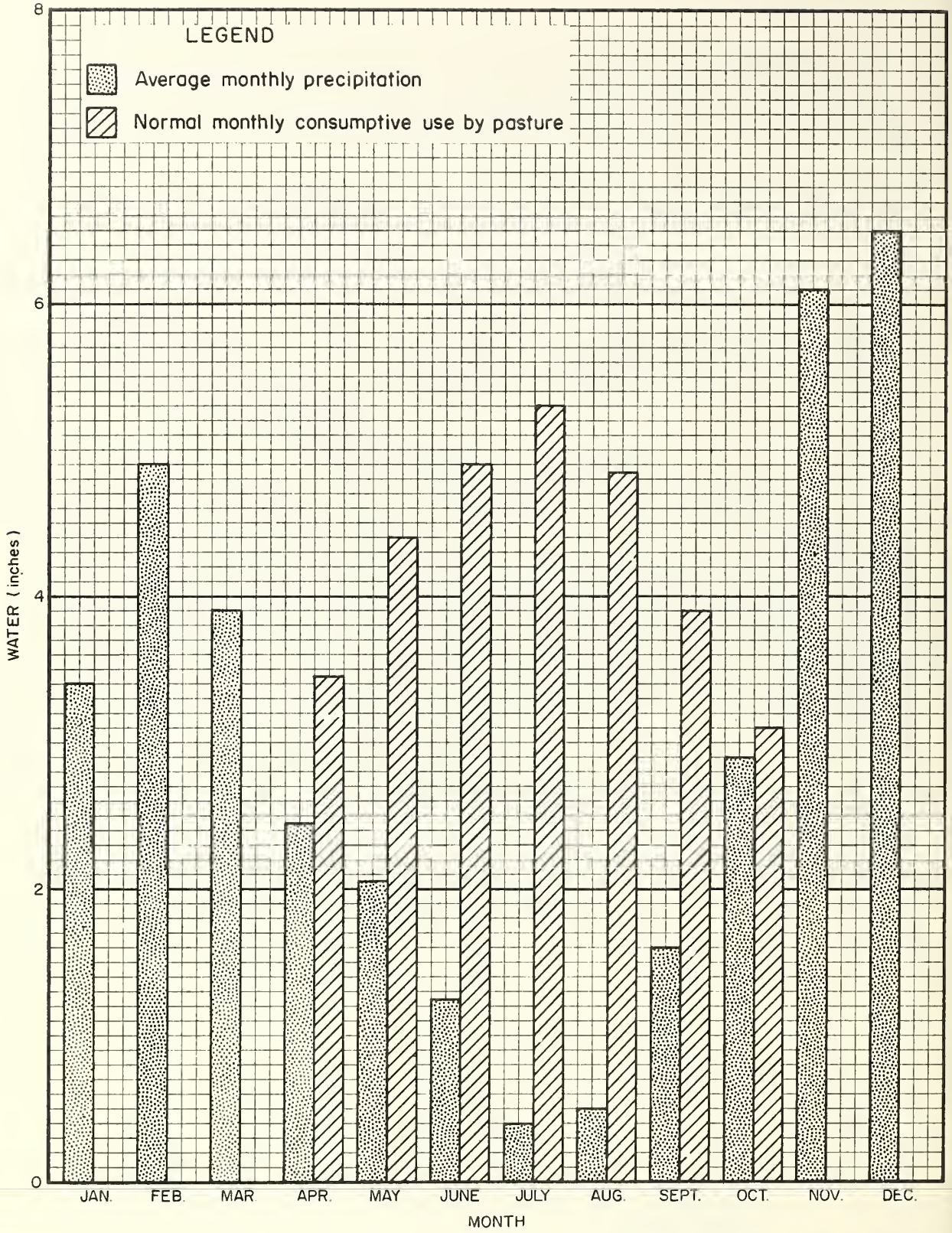
The total farm income in the five counties representative of the basin has increased each census year since 1939 (fig. 21). Income from the sale of farm crops has been increasing faster than income from livestock products. The percentage of total farm income attributed to the sale of livestock and livestock products decreased from 45 percent in 1939 to 33 percent in 1959 while income attributed to the sale of crops increased from 54 percent in 1939 to 65 percent in 1959. At the same time, income from farm forest products sold increased from 1 percent of the total farm income in 1939 to 2 percent in 1959.

Part of the increase in value of farm products is a reflection of the decrease in purchasing power of the dollar. In order to show the real increase in production of crops and livestock, the value of pro-



Source: U. S. Census of Agriculture data for Benton, Linn, Marion, Polk, and Yamhill Counties and price indexes from Statistical Reporting Service, U. S. Department of Agriculture.

Figure 22. Value of products sold in 1949 dollars for five principal counties in the Middle Willamette River Basin, Oregon, 1939–1959



Source: Irrigation Requirements, F. M. Tileston and J. M. Wolfe Stat. Bul. 500, Agr. Exper. Stat., Oregon State College, Corvallis, Oregon.

Figure 23. Average monthly precipitation and consumptive use of water by pasture, Salem, Oregon.

rooted crops such as filberts, prunes, and walnuts can live through the dry months of July and August without irrigation.

Other crops such as vegetables, peppermint, and pasture require irrigation to sustain maximum growth throughout the summer months. The length of the irrigation season varies considerably depending on crops grown and production practices. H. H. Stippler found in a study of irrigation practices in the Willamette Valley in 1950 that the average length of irrigation seasons varied from 5 days for grain crops to 102 days for pastures (table 22). The average number of irrigations varied from a low of 1.1 for small grains to a high of 9.4 for pole beans. Pastures were irrigated about 7 times.

Table 22.--Approximate length of irrigation season, by major groups of crops, 111 survey farms, Willamette Valley, Oreg., 1950

Crop irrigated	First irrigation: Average date	First irrigation: Range in dates	Last irrigation: Average date	Last irrigation: Range in dates	Average length of season 1/
					Days
All crops..	June 10	April 16 -Aug. 16	Aug. 31	July 10 -Oct. 15	82
Grain.....	June 20	May 1 -July 15	June 25	June 1 -July 15	5
Forage.....	July 1	May 10 -Aug. 15	Aug. 15	July 10 -Sept. 30	46
Pastures...	June 1	April 20 -Sept. 1	Sept. 10	July 10 -Oct. 15	102
Row crops..	June 15	May 1 -Aug. 10	Aug. 15	June 15 -Sept. 25	61

1/ Number of days between average dates of first and last irrigation.

Source: Sprinkler Irrigation in the Pacific Northwest, by Henry H. Stippler, USDA, ARS, Agr. Bul. No. 166, Nov., 1956.

Irrigated Acreage

About 128,510 acres were irrigated in the Middle Willamette River Basin in 1961. About 51,830 acres, or 40 percent of the total, were in the Pudding Subbasin; 44,200 acres, or 35 percent, were in the Santiam Subbasin; and 32,480 acres, or 25 percent, were in the Coast Range Subbasin (table 23).

The largest acreage of irrigated land was used for pasture and the second largest for vegetable crops. Beans and sweet corn were the major vegetable crops irrigated. Note that 94 percent of the land in

vegetable crops was irrigated. Vegetables must be irrigated not only to produce optimum yields but also to insure quality products. Processors will no longer award contracts to producers who grow these crops without irrigation. All of the hops and 98 percent of the mint was irrigated while only 1 percent of the acreage in small grains was irrigated.

Table 23.--Irrigated land use, Middle Willamette River Basin, Oreg., 1961

Irrigated crop	Subbasin 5 Santiam	Subbasin 6 Coast Range	Subbasin 7 Pudding	Total	Percentage of crop irrigated
	Acres	Acres	Acres	Acres	Percent
Pasture	10,190	9,650	13,460	33,300	23
Vegetable crops	11,030	8,220	11,730	30,980	94
Hay and silage	5,660	5,680	5,570	16,910	16
All fruits, nuts, and vineyards	4,790	3,120	7,480	15,390	28
Mint	5,730	1,140	2,980	9,850	98
Field corn	3,150	1,460	3,680	8,290	40
Small grain	1,150	1,070	1,890	4,110	1
Hops	30	580	3,460	4,070	100
Other crops	2,470	1,560	1,580	5,610	15
Total	44,200	32,480	51,830	128,510	12

Source: Compiled from data from the USDA Field Party survey and the Census of Agriculture.

Source of Water and Method of Application

With some exceptions, irrigation is practiced on the better soils along or near the main stem of the Willamette River and its tributaries. Water is obtained from streams or shallow wells. Streamflows are the source of water for 50 percent of the irrigated acreage; ground water is the source for 45 percent; and reservoir and pond storage, which may include both ground and surface water, is the source for 5 percent (table 24). Figure 24 shows irrigation from a small reservoir in the Pudding Subbasin.

Ground water is the chief source of irrigation water in the Santiam and Pudding Subbasins while streams are the major source in the Coast Range Subbasin.

Although surface water is the source of over half of the irrigation water in the basin, only 9 percent of the land is irrigated by gravity-diverted water. The rest is pumped from streams, wells, or reservoirs. Most of the water diverted by gravity is also subsequently pumped and applied by sprinkler irrigation. Only 2 percent of the land in the basin was irrigated by flooding in 1961.

Table 24.--Source of irrigation water and method of application, Middle Willamette River Basin, Oreg., 1961

Item	Subbasin 5 Santiam	Subbasin 6 Coast Range	Subbasin 7 Pudding	Total
	Acres	Acres	Acres	Acres
Source of water:				
Direct stream diversion	3,850	120	7,310	11,280
Pumped from streams	17,370	19,275	16,265	52,910
Pumped from wells	22,050	12,110	24,010	58,170
Reservoir and pond storage	930	975	4,245	6,150
Total	44,200	32,480	51,830	128,510
Method of application:				
Sprinkling	42,420	32,250	51,310	125,980
Flooding	1,780	230	520	2,530
Total	44,200	32,480	51,830	128,510

Source: USDA Field Party survey data (table 17).

Figure 24.--Irrigation of pole beans with water from a small reservoir in the Pudding Subbasin. SCS photo. SCS 1

Sprinkler irrigation is used in the basin for the following reasons:

1. Most irrigation development has been near streams. Many soils in these areas are not suitable for gravity irrigation because of coarse texture or because gravity methods would aggravate existing drainage problems.

2. Most irrigation water is obtained on an individual farm basis by pumping from streams or wells. Gravity diversion from streams for the small acreages is often impractical for individual farms.

3. Some areas of rolling topography are not suitable for gravity methods.

4. Because of the historical development of irrigation by sprinkler methods, flood irrigation has not been considered in some cases where it might be more practicable and less costly.

Size of Irrigated Acreage

In 1959, the average acreage irrigated by farmers reporting irrigation was 35 acres. However, about 56 percent of the farmers reporting irrigation had 19 acres or less under irrigation, and 67 percent irrigated less than 29 acres (table 25).

Table 25.--Distribution of farms reporting irrigation by acreage irrigated, five principal counties in the Middle Willamette River Basin, Oreg., 1959

Irrigated acreage distribution	Number of farms reporting irrigation	Percentage distribution of farms
	Number	Percent
1 to 9 acres	1,040	36
10 to 19 acres	577	20
20 to 29 acres	312	11
30 to 49 acres	431	15
50 to 99 acres	320	11
100 to 199 acres	149	5
200 or more acres	65	2
Total	2,894	100

Source: U. S. Census of Agriculture data for Benton, Linn, Marion, Polk, and Yamhill Counties.

Cost of Irrigation

Because most of the irrigation is accomplished by sprinkler systems, irrigation costs per acre in the Middle Willamette River Basin

are quite high. In a study of sprinkler irrigation systems in the Willamette Valley, 1/ Stippler found that irrigation costs varied considerably by type of crops irrigated (table 26).

Table 26.--Computed water use and irrigation costs per acre inch of water applied and per acre of major crops irrigated, survey farms, Willamette Valley, Oreg., 1950

Crop	Average size of field	Computed water use per acre	Irrigation costs	
			Per acre inch	Per acre
	Acres	Acre inches	Dollars	Dollars
Barley	16.7	2.2	2.35	4.53
Alfalfa	6.1	12.2	1.47	15.27
Red clover	19.6	7.0	1.89	8.98
Pasture	14.7	25.2	1.43	28.71
Pole beans	9.3	13.8	2.97	37.76
Sweet corn	13.3	6.3	2.30	12.67
Mint	31.5	23.3	1.34	29.14
Strawberries	6.0	4.2	3.44	13.59

Source: U. S. Department of Agriculture, Agricultural Information Bulletin 166.

Stippler found that the average cost of irrigation for all farms was $25.92 per acre, or $2.02 per acre inch. Of this amount, about 31 percent was labor cost. The average investment per sprinkler system was $2,900, or $116 per acre. The average system irrigated 34 acres.

Trends in Irrigation

Irrigation has been practiced in the basin on a limited scale for many years, but it was not until the late 1940's that irrigation development began to expand rapidly. From 1944 to 1959 irrigated acreage in the five principal counties in the basin increased from 16,258 acres to 101,037 acres (table 27). During this same period the percentage of farms reporting irrigation increased from about 6 percent to 27 percent.

Future Irrigation

Future irrigation development in the basin will be governed by several physical and economic factors. The two most important physical factors are the availability of suitable land and the availability of suitable irrigation water for this land. There are about 1,613,800 acres in land capability classes I through IV in the basin (table 28). On the basis of soils alone, this is the land that is generally sus-

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1/ Sprinkler Irrigation in the Pacific Northwest, by Henry H. Stippler, U. S. Department of Agriculture, Agricultural Information Bulletin 166, November 1956.

Table 27.--Irrigated acreage and farms reporting irrigation for five principal counties in the Middle Willamette River Basin, Oreg., 1929-59

Year	Acres irrigated	Average acres irrigated per farm	Farms reporting irrigation	Percentage of farms reporting irrigation
	Acres	Acres	Number	Percent
1929	...	...	227	1.6
1939	16,258	20	819	5.6
1944	17,801	26	687	4.8
1949	50,483	28	1,786	12.5
1954	91,652	32	2,863	22.1
1959	101,037	35	2,894	27.1

Source: U. S. Census of Agriculture data for Benton, Linn, Marion, Polk, and Yamhill Counties.

ceptible to irrigation. However, only about 1,033,350 acres of this land are presently being used as cropland or cropland pasture. The rest is in timber, brush, swamp, and other noncropland uses.

Estimates obtained from the USDA reconnaissance survey of the basin indicate that there are about 110,100 acres that could easily be converted to cropland use in the future (table 28). Over half of this is in the Santiam Subbasin. It was also estimated that an additional 895,800 acres, or almost 80 percent of the existing and potential cropland, could be irrigated. Data obtained in the survey indicates that present streamflows and ground water would be adequate to irrigate about 26 percent of the potentially irrigable land. Storage facilities would be needed to irrigate a large acreage.

Table 28.--Estimated present and potential cropland and irrigated land, Middle Willamette River Basin, Oreg., 1961

Item	Subbasin 5 Santiam	Subbasin 6 Coast Range	Subbasin 7 Pudding	Total
	Acres	Acres	Acres	Acres
Land capability classes I-IV	684,000	564,300	365,500	1,613,800
Total cropland	321,110	381,920	330,320	1,033,350
Potential cropland	54,300	21,600	34,200	110,100
Irrigated land	44,200	32,480	51,830	128,510
Potentially irrigable land	298,500	316,300	281,000	895,800

Source: USDA, Soil Conservation Service, and USDA Field Party survey data (table 17).

Two problems of a physical nature that complicate irrigation development in the basin are drainage and flooding. These problems are covered in detail in the latter sections of this report, but it should be noted at this point that about 130,410 acres are flooded annually in the basin, and about 406,500 acres of arable land have drainage problems. Much of this is potentially irrigable land.

Resources for additional irrigation development exist in the basin. However, the degree to which this development occurs will depend on several social and economic factors.

One of the social factors is the large number of part-time farmers; another is the reluctance of farmers to change their present farming systems. However, if the economic incentive for irrigation is strong enough, most social barriers will gradually dissolve.

In order for irrigation to be economically feasible, irrigation water, like any other input used in producing agricultural products, must either add to the stability of the farm enterprise or result in a higher net profit to the user. In the past, irrigation of vegetables and other specialty crops has proven to be profitable. However, most of these crops are sold on a contract basis, and expansion of irrigated acreage will be controlled by the processors' ability to expand markets. Irrigation of pasture has also proven feasible on many dairy farms and on some beef and sheep farms. Prices for livestock products will largely govern the expansion of irrigation on pasture.

There is an apparent need for more information on the relationship between irrigation water use and response by the various crops to irrigation in the Willamette Basin. Farmers are also in need of more information on the economic returns resulting from irrigation. In the more arid regions of the state where irrigation is necessary for the production of most crops, the alternatives without irrigation are limited; but in the Willamette Valley agriculture has been sucessful without irrigation. Irrigation is not necessary to make the valley bloom. Thus, any analysis of irrigation in the Willamette Valley should consider the alternatives under dryland conditions.

A comprehensive analysis would be necessary to determine the future economic returns from irrigation. Such an analysis should consider several factors that as yet have not been appraised comprehensively. Among these factors are the following:

1. Regional and National requirements for agricultural products based on projected population growth, improved dietary standards resulting from higher levels of economic output per capita, and expected shifts in foreign demand for U. S. agricultural products.

2. Shifts in economic advantage between regions of the country for production and marketing of major classes of agricultural products.

3. Growth of nonagricultural uses of the land and water resouces, depletion of resources now used for agricultural production, retirement of inferior land from agricultural use, and the probable effects of these factors on availability of land for agricultural production.

4. Advancement in agricultural production technology resulting from research and educational and technical assistance programs, and the resulting increase in production and utilization of crops and pasture.

5. Opportunities for resource development with expected levels of agricultural output and costs.

An essential first step in analyzing the feasibility of water developments is to determine the agricultural use of the land and water resources and to identify some of the problems involved. This in turn would indicate opportunities for adjustments and improvements.

The time limit imposed for the completion of this report has restricted the scope of the material presented here to (1) the collection and analysis of historical data that could be oriented to or would be indicative of the current agricultural situation in the basin, and (2) an indication of some of the needs and opportunities for water resource development in the basin.

Willamette River Basin that is readily available to land near the river in this basin. In fact, about 1,100 acres in this basin are irrigated from the McKenzie River. There is also about 835,000 acre feet of storage space in five Corps of Engineers, U. S. Army, reservoirs reserved for irrigation in the Willamette Valley by the U. S. Bureau of Reclamation. Stored water from the above reservoirs is also available to other land that is less accessible but could in most cases be used economically only through group projects. Small watershed projects with an irrigation aspect under Public Law 566 should consider this source of water along with others to determine the most economical source. It is expected that at least another 600,000 acre feet of water will be made available for irrigation in four reservoirs that are presently either under construction or authorized for construction.

Some small tributaries with rather short or low elevation watersheds have irrigation water shortages. Many of these streams have less than one percent of their annual flow during any late summer month. For instance, 36 of the 57 tributary watersheds studied have a summer water shortage at the present time (table 29).

Table 29.--Summary of tributary watersheds with inadequate irrigation water supply, Middle Willamette River Basin, Oreg., 1962

		Subbasin			
		5	6	7	
	Unit	Santiam	Coast Range	Pudding	Total
Tributaries studied	Number	21	24	12	57
Tributaries with water shortages	Number	8	18	10	36
Presently irrigated land with water shortages	Acres	800	3,000	3,670	7,470
Tributaries with inadequate water for potential irrigable land	Number	16	23	10	49
Potentially irrigable land needing surface water development	Acres	196,700	256,600	209,300	662,600

Source: USDA Field Party survey data (tables 17A-17D).

There is an estimated 895,800 acres of potentially irrigable land in the Middle Willamette River Basin. This is nearly seven times the present irrigated acreage, or about one-half of the land in capabilities I through IV (table 28). All but one of the watersheds studied have some potentially irrigable land. If all potentially irrigable land were irrigated and growing proportionally the same crops as the presently irrigated land, approximately 3,000,000 acre feet of water would be needed for irrigation. This would amount to about one-fourth of the

total annual yield of the basin and nearly three times the yield of the basin during the irrigation season, June through September. It is obvious that considerable ground water resources and reservoir storage would have to be developed before irrigation in the basin could expand to this extent. Stored water is already available in the North Santiam and Willamette Rivers from the reservoirs built by the Corps of Engineers, U. S. Army. However, due to location of dryland and costs of delivery, alternative sources by construction of small reservoirs should be considered on some of the smaller streams.

The acreage of arable land and irrigable land is compared in table 28.

Livestock

There is usually an adequate water supply for consumptive use by livestock in this area. In those areas where there is not an adequate supply from natural streams and springs, water developed primarily for domestic and irrigation uses supplements that furnished by nature. This has usually been adequate in this basin as the farms are usually not very large.

Forestry and Related Uses

There are few water supply problems on forest land in the Middle Willamette River Basin. Natural streamflows are generally adequate to meet all consumptive requirements. Some relatively minor pollution problems have developed when timber harvesting or heavy recreational activity has taken place upstream from the source of domestic water supplies. Some major pollution and siltation problems have developed where improperly planned timber harvesting has been carried on or where forest fires have occurred in watersheds that are a source of municipal water supplies.

Water supply problems are expected to become greater as use of forest land is intensified and as the demand for water for agriculture and industry in the Willamette Valley becomes larger. Prevention of stream pollution will be a more serious problem with increased recreational use and improvement of access to all parts of most watersheds.

There will be increasing problems in maintaining adequate streamflows and lake levels for fish and wildlife and for recreation. The needs for a larger supply of water for irrigation and industry in the Willamette Valley will have to be met by greater reservoir storage of water from forested watersheds. There will be increased pressure from irrigation water users for release of more water from reservoirs now used for boating and fishing. If reservoirs are drawn down during the season of heavy recreational use, the water becomes less accessible and less attractive for recreation, pollution problems increase, and fish life is endangered. Natural lake levels and streamflows may also be lowered by increased water consumption.

The water needed to meet consumptive and nonconsumptive needs on forest land now and in the future is inadequately protected from appropriation for industrial, agricultural, and other water uses. Few water rights are held by public agencies for protection of domestic or recreational water supplies or to maintain streamflows and lake levels. There is no existing administrative water policy to adequately control future outside appropriation of the waters of the high mountain lakes of the basin.

IRRIGATION SYSTEMS

Irrigation development in the Middle Willamette River Basin has been accomplished primarily on an individual farm basis. Presently there are only eight group irrigation projects in the basin irrigating about 14,000 acres. Most irrigation is on land near the major streams where water is readily available. Water is pumped from streams or wells and applied by sprinkler irrigation.

There is a limited amount of additional irrigable land that can be irrigated on an individual farm basis. Most of the remaining irrigable land lies on benches or in areas that are presently short of summer water. Water development for irrigating this land will require group action. In order to minimize irrigation costs per acre, it will be necessary to irrigate sizable contiguous blocks of land. Therefore, it is imperative that a majority of farmers in a given project area be interested in irrigation.

In the past, there has been a lack of interest by farmers in organizing group irrigation projects. For instance, H. W. Caldwell and E. N. Castle made a study of a proposed Bureau of Reclamation project in the Dallas-Monmouth area. 1/ This project would provide irrigation water to about 35,600 acres. They found that only 34 percent of the total number of farmers in the area indicated an interest in the project. Some of the reasons given for lack of interest in the project were age of operator; unadapted land; labor not available; does not fit organization; lack of markets; lack of capital; lower expected income; and water available from other sources.

Of those farmers who were interested in the project, acquiring the necessary capital to make the transition to the new type of farming was the most important problem confronting them.

The chief reason underlying lack of interest by all farmers within an irrigation project area is that many crops can be raised successfully without irrigation. Some farmers will always have legitimate reasons for not wanting to change their present farming system. Under these circumstances, a major problem confronting those farmers who are interested in irrigation within an area where group action is necessary is one of getting a majority of the farmers interested in irrigation.

1/ Economics of Supplemental Irrigation on Polk County Farms, H. W. Caldwell and E. N. Castle, Misc. Paper 39, Agricultural Experiment Station, Oregon State College, Corvallis, April 1957.

DRAINAGE

Approximately 557,100 acres, or about 34 percent of the total arable soils in the Middle Willamette River Basin, have a major problem of excessive wetness. These figures are based upon a capability inventory, as much of the basin has not been surveyed in recent years and those areas that are surveyed have not been summarized by class and problem. Some wet soils have been drained to a degree suitable for the crop grown or are being used for purposes that do not require drainage. An estimated 406,500 acres, or about 73 percent of the excessively wet soils, need to be drained for best production under present use. An estimate of the acreage of soils with major excessive wetness problems and areas needing drainage by subbasins is shown in table 30.

Table 30.--Estimate of soils whose major problem is wetness within land capability classes I-IV and areas needing drainage, Middle Willamette River Basin, Oreg., 1962

		Subbasin			
	Unit	5 Santiam	6 Coast Range	7 Pudding	Total
I	Acres	...	...	...	...
II	Acres	88,600	55,900	58,200	202,700
III	Acres	46,200	74,600	30,100	150,900
IV	Acres	152,800	26,600	24,100	203,500
Total	Acres	287,600	157,100	112,400	557,100
Area needing drainage	Acres	183,500	123,000	100,000	406,500
Percentage distribution of soils with major problem of wetness	Percent	52	28	20	100
Percentage distribution of acres needing drainage	Percent	45	30	25	100

Source: USDA Field Party survey (tables 17A-17D) and USDA Soil Conservation Service (table 1).

In this basin the elimination of prolonged flooding is often a prerequisite to successful drainage. In most cases this can be classified as flood control. However, surface drainage is required in some instances where the problem arises on level fields.

Another major problem affecting drainage in many instances is inadequate outlets. The lack of outlets of sufficient depth and capacity is a problem closely related to flood prevention since in this basin adequate floodwater channels would ordinarily fulfill the basic requirements for drain outlets.

The specific field treatment needs vary widely depending principally upon the soils involved. In a general way, the problems and accompanying needs are listed for most of the wet soils of the basin in table 31.

WATER RELATED DAMAGES

Flood problems in the Middle Willamette River Basin result from both natural factors and management of the land. The largest recorded flood was in December, 1861, so apparently many flood problems existed before the beginning of white settlement. There is evidence that the Indian population managed certain areas in ways that would affect runoff including annual burning of certain areas. Modern man has greatly intensified flooding problems through his intensive use of the land and natural resources.

The flood season is from November through April, but more than two-thirds of the recorded floods have occurred from December through February. Floods are characteristically flashy; streams rise rapidly, remain at peak stage for a few hours or less, and subside rapidly, returning to normal levels in less than a week even on the large rivers.

Major floods result from a certain sequence of climatic phenomena. Fairly continuous rainfall for a long time saturates the watershed and increases the river flow. Heavy snows store a large surplus of water over the watershed area. Then warm rains melt the snow rapidly and the runoff of precipitation and snowmelt builds up flood peaks to disastrous levels. Major floods occur about every four or five years. Smaller floods in the major rivers are almost an annual occurrence. Many small streams flood several times a year.

Spring and summer floods from cloudbursts are practically unknown in this basin. Such infrequent occurrences affect only small portions of a tributary watershed and cause slight damages.

Previous studies have indicated that the discharge of the 1861 flood was 530,000 cubic feet per second for the Willamette River at Salem, Oreg. 1/ This is an estimated equivalent of 13 inches depth on the watershed, or about one-third of the normal annual runoff. It is estimated a flood of this magnitude might occur once in 100 years. A flood equivalent to a little more than five inches depth on the contributing watershed is estimated to occur once in 15 years.

Peak flows for the largest floods represent unit rates of discharge of 120 cubic feet per second per square mile of drainage area for some tributary watersheds of a few hundred square miles area to 70 cubic feet per second per square mile for the Willamette River at Salem, Oreg. Highest rates occur in the streams draining the high elevations in the Cascade Mountains, lowest rates in the streams draining the foothill valley fringes and the Coast Range.

1/ Report on Agricultural Program, Willamette Basin Subarea, U. S. Department of Agriculture, May 1954 (unpublished report).

Table 31.--Generalized drainage requirements for typical wet soils, Middle Willamette River Basin, Oreg., 1962

Soils	Drainage thru the soil	Improved drain outlets	Improved surface: Bedding	Improved surface: Leveling	Open drains	Improved sub-surface drains: Random	Improved sub-surface drains: Pattern	Interception	Remarks
Upland soils formed in place:									
On sedimentary rock:									
Panther	Poorly drained	...	...	...	Possibly	...	...	Yes	
Dupee	Moderately well to imperfectly drained	...	...	...	Possibly	...	...	Yes	
Steiwer	Well to moderately well drained	...	...	...	Possibly	...	...	Possibly	
Hazelair	Moderately well to imperfectly drained	...	...	...	Possibly	...	...	Yes	
On basic igneous rock:									
Viola	Poorly drained	...	...	...	Possibly	...	...	Yes	
Alluvial soils associated with residual upland soils:									
On fan position:									
Carlton	Moderately well drained	...	...	...	Possibly	...	Yes	Yes	
Chehalem	Imperfectly drained	...	...	...	Possibly	...	Yes	Yes	
Crossett	Poorly drained	...	...	...	Possibly	...	Possibly	Yes	
Witham	Moderately well to imperfectly drained	...	...	...	Possibly	...	...	Yes	
Gellatly	Poorly drained	...	...	...	Possibly	...	...	Yes	
Grand Ronde	Poorly drained	...	Possibly	...	...	...	Yes	Yes	
On floodplain position:									
McAlpin	Moderately well drained	...	...	...	Possibly	...	Yes	Yes	
Waldo	Poorly drained	...	...	...	Yes	...	Yes	...	
Cove	Very poorly drained	Yes	Yes	...	Yes	...	...	...	Closed drains are not feasible.
Tangent	Very poorly drained	Yes	Yes	...	Yes	...	...	...	Closed drains are not feasible.
Soils of the Willamette terraces and benches:									
Silty parent material:									
Woodburn	Moderately well drained	...	...	...	...	Possibly	Yes	...	
Amity	Imperfectly drained	...	...	...	...	Possibly	Yes	...	
Concord	Poorly drained	Possibly	...	Possibly	...	Possibly	Yes	...	
Holcomb	Poorly drained	Yes	Yes	Possibly	...	...	Possibly	...	Place tile under claypan.
Dayton	Poorly drained	Yes	Yes	Possibly	...	Possibly	Possibly	...	Place tile under claypan.
Gravelly parent material:									
Clackamas	Imperfectly drained	...	...	...	Possibly	Possibly	Yes	...	
Courtney	Poorly drained	Possibly	Yes	...	Yes	Yes	Possibly	...	
Winlock	Moderately well drained	...	...	...	Possibly	...	Yes	Yes	
Santiam	Moderately well to imperfectly drained	...	...	...	...	...	Yes	Yes	
Gilkey	Poorly drained	...	Yes	...	Yes	...	...	...	Closed drains are not feasible.
Recent alluvial soils of the Willamette Valley:									
Maytown	Moderately well drained	Possibly	...	...	...	Possibly	Yes	...	
Wapato	Imperfectly drained	Yes	Possibly	Possibly	...	Possibly	Yes	...	
Reed	Poorly drained	Yes	Possibly	Possibly	Yes	Possibly	Yes	Yes	
Whiteson	Poorly drained	Yes	Possibly	...	Possibly	Possibly	Yes	Possibly	

Source: U. S. D. A., Soil Conservation Service, Technical Guide.

Forested Watersheds

Carefully planned management of forest resources can result in maximum economic and social benefits without impairment of soil and watershed values. However, poorly planned management of forest resources can produce or intensify flood, erosion, and sedimentation problems in the basin. Forests are generally on steep ground where the degree of water erosion is intensified. Water erosion and rapid runoff of precipitation may be very damaging if protecting vegetation is entirely removed from large areas.

There are many areas that are susceptible to slumps and slides. A lack of detailed information about soils, geology, and hydrology handicaps the efforts of forest land managers in planning adequate soil and watershed protection in connection with road development, timber harvesting, and other forest uses. Some forest land managers have taken an indifferent attitude toward soil and watershed protection because some protection measures are costly and may not provide a direct economic benefit to the landowner.

Timber harvesting and road construction can result in excessive damage to watersheds and downstream areas. Poorly planned and constructed roads are major sources of erosion. Slash resulting from logging or road right-of-way clearing that accumulates in streams can block fish passage and pose a threat of flash floods during severe winter storms (fig. 26). Planning and timing of logging operations without adequate regard for such factors as soil characteristics, steepness of slope, and moisture conditions often magnifies the erosion hazards.

Climatic conditions in the basin are generally favorable for rapid revegetation of cutover forest land. However, skid trails, fire lines, and road cut and fill slopes present a major erosion hazard and often need special measures such as adequate drainage and installation of a protective plant and mulch cover (fig. 27).

Overgrazing of forest land is a serious watershed management problem in areas near the Willamette Valley. Many farmers and ranchers graze cattle and sheep on cutover forest land. Much grazed forest land is too steep or has too great an erosion hazard to be suitable for the present intensity of use. Overgrazing depletes soil-protecting vegetation, destroys tree seedlings, and compacts the soil. Much grazed forest land near the Willamette Valley could be more profitably used for forest development, and the relatively small amount of forage it produces could be replaced through increased forage production from cropland pasture.

About 25 percent of the forest land in the basin is in individual ownerships of less than 500 acres each. Many of these ownerships are too small for efficient, profitable management on an individual basis. The owners often lack forestry training and experience and cannot afford to hire consultants. Many owners are unaware of the profitability of sound forest management. For these reasons, many small private forest holdings are rather poorly managed. For instance, data from the

Figure 26.--This jam of logging debris has blocked fish passage and caused streambank erosion. USFS photo.

Figure 27.--Straw mulch is being applied to grass-seeded fill slope on this forest road as a temporary soil protective measure. USFS photo.

1952 Timber Resources Review indicated that many small private holdings are cutover at too young an age for maximum profits and that there is often inadequate provision for regeneration. Small forest holdings owned by farmers tend to be better managed than those owned by non-farmers, but many farmers tend to put their forest land to other uses such as pasture that will produce cash profits in a short time. Forest values for water, recreation, and wildlife are often neglected on small holdings because of indifference or economic impossibility.

Forest fires have destroyed the vegetative cover over large areas, and much valuable watershed has been damaged. Hasty and poorly planned action to salvage fire-killed timber in rugged mountain watersheds has sometimes produced further watershed damage (fig. 28).

Figure 28.--Salvage logging in this burned over area has intensified the erosion hazard. USFS photo.

Unsatisfactory watershed management practices are most common in the Willamette Valley zone of the basin, mainly because most of the forest land is in small holdings whose owners give little consideration to soil and watershed values. Grazing and other agricultural use of land with high erosion hazards and a lack of erosion control and adequate regeneration after timber harvesting are the most common problems in this zone (fig. 29).

Figure 29.--Clearing of this 40 to 60 percent slope for conversion to rangeland has increased the erosion hazard. This land in land capability class VIIe needs forest cover to adequately protect the soil. SCS photo. 7-634-4

Large private, state, or federal owners hold most of the land in the principal forest zone of the basin. Generally, watershed management problems in this zone can be identified with the policies of a particular landowner or to a lack of sufficient regard for watershed values by forest land managers. This zone receives a very high intensity of precipitation, much of which occurs as rainfall. Most soils with forest cover have only moderate surface erosion hazards, but there are many large areas with slide or slump hazards. Roads are a major source of sediment if located in these areas, if they have inadequate drainage structures, if cut and fill slopes are not protected with plant and mulch cover, or if road surfaces and drainage structures are not adequately maintained. Erosion is likely to occur on logging areas if logging methods are used that are not suitable for the terrain, if skid trails, fire lines, and landings are not given special treatment, or if broadcast slash burning destroys an undue amount of soil protecting litter.

The upper slope and alpine forest zones are mostly in federal ownership. Overgrazing of mountain meadows by livestock and heavy use

of trails by recreational visitors have resulted in some erosion hazards. Problems associated with roads and logging areas may also occur.

Valley Areas

Floodwater damage is widespread in the valley areas of the Middle Willamette River Basin. The problems resulting from excessive streamflow range from erosion and sedimentation to losses of crops, property, and life. Figure 30 shows the major flood problem areas in the basin.

Agricultural damages consisting primarily of crop and property losses usually make up nearly half of the total evaluated flood damage in the basin. However, land damage from erosion, leaching, scour, and deposition contributes a significant part of the total but is difficult to evaluate and is probably inadequately appraised. As an example, an estimated 45 percent of the agricultural flood damage caused by the major flood of 1943 consisted of land damage and land loss. Some twenty million tons of farm soils were washed into the streams by this flood from the entire Willamette River Basin to the permanent detriment of the productive capacity of the valley.

Considerable arable land is lost through streambank erosion. Damage is usually most prevalent in the swifter portions of the streams, but the mainstem of the Willamette River and other large slower streams have also been very damaging in many places. Thomas Creek, a medium sized stream in subbasin 5, produces much streambank erosion (fig. 31).

Sheet, gully, and rill erosion is a serious problem on cultivated land left to fallow or otherwise unprotected by vegetative cover during the winter months (figs. 32, 33, and 34).

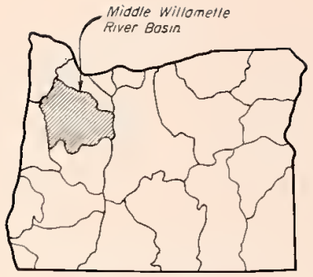
Sediment and debris deposition by flood waters present serious problems in the basin, as they reduce storage space in reservoirs; cut down capacity and increase maintenance on stream channels, irrigation, and drainage ditches; damage crops and cropland; affect navigability of major streams; and lower the quality of water.

While the overall rate of sediment production in the Middle Willamette River Basin is low, it is quite high in some local areas. The limited stream sediment sampling that has been done within the basin indicates that sediment production averages about 0.1 acre foot of suspended material per square mile of watershed. The suspended sediment production hazard has been estimated to vary from 20 to 500 tons per square mile per year. Sediment concentrations of nearly 1,000 parts per million have been measured during flood stage. Although siltation has not been as damaging to reservoirs and other water carrying structures in this basin as elsewhere, it has been serious in the channel and flood plain of the Willamette River where sediment and debris is a serious threat to agriculture and navigation. Much material is carried along the bottom of the river as bed load and is not measured as suspended sediment.

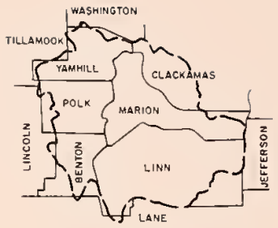
It is very costly to remove sand, gravel, logs, and other debris deposited in channels, fields, ditches, and other improvements by major

Figure 31.--This bank erosion is on Thomas Creek, subbasin 5. The water is about 10 feet deep and the bank about 6 feet above the water line. SCS photo. SCS 7-602-6

Figure 32.--Sheet erosion is an annual occurrence in clean cultivated orchards in the basin not protected by winter cover crops. The filbert orchard is in subbasin 7. SCS photo. SCS F-4-1



RIVER BASIN LOCATION



COUNTY LOCATION

SUBBASINS

5 SANTIAM

6 COAST RANGE

7 PUDDING

LEGEND

- Flood Problem Areas
- A, C2 — Watershed Boundary and Letters
- 6 — Possible Reservoir Site and Index Number
- River Basin Boundary
- Subbasin Boundary
- National Forest and/or Primitive Area Boundary

FIGURE 30

GENERALIZED FLOOD PROBLEM AREAS, POSSIBLE RESERVOIR SITES & WATERSHED BOUNDARIES

MIDDLE WILLAMETTE RIVER BASIN

OREGON

JULY 1962

SCALE IN MILES 5 0 5 10

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE PORTLAND, OREGON M-3632

7-E-17284-N

Figure 33.--Gully erosion caused by leaving land in fallow during winter months in subbasin 7. SCS photo. 7-495-4

Figure 34.--These rills are washed annually in field of strawberries planted up and down the hill with no cover crop used in winter months in subbasin 7. SCS photo. 7-483-2

floods. Sediment is harmful to fish life both in the main streams and in the tributaries. Streamflow characteristics may be seriously altered, spawning beds ruined, and food sources reduced.

Crop damage is often a source of great loss to the farmer. Floods in early fall have caused many farmers to lose all or part of land harvested crops. Onion and carrot crops are among those most frequently damaged (fig. 35). Winter and spring floods damage crops by washing out roots and new plantings and by burying small plants and seed under sediment. Many acres of land along small streams have not been developed for cropland because of serious drainage problems and frequent flooding.

Figure 35.--Crew is attempting to salvage onion crop from floodwaters of an unusually early fall flood. Little Pudding River Small Watershed Project will partially correct this local problem. SCS photo. 7-692-9

Man-made structures and improvements are often damaged by flooding (fig. 36). Many of the towns are located above ordinary flood stage, but larger floods cause damage to some of them. A few such as Turner suffer flood damage almost every year and have been known to receive extensive damages several times in one year. Many county roads in the basin are frequently closed and damaged by high water (fig. 37).

Figure 36.--This small creek in subbasin 6 is normally 20 feet wide. SCS photo. 7-595-7

Figure 37.--A county road flooded by Thomas Creek in subbasin 5. SCS photo. 7-1078-8

Municipal water supplies and diversion works are often damaged by high water and sediment. Sudden early fall or late spring floods frequently inundate farm irrigation pumping plants, tractors, and other equipment left in the fields.

NEEDS AND OPPORTUNITIES FOR IMPROVED MANAGEMENT OF WATER AND RELATED LAND RESOURCES

WATERSHED MANAGEMENT

Maintenance and improvement of the condition of all tributary watersheds in the basin should be continued. In general, the best watershed conditions will prevail when all resources are managed in a manner that insures the optimum sustained production. The most important management items pertaining to forestry and agriculture are outlined in the following sections.

Forested Land

There is need for improvement of the condition of forested watersheds in the basin. On public land, good watershed management is a matter of public policy which should be strengthened and extended to all phases of forest resource management. On private land, good watershed management provides few direct profits to the landowner since he uses little of the water that flows from his land, and any reduction in soil fertility due to poor watershed management may only be apparent over a long period of time. However, good watershed management on all forest land is vital to water users and to landowners in downstream areas. Recently, public pressure and enforcement of antipollution laws have caused some improvement in the watershed management on private land. There is need for much additional improvement. Some factors that would tend to produce better forest watershed management are:

1. Greater monetary returns from tree farming would encourage landowners to keep their land in a productive condition and might incidentally provide for some soil protection. Roads would be constructed and maintained in a permanently good condition, so would tend to be a lesser source of erosion.

2. Continuation and strengthening of extension programs to inform landowners and the general public of the value of water and watersheds and the importance of good watershed management would encourage a gradual improvement in watershed management practices.

3. Increased public pressure from recreationists, fishermen, and water users would cause many private owners to give greater consideration to good watershed management practices.

4. Enactment and enforcement of stricter regulations controlling land management practices that produce stream siltation, debris jams, and flood hazards may be necessary if forest landowners fail to redeem their watershed management responsibilities. Regulation has often been necessary to control other sources of water pollution such as sewage and wastes from manufacturing processes.

Forest land managers need additional knowledge about many phases of forestry to enable them to do a better job of watershed management. One of the most important needs is for more detailed information about forest soils and geology so that areas with serious surface erosion, slump, and slide hazards may be recognized. Increased detailed hydrological data for forested watersheds is also needed for better planning of drainage structures on access roads. Timber harvesting methods need to be developed that minimize watershed damage.

Along with increased knowledge and tools for better watershed management must go increased recognition by forest land managers of their responsibility for management of all forest resources. Management practices that can help enhance watershed values without diminishing the value of forest land for other uses have been stated previously. The forest land manager, particularly the trained forester, can exert an important influence in encouraging good watershed management practices. Foresters play a dominant role in determining the management of public land, and private landowners are increasingly seeking their advice. Thus, foresters have an opportunity to sell multiple use management of all forest resources.

Small forest landowners particularly need the advice and assistance of trained foresters to help them realize maximum benefits from their land. Assistance is particularly needed in such phases of management as reforestation, planning of road systems, harvesting operations, marketing of forest products, and development of recreational and wildlife resources. At the same time, small forest landowners can be encouraged to follow good watershed management practices.

Agricultural Land

The pressures from a rapidly increasing population and its accompanying industrial and urban developments are exerting an increasing strain on land and water resources of the Middle Willamette River Basin. In order to make the best use of these resources it is imperative that they be developed and improved to the greatest extent possible. In order to do this there is a continuing need for more conservation cropping systems and erosion controlling practices, improved and increased irrigation water use, and drainage measures. Many native and marginal hay and pasture fields should be replanted to better adapted species of grasses and legumes and managed for increased production. The rangeland, mostly in a belt near the edge of the valley, should be put to a use that is within its capabilities for sustained production. That is, the areas that are suited to forage production need more intensive development while the areas best suited for forest production should be protected and developed for this use. A summary of needed measures directly related to water follows.

Irrigation. About 98 percent of the irrigated land in the basin is irrigated by the sprinkler method which is easy to manage for proper use of water and is best to use under the existing conditions. To assure maximum benefits from irrigation even the best designed system needs careful attention to the amount and frequency of water application. Both should be adapted to the soil, crop, and weather. The technical

advisor and farmer are in need of more factual information on water-holding capacity and intake rates of the soils to facilitate more efficient use of water. All types of sprinkler systems are used in the basin; the opportunities for variation in design in the field of irrigation are unlimited (fig. 38).

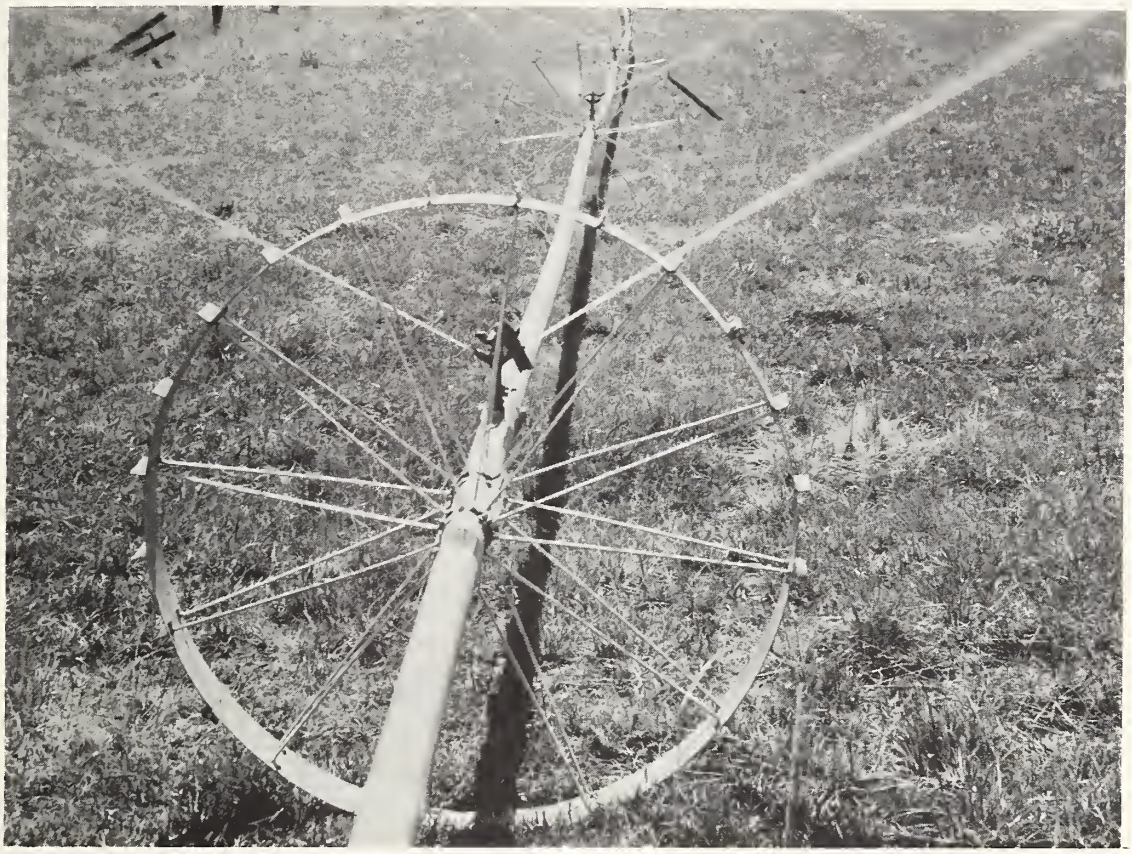


Figure 38.--One type of sprinkler irrigation system that is used in the basin. SCS photo. 8-696-5

A limited amount of irrigation can be developed in the basin by individuals from ground water, small ponds, and in some places natural flow. However, most future development will need to be on a group basis. At present, there are only 8 organized group irrigation projects in operation and three under consideration. Figure 39 shows a multiple pumping plant on the North Santiam River that will supply water to about 360 acres under pressure for the Kingston Irrigation Association.

An example of a group project diverting water by gravity is shown in figure 40.

Drainage. Approximately one-third of the arable soils in the basin have a major problem of excessive wetness. Three-fourths of this land, or about 406,500 acres, needs drainage for maximum production in its present use. Drainage would significantly increase the production on this land and would also increase the number of species and variety

Figure 39.--This pumping plant was installed in 1960 to pump water from the North Santiam River to 360 acres under constant pressure, subbasin 5, Middle Willamette River Basin, Oreg. SCS photo. 7-1046-9

Figure 40.--A concrete structure above the flume on the Lacomb Irrigation District ditch diverts water from Crabtree Creek, subbasin 5, Middle Willamette River Basin, Oreg. SCS photo. 7-936-12

of crops that could be grown. Soluble salts are not a problem in this area, so the water drained from the land can be used for irrigation. This is a fairly common practice in some parts of the basin. Figure 41 shows an example of one type of sump used to store drainage waters for irrigation. There are opportunities for many similar developments for small acreages, and sometimes these sumps can be stocked with fish to provide recreational benefits.

Figure 41.--This sump stores drainage and surface water to irrigate a small area and furnish family recreation. Note the small electric driven pump on a float in the background, subbasin 7, Middle Willamette River Basin, Oreg. SCS photo. F-1-8

Often sufficient drainage for the desired use can be accomplished by removal of surface water by leveling, bedding, or diversion, or by removal of seepage water from higher ground with interception drains. However, most of the land and crops require extensive pattern or random drainage systems (fig. 42) based upon soil characteristics (table 31).

Many areas subject to overflow need to be protected by increasing the capacity of channels with dikes and/or channel work.

Figure 42.--Clay tile is laid in trenches spaced in a pattern for good drainage, subbasin 6, Middle Willamette River Basin, Oreg. SCS photo.
7-883-11

In this basin many miles of tile, ditching, and diking have already been built, but much more is needed. At the present time, about 2 million feet of new tile are laid annually.

Erosion Control. Erosion on cultivated land is mainly the result of water action cutting away fields by streambank erosion and the washing and leaching away of surface soil from unprotected fields by rilling, gullying, and sheet erosion. Erosion from wind action is usually negligible.

There is a need for more stream channel work such as dredging in the main river channels; removal of gravel bars, drift, and brush; and channel enlargement and realignment on the small streams (fig. 43). River and creek banks in many places need more protection by use of rock riprap or other protective measures (fig. 44). Stream channel work is most beneficial when a complete unit of stream channel is improved in a single coordinated project rather than by piecemeal work by individual landowners.

Some arable land is effectively protected from sheet, rill, and gully erosion by perennial sod forming crops. A large acreage of annual and clean cultivated perennial crops requires annual protection

Figure 43.--A channel realignment job is nearly completed on Evergreen Creek, subbasin 6, Middle Willamette River Basin, Oreg., 1961. SCS photo. 7-1164-1

Figure 44.--This rock riprap on Thomas Creek was placed in 1954 and 1955, subbasin 5, Middle Willamette River Basin, Oreg. SCS photo. 7-605-1

due to the heavy winter precipitation and overflow. This problem can be solved each year by carefully selecting the time of working and planting fields or by the use of good, well established winter cover crops (fig. 45).

Figure 45.--The erosion is the result of leaving one-half of the field unprotected, subbasin 6, Middle Willamette River Basin, Oreg. SCS photo. 7-609-7

The soil on which the many perennial row crops, such as strawberries, are grown in this basin needs to be protected by winter cover crops. Figure 46 shows one of the few fields of strawberries with such a cover crop between the rows.

In this basin, winter cover crops are usually worked into the soil as a green manure crop in the spring to help maintain the organic content of the soil. This helps the soil maintain a high water intake rate and high water-holding capacity (fig. 47).

Two other water erosion control practices that are needed in many fields are contour farming and grassed waterways as shown in figure 48.

Figure 46.--Strawberry land is protected by winter cover crops, subbasin 7, Middle Willamette River Basin, Oreg. SCS photo. 7-1201-9

Figure 47.--Pole bean yards in this basin are usually protected by winter cover crops that are returned to the soil in the spring as a green manure crop, subbasin 5, Middle Willamette River Basin, Oreg. SCS photo. 7-631-3

Figure 48.--This field is being plowed around the hill, but the permanent grassed waterway is left, subbasin 7, Middle Willamette River Basin, Oreg. SCS photo. 7-495-10

WATER DEVELOPMENT

There is a great potential for development of the water resources of the Middle Willamette River Basin to better serve all phases of the economy. Ground water, surface water, and water storage can all be used to advantage to help meet the water requirements of the growing population. Provision of adequate water supplies for agriculture will be a major purpose of future water development projects in the basin. For instance, an estimated 895,800 acres of existing and potential cropland could be irrigated if sufficient water supplies were developed. Better utilization of ground and surface water supplies can result in ample water to irrigate this land. However, most major future water development projects will need to include several phases of water use and control such as flood control, navigation, power, domestic, municipal, industrial, fish, wildlife, recreation, and pollution abatement uses.

For instance, there is an increasing need for recognition of fish life, wildlife, and recreational values in the planning of water development projects throughout the basin. Such recognition will be particularly needed in the future on forest land that is heavily used for rec-

reation. There will be an increasing demand for water-based recreational opportunities and an increasing need for reservoir projects to include provision for recreational development. Careful planning and consideration of all resource values is necessary if the maximum beneficial use of water is to be obtained.

The lakes and streams of the high Cascades are very valuable for recreation, wildlife, and fish life. Water development projects that will adversely affect streamflows and lake levels in the high Cascades should be avoided. Waters of the lakes should be considered to be primarily of value for domestic, recreational, wildlife, and fish life uses.

Since the delineation of water resource needs for agriculture is a major purpose of this report, agricultural water uses are emphasized in the following sections pertaining to ground water, surface water, and water storage.

Ground Water

Agriculture in the basin is already a heavy user of ground water. It has been estimated that over 58,000 acres, or about 45 percent of the total irrigated acreage, are presently irrigated from wells (table 24). It is the chief source of water in subbasins 5 and 7.

Ground water is still a good source for future development in some areas of the basin, particularly the alluvial fill of the central part of the valley mostly south of Salem. This ground water reservoir covers about 1,100 square miles. It has a subsurface zone of coarse stream-deposited material above a mostly impervious bedrock formation. It has been estimated that this area is capable of an annual recharge and discharge of 500,000 acre feet. A few wells in the area will yield as much as 1,000 gallons per minute. The quality and quantity of the water are usually adequate for domestic, agricultural, or industrial needs. However, a few local ground water shortages have occurred usually from improper spacing of wells rather than a real lack of water.

The hill portions of subbasin 5 and 7 and a major part of subbasin 6 do not have as dependable a ground water supply due to less favorable geologic formations. Ground water in the underlying bedrock strata, tapped by a few deep wells, is sometimes highly mineralized and unsatisfactory for general use. Ground water could be developed to irrigate an estimated additional 96,000 acres in the Middle Willamette River Basin according to data gathered from various sources.

Surface Water

Additional individual and group irrigation systems are needed to provide irrigation water to lands that are reasonably close to the main rivers. Most of these areas have a water supply from natural streamflow. In addition to natural flow water, there is water available in the streams from the existing storage reservoirs built by the Corps of Engineers, U. S. Army. Sometimes water can be pumped directly from the streams by individuals or groups, but it will be necessary to develop

some major irrigation systems for transmission, control, and delivery of water to larger compact blocks of farmland if the optimum use of these major sources of water and land is to be realized.

Some small streams have a limited amount of natural surface water that can be used beneficially for agriculture.

It is estimated that 140,000 additional acres could be irrigated in the basin from natural flow and existing stored water.

Storage

The conservation of excessive, often damaging, runoff water in reservoirs for flood protection and subsequent use for irrigation, industry, domestic, recreation, pollution abatement, and fish life has considerable potential in the Middle Willamette River Basin (fig. 49).

Figure 49.--A typical medium sized reservoir constructed for multiple use in subbasin 7, Middle Willamette River Basin, Oreg. SCS photo. F-1-5

A summary of estimates from various parts of the basin have indicated that it would be necessary to construct both large and small reservoirs to supply water for about 660,000 irrigated acres for optimum agricultural development (table 29). This storage capacity can be

developed where and when it is needed. There is a definite potential for more farm ponds and small reservoirs. In addition, there are many medium sized reservoir sites of 100 to 25,000 acre feet storage capacity that should be considered for water development for individual and group needs. Table 32 summarizes reconnaissance data assembled by the Department of Agriculture on 102 sites that appear to have some merit and warrant future consideration. The location of these sites are shown on figures 30 and 50.

The Corps of Engineers, U. S. Army, has dams planned or under construction, some of which will have water stored for irrigation purposes. In order to be feasible, almost all new reservoirs need to be developed for multipurpose use, considering all possible uses and benefits from the stored waters.

Table 32.--Reconnaissance data on some reservoir sites, by subbasin, Middle Willamette River Basin, Oreg., 1962

Subbasin Number and name	Stream Name	Watershed index Letter	Reservoir index Number	Drainage area Sq.mi.	Annual yield Acre ft.	Storage Acre ft.	Surface area Acres	Fill + storage Cy/ac.ft. 1/	Possibilities Uses 2/
5. Santiam.....	Bear Branch	E	1	10.6	19,200	2,120	212	15	I,F,R
	Sucker Slough	F	2	4.7	7,000	660	75	58	F,R
	Thomas Creek	G	3	55	164,300	17,600	294	69	I,F,R
	Neal Creek	G	4	9	22,100	1,670	38	213	I,F,R
	Beaver Creek	I	5	26.8	37,100	660	150	30	I,F,R
	Crabtree Creek	I	6	66.9	182,000	4,020	150	87	I, R
	Do.	I	7	66	179,500	9,400	202	72	I,F,R
	Onehorse Slough	J	8	10.3	14,200	6,270	392	36	R
	Hamilton Creek	R	9	32.6	52,200	2,280	237	35	I,F,R
	Butte Creek	M	10	3.5	2,600	1,180	80	231	I,F,R
	Oak Creek	L	11	4.8	4,100	1,000	50	138	I,F,R
	McDowell Creek	S	12	23.6	45,300	2,640	206	12	I, R
	Butte Creek	M	13	7.2	5,400	3,780	118	106	I,F,R
	Noble Creek	J	14	10.3	11,000	1,060	156	36	I, R
	Ames Creek	U	15	7.8	14,900	910	38	117	F,R
	Not Named	M	16	4.9	7,900	2,510	112	90	F,R
	Courtney Creek	F	17	8.8	12,200	4,580	143	154	I,F,R
	Little Muddy Creek	O	18	2.2	2,100	900	56	86	I,F,R
6. Coast Range....	Turner Creek	A	1	15.0	35,200	3,090	143	103	I,F,R
	Not Named	A	2	4.8	7,600	6,000	150	198	I,F,R
	North Yamhill River	A	3	25.4	89,500	3,630	168	27	I,F,R
	Not Named	A	4	3.7	5,000	1,530	212	35	I,F,R
	Haskins Creek	A	5	15.1	46,700	24,500	567	22	I,F,R
	Newland Creek	C_1	6	2.8	3,500	1,120	56	75	I,F,R
	Fanther Creek	E	7	12.3	26,800	3,310	156	50	I,F,R
	Baker Creek	F	8	14.8	23,700	700	44	71	I,F,R
	Do.	F	9	22.9	36,600	1,050	187	25	I,F,R
	Falmer Creek	M	10	33	22,000	11,600	...	14	I, R
	Cozine Creek	L	11	1.9	2,400	1,550	69	79	I, R
	Muddy Creek	G	12	6.5	9,700	5,360	268	63	I,F,R
	Do.	G	13	12.3	18,400	1,520	131	59	I,F,R
	Deer Creek	G	14	11.4	23,000	2,880	100	240	I,F,R
	Do.	G	15	26.2	44,600	2,000	125	56	I,F,R
	Do.	G	16	33.0	56,400	1,400	174	30	I,F,R
	Dupee Creek	G	17	3.8	5,600	1,300	69	74	I, R
	Willamina Creek	H	18	24.6	60,400	3,800	116	55	I, R
	Do.	H	19	66.6	163,400	22,180	560	46	I,F,R
	Coast Creek	H	20	9.3	22,600	2,920	81	84	I, R
	Tindle Creek	H	21	5.8	11,100	1,740	87	76	I,F,R
	Cosper Creek	I	22	4.3	10,200	700	44	73	I,F,R
	Agency Creek	J	23	17.6	61,800	3,640	130	37	I,F,R
	Rock Creek	L	24	5.8	9,200	3,670	137	74	I,F,R
	Rogue River	K	25	5.1	17,900	1,490	93	76	R
	Ballston Slough	L	26	3.2	4,000	1,680	108	78	I,F,R
	Not Named	O	27	1.5	1,800	260	41	83	I, R
	Do.	N	28	3.8	2,400	220	56	32	I, R
	Athey Creek	N	29	1.8	2,000	1,120	56	149	I, R
	Not Named	O	30	1.2	1,400	490	44	114	I,F,R
	Spring Valley Creek	C_3	31	3.5	2,200	680	100	56	I,F,R
	Ellendale Creek	R	32	2.5	4,900	740	37	72	I,F,R
	North Fork Ash Creek	S	33	2.1	3,700	620	62	91	I, R
	Middle Fork Ash Creek	S	34	2.4	2,500	1,720	143	26	I,F,R
	North Fork Pedee Creek	U	35	7.3	23,200	2,720	81	171	I,F,R
	Not Named	U	36	3.9	2,500	1,570	218	13	I,F,R
	Jont Creek	U	37	5.1	12,000	1,180	87	92	I,F,R
	Staats Creek	V	38	2.1	4,400	3,140	187	58	I,F,R
	Maxfield Creek	U	39	7.3	18,600	4,200	118	99	I,F,R
	Do.	U	40	2.1	5,200	3,780	150	34	I,F,R
	Price Creek	U	41	4.1	10,500	2,360	81	130	I,F,R
	Soap Creek	V	42	10.0	19,200	3,900	212	62	I, R
	Vincent Creek	U	43	10.5	23,500	8,510	367	51	I,F,R
	Horton Creek	W	44	2.7	6,600	1,040	118	52	F,R
	Oak Creek	W	45	3.0	5,200	880	44	148	F,R
	Woods Creek	W	46	8.1	18,900	3,720	93	104	I, R
	Rock Creek	W	47	10.1	30,200	3,600	100	55	R
	Evergreen Creek	X	48	1.3	2,400	510	44	99	I,F,R
	Beaver Creek	X	49	10.7	27,300	2,560	149	61	I,F,R
	Reese Creek	X	50	6.1	13,300	3,180	199	24	I,F,R
	Oliver Creek	X	51	13.0	31,800	2,060	143	48	I,F,R
7. Pudding.....	Buckner Creek	H	1	11.7	15,000	3,020	189	21	I,F,R
	Cedar Creek	H	2	2.3	3,300	2,960	168	49	I,F,R
	Do.	H	3	4.2	5,400	520	25	139	I,F,R
	Bear Creek	E	4	18.7	18,900	2,090	249	16	I, R
	Not Named	E	5	3.8	4,000	1,210	137	13	I, R
	Rock Creek	D	6	51.2	71,000	8,080	697	7	I,F,R
	Teasel Creek	D	7	3.5	5,300	810	81	15	I, R
	Rock Creek	D	8	3.7	7,000	1,440	50	155	I,F,R
	Beaver Creek	I_1	9	3.1	6,000	440	50	53	I, R
	Butte Creek	I_1	10	49.4	118,500	7,000	175	31	I,F,R
	Do.	I_1	11	30.2	72,500	3,550	102	36	I,F,R
	Molalla River	G	12	71.8	268,000	8,990	212	82	I, R
	Abiqua Creek	I_3	13	66	172,000	5,800	136	100	I,F,R
	Little Pudding River	J	14	31.6	30,300	3,000	425	13	I,F,R
	Silver Creek	I_4	15	46	125,100	7,100	164	26	I,F,R
	Do.	I_4	16	41	111,500	12,500	260	30	I,F,R
	Do.	I_4	17	39	106,100	8,700	178	34	I,F,R
	Drift Creek	I_5	18	24.7	47,400	400	20	83	I,F,R
	Do.	I_5	19	17.2	42,200	13,300	340	9	I,F,R
	Do.	I_5	20	10.9	26,600	3,200	72	20	I,F,R
	Do.	I_5	21	4.3	9,400	4,500	192	71	I,F,R
	Beaver Creek	I_6	22	7.6	9,700	4,750	260	7	I,F,R
	Do.	I_6	23	3.5	4,900	650	55	49	I, R
	Fudding River	I_7	24	22.7	36,300	2,860	429	4	I,F,R
	Do.	I_7	25	3.2	6,100	5,100	260	8	I, R
	Do.	I_7	26	4.6	8,800	4,200	242	19	I, R
	Battle Creek	K	27	3.2	2,700	770	60	70	I,F,R
	Do.	K	28	5.5	4,600	1,540	84	48	I,F,R
	Rogers Creek	K	29	2.4	2,000	1,600	83	24	I,F,R
	Mill Creek	K	30	10.5	21,200	7,400	230	110	I,F,R
	Do.	K	31	8.5	17,200	2,640	79	65	I,F,R
	Do.	K	32	6.8	13,800	2,400	80	85	I,F,R
	Zollner Creek	I_2	33	7.2	9,200	730	77	15	I,F,R

1/ A comparative figure derived from dividing the estimated earth fill in cubic yards by the estimated water storage capacity in acre feet.
2/ I-irrigation, F-flood protection, R-recreation--fishing, hunting, and boating.

Source: Based on a survey by the U. S. Department of Agriculture Field Farty.

OPPORTUNITIES FOR WATERSHED PROTECTION AND FLOOD PREVENTION PROJECTS

The Watershed Protection and Flood Prevention Act, Public Law 566, as amended, authorizes the Secretary of Agriculture to cooperate with local organizations in planning and carrying out works of improvements for flood prevention and/or for the conservation, development, utilization, and disposal of water in watershed or subwatershed areas smaller than 250,000 acres. The act provides for technical, financial, and credit assistance by the U. S. Department of Agriculture to landowners, operators, and other people living in small watersheds. Project-type action under the act is intended to supplement other soil and water conservation programs and other programs for the development and flood protection of major river valleys.

The USDA Field Party made a survey of the potential for P. L. 566 work in the Middle Willamette River Basin to provide information as a guide to long range coordination and planning of possible future projects. The basin was divided into 57 tributary watershed areas which are designated by letter and are delineated on figures 30 and 50. Minor tributaries of the Willamette River in each subbasin and tributaries of the Upper Pudding River in subbasin 7 were delineated as subwatersheds and designated by letter and number. A preliminary survey was made of each watershed and subwatershed to gather basic reconnaissance data on land and water use and water related problems, which are summarized in tables 17A through 17D.

Based upon a review of the reconnaissance data for each watershed in relation to current programs of the U. S. Department of Agriculture and other agencies and groups having watershed planning responsibilities, 29 watersheds were eliminated from further study for this report because of lack of time. The watersheds which were eliminated are covered by proposed, planned, or authorized projects of the U. S. Department of Agriculture or other agencies or groups, or have problems and conditions that are not applicable to P. L. 566 work under existing laws. These watersheds and the reasons for eliminating them from further study are indentified in table 33.

A total of 28 watersheds and one subwatershed were considered worthy of further study by the field party. A field reconnaissance and an evaluation of available data for each watershed was then made to obtain additional information on watershed area, physiographic conditions, land use and ownership (table 35), water yield and its seasonal distribution, water related problems and needs, and opportunities for P. L. 566 action. Information concerning some items is limited because of a lack of time for making detailed field observations. The purpose of this reconnaissance review of small watersheds was not to make an economic study of feasibility but, by limited observation, to delineate those watersheds which have physical problems whose solution appears to be feasible under P. L. 566. Further detailed investigations would be necessary to determine engineering and economic feasibility of a given project. The field party's findings, indicating which watersheds have problems that appear to have the best possibility for P. L. 566 action, are presented in individual watershed reports, summarized in table 34, and shown on figure 50.

Table 33.--Watersheds excluded from detailed reconnaissance, Middle Willamette River Basin, Oreg., 1/

Subbasin and watershed	Reason for exclusion
5. Santiam Subbasin:	
A. Little North Santiam	The drainage area is large with a heavy water yield and very few problems or benefits to offset heavy costs of improvements.
B. Lower North Santiam	The problems are largely solved by the Detroit and Big Cliff dams of the Corps of Engineers, U. S. Army.
C. Main Stem Santiam	The flooding and irrigation problems will largely be solved by completion of the Green Peter and Foster dams by the Corps of Engineers, U. S. Army.
G. Thomas Creek	A flood control and drainage project study by the Corps of Engineers, U. S. Army has been authorized.
H. Upper North Santiam	The drainage area is large with heavy water yield. Problems are largely of a land treatment nature and are not currently suitable for P. L. 566 solution.
J. South Santiam	Most water problems are the result of the main river. Many of them will be reduced by completion of the large dams on the headwaters by the Corps of Engineers, U. S. Army.
L. Oak Creek	The Corps of Engineers, U. S. Army have an inactive plan to do 11 miles of channel work.
M. Calapooya River	An authorized project of the Corps of Engineers, U. S. Army is presently inactive because of lack of local interest.
N. Willamette River	Authorized projects of the Corps of Engineers, U. S. Army will correct many problems, which are generally beyond the scope of P. L. 566.
O. East Muddy Creek	A flood control and drainage project by the Corps of Engineers, U. S. Army has been authorized but at present is inactive.

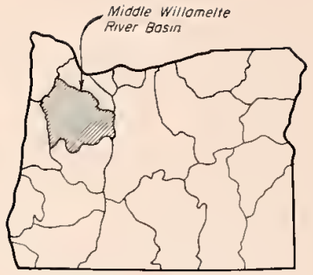
1/ Some watersheds excluded from this detailed reconnaissance at this time may later need to be considered.

Table 33.--Watersheds excluded from detailed reconnaissance, Middle Willamette River Basin, Oreg.--Continued

Subbasin and watershed	Reason for exlusion
P. Walton Slough.....	This is part of the Calapooya River project of the Corps of Engineers, U. S. Army, which has been authorized but is presently inactive.
Q. Lake Creek.....	This is part of the Calapooya River project of the Corps of Engineers, U. S. Army, which has been authorized but is presently inactive.
T. Middle Santiam....	Green Peter Dam under construction by the Corps of Engineers, U. S. Army will help solve many of the water problems.
U. Upper South Santiam.....	A large dam is recommended by the Corps of Engineers, U. S. Army that will solve many problems. Other problems are of a land treatment nature and are not currently suitable for P. L. 566 solution.
6. Coast Range Subbasin:	
C. Willamette River..	This is a group of seven areas along the Willamette River, one of which (C7) is covered by a summary report. Authorized projects of the Corps of Engineers, U. S. Army will correct many problems, which are generally beyond the scope of P. L. 566.
D. Hawn Creek.....	Considerable work has and is in the process of being done by groups and individuals.
L. South Yamhill River.....	The water problems are generally too large to be applicable for a P. L. 566 project.
N. Ash Swale.....	A flood control and drainage project by the Corps of Engineers, U. S. Army has been authorized but is now inactive.
O. Salt Creek.....	A flood control and drainage project by the Corps of Engineers, U. S. Army has been authorized but is now inactive.
Q. Mud Slough.....	A flood control and drainage project by the Corps of Engineers, U. S. Army has been deferred for restudy.

Table 33.--Watersheds excluded from detailed reconnaissance, Middle Willamette River Basin, Oreg.--Continued

Subbasin and watershed	Reason for exclusion
S. Ash Creek.....	A flood control and drainage project by the Corps of Engineers, U. S. Army has been authorized but is now inactive.
V. Soap Creek.....	A flood control and drainage project by the Corps of Engineers, U. S. Army has been authorized; it is now deferred for restudy.
W. Marys River.....	A flood control and drainage project by the Corps of Engineers, U. S. Army has been authorized.
X. Muddy Creek.....	A flood control and drainage project by the Corps of Engineers, U. S. Army has been authorized.
7. Pudding Subbasin:	
A. Willamette River..	This is a group of four areas along the Willamette River. Authorized projects of the Corps of Engineers, U. S. Army will help solve many problems in these areas.
I. Upper Pudding River.....	An application for assistance under P. L. 566 has been made and some preliminary investigations completed.
J. Little Pudding River.....	A P. L. 566 project has been approved and is partly completed.
K. Mill Creek.....	An application for assistance under P. L. 566 has been made and some preliminary investigations completed.
L. Beaver Creek.....	A work plan for a P. L. 566 project has been prepared and approved, and surveys are partially completed for final design and construction.



RIVER BASIN LOCATION

COUNTY LOCATION

SUBBASINS

5 SANTIAM

6 COAST RANGE

7 PUDDING

LEGEND

- Flood Problem Areas
- A, C_2 Watershed Boundary and Letters
- 6 Possible Reservoir Site and Index Number
- River Basin Boundary
- Subbasin Boundary
- Notional Forest and/or Primitive Area Boundary

WATERSHEDS WITH SUMMARY REPORTS

- Best PL. 566 possibilities
- Others reported

WATERSHEDS WITHOUT SUMMARY REPORTS

- Approved for construction PL. 566
- Application approved PL 566
- Others not reported

FIGURE 50

INDEX MAP OF WATERSHED AREAS AND POSSIBLE RESERVOIR SITES

MIDDLE WILLAMETTE RIVER BASIN

OREGON

JULY 1962

5 0 5 10

SCALE IN MILES

7-E-17380-N

Table 34.--Watersheds included in detailed reconnaissance and summary reports, Middle Willamette River Basin, Oreg.

Subbasin and watershed	Project possibilities under P. L. 566
5. Santiam Subbasin:	
D. Millersburg-Dever	A project including drainage, flood control, and/or irrigation might be feasible.
E. Bear Branch	A project including irrigation and/or drainage and flood control appears to be feasible.
F. Sucker Slough	A stream channel program benefiting flooded and wet areas and/or an irrigation project appears to be feasible.
I. Crabtree Creek	A project partially solving flood control and drainage problems or a multipurpose project on some parts of the watershed might be feasible.
K. Albany Flats	A complete project including irrigation, drainage, flood control, and land treatment appears to be feasible.
R. Hamilton Creek	A project does not appear feasible under existing conditions and laws.
S. McDowell Creek	A project does not appear feasible under existing conditions and laws.
6. Coast Range Subbasin:	
A. North Yamhill River	An application for a P. L. 566 plan has been received and approved. A project involving flood control, irrigation, drainage, municipal water, and land treatment appears to be feasible.
B. Chehalem Creek	An application for a P. L. 566 plan has been received and approved. A project including irrigation, flood control, drainage, and land treatment appears to be feasible.
C7. Bowers Slough	A stream channel program benefiting flooded and wet areas and/or an irrigation project appears to be feasible.
E. Panther Creek	A project based on irrigation, flood control, drainage, and municipal use appears to be feasible.

Table 34.--Watersheds included in detailed reconnaissance and summary reports, Middle Willamette River Basin, Oreg.--Continued

Subbasin and watershed	Project possibilities under P. L. 566
F. Baker Creek	A project for irrigation, flood control, drainage, and land treatment appears to be feasible.
G. Deer Creek	A project for irrigation, flood control, drainage, and land treatment might be feasible.
H. Willamina Creek	An overall project does not appear feasible under existing conditions and laws.
I. Cosper Creek	A project does not appear feasible under existing conditions and laws.
J. Agency Creek	A complete project including irrigation, flood control, and drainage might prove feasible.
K. Upper South Yamhill	A project for the entire watershed does not appear favorable under existing conditions and laws.
M. Palmer Creek	A project for flood control, irrigation, drainage, and land treatment appears to be feasible.
P. Mill Creek	A project does not appear to be feasible for the area included within the present boundaries.
R. Rickreall Creek	A project for flood control and drainage might be feasible.
T. Little Luckiamute River	A multipurpose project might be feasible under present conditions and laws.
U. Luckiamute River	A project for the entire area has very little possibility under existing conditions and laws, but a project might be possible in cooperation with the Corps of Engineers; or a project might be feasible involving a portion of the area.
7. Pudding Subbasin:	
B. Champoeg Creek	A project for flood control, drainage, and irrigation might be feasible. An irrigation project bringing water from outside the watershed and including other land appears to be feasible.

Table 34.--Watersheds included in detailed reconnaissance and summary reports, Middle Willamette River Basin, Oreg.--Continued

Subbasin and watershed	Project possibilities under P. L. 566
C. Lower Pudding River	A project entirely within this watershed has very little possibilities under existing conditions and laws.
D. Rock Creek	A project for flood control, drainage, land treatment, and maybe irrigation appears to be feasible.
E. Bear Creek	A project for flood control, drainage, land treatment, and irrigation might be feasible.
F. Gribble Creek	A project for flood control, drainage, irrigation, and land treatment could be feasible.
G. Molalla River	A project for flood control, irrigation, and land treatment does not appear to be feasible unless combined with a flood control project by the Corps of Engineers, U. S. Army.
H. Milk Creek	A project for flood control, drainage, land treatment, and irrigation appears to be feasible.

Many of the water related problems of the Middle Willamette River Basin could be reduced or solved under P. L. 566. Under existing conditions and laws it appears that a solution of these problems may be practicable and feasible in several watersheds. The field party's findings indicate that watersheds with the best possibilities for P. L. 566 action have a combination of some of the following conditions:

1. Most of the watershed is at low elevations with relatively low summer water yields.

2. The watershed has, or has potential for, a high degree of agricultural, residential, or urban development.

3. The watershed has a large area suitable for irrigation development, and lacks water sources that can be developed by individual farmers but has water sources that can be developed by group action.

4. The watershed has localized flooding and/or drainage problems which are related to floods of moderate duration which are not influenced by flooding of large streams outside the watershed under consideration.

Table 35.--Landownership in selected watersheds, Middle Willamette River Basin, Oreg.

Subbasin and watershed	National forest	Bureau of Land Mgt.	State of Oregon	County and municipal	Large private	Other private	Total
5. Santiam Subbasin:							
D. Millersburg-Dever	...	...	...	...	...	11,690	11,690
E. Bear Branch	...	...	...	...	...	9,230	9,230
F. Sucker Slough	...	...	...	...	...	7,790	7,790
I. Crabtree Creek	...	17,400	2,500	...	31,300	46,600	97,800
K. Albany Flats	...	...	...	...	...	29,320	29,320
R. Hamilton Creek	...	4,080	120	...	8,760	15,340	28,300
S. McDowell Creek	...	1,080	...	80	8,360	6,270	15,790
6. Coast Range Subbasin:							
A. North Yamhill River	...	4,920	...	4,840	4,080	64,750	78,550
B. Chehalem Creek	...	...	...	...	...	26,320	26,320
C_7. Bowers Slough	...	...	2,520	...	...	14,690	17,210
E. Panther Creek	...	2,560	40	...	2,080	13,830	18,510
F. Baker Creek	...	1,560	...	...	160	15,140	16,860
G. Deer Creek	...	1,400	...	...	2,120	31,230	34,750
H. Willamina Creek	1,120	17,100	...	...	12,240	21,770	52,230
I. Cosper Creek	...	1,760	...	...	1,920	2,690	6,370
J. Agency Creek	3,000	4,860	...	...	5,100	3,700	16,660
K. Upper South Yamhill	2,400	4,280	600	...	31,320	29,050	67,650
M. Palmer Creek	...	...	...	...	...	21,380	21,380
P. Mill Creek	240	12,000	...	...	10,680	11,010	33,930
R. Rickreall Creek	880	3,000	400	...	13,360	23,480	41,120
T. Little Luckiamute	...	1,800	920	...	15,400	34,520	52,640
U. Luckiamute River	...	2,720	1,560	...	34,600	75,020	113,900
7. Pudding Subbasin:							
B. Champoeg Creek	...	...	400	...	...	29,280	29,680
C. Lower Pudding River	...	...	40	...	...	35,270	35,310
D. Rock Creek	...	1,280	...	...	440	38,960	40,680
E. Bear Creek	...	...	...	...	...	13,080	13,080
F. Gribble Creek	...	...	...	...	...	10,590	10,590
G. Molalla River	1,840	29,800	4,320	...	75,000	39,700	150,660
H. Milk Creek	200	3,560	...	...	5,800	56,230	65,790

5. The watershed contains one or more storage sites which appear feasible for multipurpose development.

Some of the watersheds studied have conditions and problems that do not appear to be suitable for P. L. 566 action. These watersheds usually have a combination of some of the following conditions:

1. The watershed has high water yield and large peak flows, which produce flooding and drainage problems that are beyond the scope of P. L. 566.

2. The watershed has flooding and drainage problems that are due to overflow of an adjacent large stream.

3. Most of the watershed needs are related to land treatment on forest and range areas where there is little present economic incentive for land treatment measures.

4. Only a small part of the watershed that would benefit materially from flood control and drainage is under agricultural, residential, or urban uses, and there is limited potential for expansion of these land uses.

5. The watershed has minor drainage, flooding, and water supply problems that can best be solved through individual action.

6. Group irrigation development is not feasible in the watershed because of land capability factors or lack of a potential water supply.

There are several factors that were not considered in this study that may affect the feasibility of a given watershed for P. L. 566 action:

1. Changes in basic laws and policies to give greater recognition to land treatment, flood control, recreational, wildlife, and fish life benefits would improve the possibility for P. L. 566 action in several watersheds.

2. Unforeseen demands for water arising from increased urbanization, industrialization, and demand for certain agricultural crops may improve the need for P. L. 566 action in some watersheds.

3. Small watershed projects may be feasible in some areas adjacent to, or part of, planned Corps of Engineers or Bureau of Reclamation projects. Such small watershed projects could be supplementary to the larger project.

4. The degree of local interest in a given project will influence the immediate prospects for P. L. 566 action in many watersheds where projects appear to be physically and economically feasible. Interest in irrigation and

more intensive land use will be particularly important as many potential projects center around irrigation development.

5. In a few instances, changing the boundaries of an area proposed for small watershed development might improve the possibility for P. L. 566 action. For instance, a watershed with suitable storage sites but small water requirements for irrigation, domestic, or other uses might be combined with an adjacent watershed with large water requirements but no storage potential.

6. Improvements made by individuals or groups in a watershed may reduce future benefits adversely affecting the possibilities of a P. L. 566 project.

Summary reports for each watershed studied, by subbasins, are presented in the following section.

5. SANTIAM SUBBASIN

Watershed D, Millersburg-Dever

Description. The Millersburg-Dever watershed is located in the northwestern corner of Linn County in the East Linn Soil Conservation District. It is approximately 5 miles long and 4 miles wide and contains 11,690 acres. It is bordered by the Willamette River on the west, the floodplain of the Santiam River on the north, and Hale Butte and Hardscrabble Hill on the east. The watershed is drained by Crooks Creek and McCarthy Slough which flow into the Willamette River. The average annual precipitation is 40 inches.

The watershed is composed of three distinct physiographic units which have different origin, topography, geology, and soils. An area one-fourth to one mile wide borders the watershed on the west and north and has recent alluvial soils including the Chehalis, Newberg, and Wapato series. The elevation is 185 to 190 feet with level to gently sloping topography.

Somewhat more than 50 percent of the watershed is on the Willamette Silts terrace. The soils are of the Willamette, Woodburn, Amity, Dayton, and Cove series. The elevation is 190 to 250 feet with almost level to gently sloping topography.

Approximately 10 percent of the watershed is on hill land of Hale Butte and Hardscrabble Hill which range in elevation from 250 to 500 feet with gently sloping to moderately steep topography. Both basic igneous and sedimentary rock are present. Steiwer and Hazelair series have developed on the sedimentary rock, and Jory series has developed on the basic igneous rock.

An estimated 1,400 acres are forested. There are hardwood stands along the streams and mixed coniferous and hardwood stands on the hills.

The forest land is owned by medium and small private owners. Approximately two-thirds of the forest land is grazed.

Approximately 9,890 acres in 70 farms is cropland with a variety of crops being produced. About 2,000 acres are irrigated and are used to produce row crops, mint, pasture, and other crops. The dryland is used to produce pasture, small grains, corn, nut orchards, and grass seed.

Watershed Problems and Needs. Considerable damage occurs annually from floods on Crooks Creek and McCarthy Slough from runoff of precipitation of longer duration and greater intensity than normal. There is slight erosion on pasture land and some erosion of cropland. There is no significant damage on forest land. Sediment and debris deposition cause the greatest damage to agricultural land. Farm buildings and fences are damaged, and some fences must be replaced almost annually. Some damage occurs to roads and bridges. Approximately 600 acres are inundated for extended periods of time each year, causing damage to crops and creating drainage problems. Channel clearing, shaping, straightening, and enlargement are needed to allow flood waters to move downstream without overflowing.

Approximately 7,000 acres of arable land have excessively wet soils and could be improved with subsurface drainage including both pattern drains and interception drains. There is some need for land shaping, diversion, and grassed waterways. Some problems of drain outlets exist but would be partly solved by channel improvement on the main drainages.

At present, 2,000 acres are being irrigated by pumping from streams and wells within the watershed. Part of the additional 7,800 acres considered suitable for irrigation could be irrigated by further development of surface and ground water within the watershed, but the major source would need to be the Santiam and Willamette Rivers. There is sufficient water stored upstream to meet these needs. No reservoir sites were found in the watershed.

Opportunities under P. L. 566. The information available indicates only a limited amount of the flood damaged area could be benefited by a project under P. L. 566, as an undetermined part of the flooding is caused directly or indirectly by the Willamette and Santiam Rivers and is thus beyond the scope of this act. Channel work on the two small streams would benefit drainage and give flood protection to a limited area. Irrigation benefits could also be furnished through this program from a system delivering water from the Santiam or Willamette Rivers using either natural flow or water stored in one of the reservoirs built by the Corps of Engineers, U. S. Army. It appears that a watershed program including drainage, irrigation, land treatment, and flood control might prove feasible under existing conditions and laws.

Watershed E, Bear Branch

Description. The Bear Branch watershed, a tributary of the North Santiam River in northern Linn County, covers 9,230 acres. The lower portion is in the East Linn Soil Conservation District. The entire watershed is level to moderately steep; it is about 9 miles long and averages 1.5 miles wide with elevations ranging from 390 to 1,280 feet. Average annual precipitation is about 50 inches.

The watershed can be divided into four general areas by soils based on parent material with corresponding elevation, topography, and geology. The eastern two-thirds is hill land of the Nekia series which is a soil derived from basic igneous rock. The western third divides almost equally into two soil areas of gravelly terraces of different ages. The Salkum series has formed on the older terrace. The Salem Clackamas, Courtney, and Gilkey series have formed on the younger terrace, a part of the Willamette Silts deposit. A narrow floodplain traverses the entire length of the watershed and contains the Abiqua, McAlpin, and Waldo series.

About 1,060 acres is forest land which is mixed with agricultural land as a part of farms. The forest land is on poorly drained bottomlands and on steep slopes. Forest stands are predominantly hardwoods with some scattered areas of Douglas-fir and are generally managed as farm woodlots. Most of the forest stands have experienced some cutting, and about 60 percent of the forest land is grazed.

An estimated 8,710 acres in 50 farms are used for agricultural production including 6,570 acres of cropland, 1,500 acres of rangeland, and 640 acres of grazed forest land. The 500 acres of irrigated cropland are used predominantly for production of row crops and berries. The dryland cropland is used for production of grass seed.

Part of the benefiting acreage from one operating and one planned group irrigation project are in the watershed. The Kingston Irrigation Association pumps water from the North Santiam River to irrigate about 160 acres and is increasing its capacity to 360 acres. A similar project for the Queener Irrigation Association is planned to provide irrigation water for an additional 750 acres.

Watershed Problems and Needs. There is a relatively large potential for agricultural development. About 1,600 acres could be developed for additional cropland, and 6,000 acres of additional land are suitable for irrigation. Sufficient water to meet all potential irrigation needs is available from storage in Detroit Reservoir on the North Santiam River. There is also one reservoir site (number 1) in this watershed.

Heavy grazing of forest land has seriously depleted ground cover and discouraged regeneration on cutover areas. Some steep slopes have experienced sheet and gully erosion. Modification of grazing practices and some land treatment are needed. Approximately 100 acres of pasture and cropland are flooded, but flooding has not been a serious problem in this waterhsed. Gullying and sheet erosion occur on the steep range-

lands, and sheet erosion is common on cropland without cover in winter months. There has been some scattered damage to farm facilities, roads, and bridges.

Some channel shaping and clearing is needed to improve capacity and flow.

About 2,000 acres of arable land have excessively wet soils and are in need of subsurface drainage. Improved drainage would increase yields, give wide choice of crops, lengthen the season of use, and increase returns. Drainage can be provided by installing closed drains and improving outlets.

Opportunities under P. L. 566. A water supply for irrigation development, the major need in this watershed, can probably be most economically supplied through further pump diversion of water from the North Santiam River rather than by development of storage within the watershed. Stream channel improvements would alleviate most of the flooding, a minor problem, and provide outlets for drainage. Development of additional irrigated pasture would eliminate much of the need for grazing of forest land, permitting re-establishment of vegetative cover. Although benefits and costs were not computed, a program of irrigation development, channel improvement for flood control and drainage, and land treatment appears to be feasible under P. L. 566.

Watershed F, Sucker Slough

Description. The Sucker Slough watershed, a tributary of Thomas Creek in northwestern Linn County, contains 7,790 acres. The lower part is in the East Linn Soil Conservation District. The entire watershed is level to moderately steep and is about 10 miles long and 1 to 2 miles wide. Elevations range from 240 to 900 feet. Average annual precipitation is about 45 inches.

The watershed has four general soils areas based on parent material with corresponding elevation, topography, and geology. The eastern third is composed of hills of the Nekia series which is a soil derived from basic igneous rock. The central third consists of soils of the Salkum series developed on an old gravelly terrace. The western third consists of Clackamas, Courtney, and Gilkey soils developed on a younger gravelly terrace, a part of the Willamette Silts formation. The Abiqua, McAlpin, and Waldo series have developed on a narrow floodplain which traverses the entire length of the watersheds.

Most land is in farms, and an estimated 7,490 acres in 25 farms are used for agricultural production including 6,090 acres of cropland, 1,000 acres of rangeland, and 400 acres of grazed forest land. About 300 acres of cropland are irrigated and used for pasture and row crops. Pasture, grass for seed, and small grains are the principal dryland crops.

An estimated 500 acres is forest land which is mixed with agricultural land as a part of farms. Most of the forest land is covered with hardwoods and used for livestock pasture.

Watershed Problems and Needs. Limited flooding and a lack of effective drainage affect important areas of agricultural land. An estimated 400 acres are flooded annually by overflow from Sucker Slough during winter and spring storms, and there is considerable resulting sedimentation of flooded areas. Road bridges and culverts are damaged by washing and sediments. An estimated 5,000 acres lacks adequate drainage and is in need of closed drain systems.

There is considerable potential for intensified agricultural land use. All arable land has been developed, but an additional 5,000 acres are considered suitable for irrigation development.

There are no significant watershed problems on forest land. One reservoir site (number 2) was located.

Opportunities under P. L. 566. The volume of runoff from this watershed is such that most flooding and some drainage problems could be controlled through clearing and enlarging the presently brush-choked stream channel. Considerable periodic channel maintenance would be necessary in this slow-flowing stream. The location and capacity of the reservoir site makes it of limited value for flood control and irrigation. The North Santiam River may be a less costly source of irrigation water using either natural flow or water stored in the Detroit reservoir. Sufficient information is not available to determine benefits and costs, but it appears a program of stream channel improvement, land treatment, and irrigation development would be feasible under P. L. 566.

Watershed I, Crabtree Creek

Description. The Crabtree Creek watershed, a tributary of the South Santiam River in west-central Linn County, contains 97,800 acres, mostly within the East Linn Soil Conservation District. Crabtree Creek and its tributaries including Beaver Creek, Roaring River, and Green Mountain Creek flow in a westerly direction from the western Cascades and enter the South Santiam River about 4 miles upstream from its confluence with the North Santiam River. The watershed is 50 miles long in an east-west direction and averages 8 miles wide in a north-south direction.

The western one-third of the watershed is in the Willamette Valley and consists mainly of sloping terrace and bottom land. The eastern two-thirds of the watershed lies in the Western Cascades and has rough terrain. Elevations range from 250 to 500 feet in the valley area and from 500 to 4,300 feet in the mountains. Annual precipitation ranges from 50 inches in the valley to 100 inches in the mountains.

There are four general areas of soils based on parent material with corresponding elevation, topography, and geology. The eastern three-fourths of the watershed is composed of soils formed from basic igneous rock. The soils are the Nekia, McCully, Kinney, and Keel series. There are areas of sedimentary rock in the vicinity of Hungry Hills and Providence School from which are formed the Willakenzie, Peavine, Steiwer, and Hazelair series. An old terrace area on the western one-fourth of the watershed contains the Salkum series. The soils on the Willamette

Silts terrace include the Salem, Clackamas, Courtney, and Gilkey group and the Amity, Dayton, and Holcomb group. The floodplain includes the Abiqua, McAlpin, Waldo group along the upper part of the stream and the Chehalis, Newberg, Wapato, Reed group in the lower section.

Forest land covers about 76,000 acres, 78 percent of the total watershed. About 26 percent of the forest land is in public ownership; 41 percent is owned by one large timber company; and 33 percent is owned by "medium" and "small" private owners. About 40 percent of the forest land has been cutover since 1930.

About 32,000 acres in 125 farms are used for agricultural production including 18,000 acres of cropland, 2,500 acres of rangeland, and 11,500 acres of grazed forest land. About 2,100 acres of cropland are irrigated and used predominantly for pasture and row crops. The remaining cropland is used primarily for pasture and for production of small grains and grass for seed.

Watershed Problems and Needs. Despite extremely widespread logging, problems on forest land are quite limited. Some of the most productive forest sites in the basin are in the Crabtree Creek watershed, and the company that owns 41 percent of the forest land is operating its lands for continuous timber production. Most cutover areas are well stocked. Some erosion is occurring where roads have been built across slide areas or on steep grades without adequate drainage. Logging debris has accumulated in Crabtree Creek and several of its tributaries to block fish migration and threaten damage to farmland dowstream. In general, however, the owners of most of the forest land recognize and are protecting watershed values.

There are about 4,000 acres of land adjacent to Crabtree Creek subject to flooding from high streamflows in winter months. An undetermined part of the flooded area is affected by the high waters of the South Santiam River which will be improved by the large dams to be completed by the Corps of Engineers, U. S. Army. Damage to cropland due to flooding occurs annually from water overflowing the creek banks as many as four times in one storm season. Only grass crops are grown on the floodplain, and they provide considerable erosion protection. There is some erosion damage on sloping fields when cultivated crops are grown.

Sediment damage to cropland is limited to a small area near Beaver Creek, but damages from deposition of debris and logs are more extensive.

Bank cutting is a source of serious damage along Crabtree Creek on the valley floor, due to high stream velocity, extreme meadering, and channel obstructions such as gravel bars and log jams. An estimated five miles of streambank are actively eroding at a rate of 2 1/2 acres of cropland per year.

There is very little irrigation water shortage reported at the present time in the watershed. The Lacomb Irrigation District has a water right for 39 cfs. from Crabtree Creek and is reportedly irrigating around 1,600 acres. There are 24,000 acres in this watershed suitable for irrigation in addition to the 2,100 acres irrigated at the

present time. About 13,600 acres are in the Scio Project proposed by the Bureau of Reclamation to be irrigated with water from the South Santiam River. An estimated additional 2,000 acres could be irrigated from natural flow and ground water. Therefore, if this watershed's irrigation potential is completely developed, around 8,400 acres would be dependent on storage development. Several reservoir sites have been explored by different groups and government agencies. In addition, three small sites (numbers 5, 6, and 7) have been investigated in connection with this report. They have a combined potential storage of around 14,000 acre feet, but their value for flood control is very limited.

Poorly drained land estimated at 16,000 acres would be a severe problem if agriculture is to become more intensified. Flood channel improvement will usually correct the drainage outlet problem. The lower part of one tributary, Beaver Creek, is especially in need of this kind of work.

Opportunities under P. L. 566. There are many problems in this watershed that are suitable for P. L. 566 action, but there are obstacles in solving some of them under this law. The volume of water in flood flow is very large and expensive to control. Reservoir sites appear to be inadequate to solve this problem. The cost of channel work for adequate flood control also appears to be prohibitive at this time. Partial flood control in the form of limited channel, dike, and bank protection might be feasible on the entire watershed, or a multipurpose project might be feasible on a portion of the watershed such as Beaver Creek.

Watershed K, Albany Flats

Description. The Albany Flats watershed contains 29,320 acres in northwestern Linn County in the East Linn Soil Conservation District. It includes Murder, Truax, Burkhart, Cox, and Periwinkle Creeks, small tributaries of the Willamette River between the Calapooya and Santiam River watersheds. The watershed is about 13 miles long and from 1 to 6 miles wide. It borders on the Willamette River on the northwest for about 4 miles.

The watershed is mostly level bench land with the exception of about 500 acres of steep hill land at Knox Butte. Elevations on the valley bottom are from 200 to 350 feet. Average annual precipitation is 36 to 40 inches.

Three general areas of soils are found based on parent material with corresponding elevation, topography, and geology. The largest area is composed of soils derived from the Willamette Silts deposits. The Clackamas, Courtney, and Gilkey are gravelly soils. The Woodburn, Amity, Holcomb, Dayton, Cove, and Reed are soils of silty origin. A small area of soils of sedimentary rock parent material are found at Knox Butte. These soils are the Willakenzie, Steiwer, and Hazelair series. The floodplain contains the Chehalis, Newberg, Wapato, and Reed series.

Albany, part of Lebanon, extensive adjacent residential development, and connecting roads and highways cover about 12,000 acres. Sizable areas of agricultural land between Albany and Lebanon are being converted to residential development.

About 1,000 acres are forested. About half of the forest land is on Knox Butte; the remainder is in tracts of less than 40 acres on poorly drained areas along stream courses. The forest stands are predominately hardwoods, and most of the forest land is grazed.

An estimated 17,320 acres in 160 farms are used for agricultural production including 15,520 acres of cropland, 800 acres of rangeland, and 1,000 acres of grazed forest land. About 500 acres of cropland are irrigated of which 400 acres are in pasture and 100 acres are used for row crop production. Grass seed is the principal dryland crop.

Watershed Problems and Needs. Only about 200 acres are suitable for additional cropland development, but 14,000 acres are suitable for additional irrigation development. The water required for irrigation development would have to be from the Willamette or South Santiam Rivers for there are no known storage sites within the watershed, and the surface and ground water supplies are not sufficient to supply the presently irrigated acreage during the latter part of the irrigation season.

Frequent flooding has caused varying damages to approximately 2,600 acres. Damage to cropland and pasture land has been in the form of sedimentation and debris deposition with some erosion occurring on cropland. Considerable damage and inconvenience results from flooding of roads, bridges, and urban housing east of Albany. Adequate channels are greatly needed in this area. There has been one group channel improvement project of 7,600 feet completed on Periwinkle Creek and sections of unknown length on other creeks. Although the outlets through Albany are adequate, channel clearing, shaping, and enlarging are badly needed in the upper reaches of the channels.

Approximately 18,000 acres of arable land has excessively wet soils; the installation of closed drains would greatly enhance the land. There are no significant problems on the forested land in the watershed.

Opportunities under P. L. 566. Opportunities exist for development of water supplies for irrigation expansion and supplementing present ground water sources. Stream channel clearing, enlarging, and shaping would alleviate much flooding and provide outlets for drainage. Improved drainage would result from the installation of closed drains. It appears that a complete watershed program including irrigation, drainage, flood control, and land treatment would be feasible under P. L. 566.

Watershed R, Hamilton Creek

Description. The Hamilton Creek watershed, a tributary of the South Santiam River in central Linn County, covers 28,300 acres. It includes the area drained by Hamilton Creek and its tributaries plus

a small adjacent area that drains directly to the South Santiam River. The watershed is about 13 miles long and 3 to 5 miles wide.

The watershed is on hilly land incised by the drainages of the streams. Elevations vary from 375 feet at the confluence of Hamilton Creek with the South Santiam River to 4,000 feet in the eastern end of the watershed. The average annual precipitation varies from 44 inches to 74 inches. Basic igneous material consisting of solid rock, tuffaceous material, and conglomerates makes up the hilly land. Soils of the Nekia, McCully, and Kinney series have developed on this parent material. Terraces have been formed along streams in the floors of the narrow valleys. Chehalis, Newberg, Maytown, and Wapato series have developed on a recent alluvial terrace. Salem, Clackamas, Woodburn, Amity, and Holcomb series have developed on older terraces.

About 21,200 acres are forested. The western third of the watershed contains mixed hardwood and softwood stands intermingled with agricultural land. The eastern two-thirds of the watershed is covered with coniferous forests. About 60 percent of the forest land has been cutover and is generally well stocked with young stands. About 81 percent of the forest land is in private ownership divided almost equally between large timber companies and "medium" and "small" private owners. About 19 percent of the forest land is in public ownership, most of which is administered by the Bureau of Land Management. Most of the eastern half of the watershed is either in public ownership or owned by large timber companies. About 23 percent of the forest land is grazed by livestock.

An estimated 12,000 acres in 110 farms are used for agricultural production including 4,000 acres of cropland, 3,000 acres of rangeland, and 5,000 acres of grazed forest land. About 400 acres of cropland are irrigated including 250 acres of row crops and 150 acres of pasture. Irrigation water is obtained by pumping from surface water supplies and is applied by sprinkling. Pasture and hay are the principal dryland crops.

Watershed Problems and Needs. The eastern half of the watershed has been heavily logged but now supports a satisfactory vegetative cover in most areas. Considerable erosion is occurring on several spur logging roads and on abandoned landings and skid roads. A limited amount of land treatment is desirable to reduce one source of downstream sedimentation.

Water related damage is comparatively minor in the western half of the watershed. Hamilton Creek floods about 100 acres of adjacent lowland annually causing deposition of debris and sediment on cropland. There is slight damage to irrigation facilities and fences, and some bank erosion is occurring.

There is considerable potential for agricultural development. An estimated 4,000 acres of additional cropland could be developed, mostly from the present rangeland. About 2,000 acres of arable land could be improved by drainage. Most of the drainage problems result

from seepage from adjacent higher ground and could be partially solved by installation of either surface or subsurface interception drainage systems.

An estimated 5,000 acres of arable land are suitable for irrigation development, but only 200 acres could be irrigated from natural streamflow and ground water. One possible storage site (number 9) on Hamilton Creek could provide enough water to meet requirements of about 2,000 acres. Water could be pumped from the South Santiam River to irrigate some land in the western part of the watershed.

Opportunities under P. L. 566. The cost of flood control measures in this watershed would probably be far greater than the presently small annual losses. However, individual or group action to provide needed streambank protection does appear to be feasible. There appears to be a sizable potential for irrigation development, but an overall watershed program including flood control, irrigation storage, land treatment, and drainage would probably not be feasible under existing conditions and laws.

Watershed S, McDowell Creek

Description. The McDowell Creek watershed, a tributary of the South Santiam River in central Linn County, covers 15,790 acres. It lies between Hamilton Creek and the South Santiam River and is about 10 miles long and 3 to 4 miles wide.

The watershed is on hilly land that has been incised by the drainages of the streams. Elevations vary from 460 feet at the confluence of McDowell Creek with the South Santiam River to 4,000 feet in the eastern end of the watershed. The average annual precipitation varies from 48 inches to 74 inches. Basic igneous material consisting of solid rock, tuffaceous material, and conglomerates makes up the hilly land. Soils of the Nekia, McCully, Kinney, and Keel series have developed on this parent material. Terraces have formed along streams in the floors of the narrow valleys. Chehalis, Newberg, Maytown, and Wapato series have developed on a recent alluvial terrace. Woodburn, Amity, and Holcomb series have developed on an older terrace.

An estimated 5,320 acres in 15 farms are used for agricultural production including 1,820 acres of cropland, 800 acres of range, and 2,700 acres of grazed forest land. Most of the cropland is along the lower 3 miles of McDowell Creek, and most of the range is on the gentler slopes near ridgetops. About 120 acres of cropland are irrigated. The agricultural economy is almost entirely based on livestock and dairy farming.

About 12,970 acres are forested. About 65 percent of the forest land is owned by large timber companies, 26 percent by "medium" and "small" private owners, and 9 percent is in public ownership. Most of the original old-growth stands were removed 10 to 30 years ago, but most cutover areas are well stocked with young coniferous stands.

Watershed Problems and Needs. This watershed has little flood related damage. Most of the forest land is well protected with vegetation and erosion is limited to a few old skid roads and spur logging roads. Damage to agricultural land is limited to a little streambank erosion. About 500 acres of arable land have a problem of excessive wetness caused by seepage of water from higher ground and would benefit from interception drainage systems.

Surface flows are adequate for present irrigation needs. An estimated 1,000 acres are suitable for additional irrigation development, but a water supply would have to be developed for 700 acres. One storage site (number 12) was located in McDowell Creek, but it is downstream from the irrigable land.

Opportunities under P. L. 566. Irrigation development could be benefited by project action but is inhibited by the lack of a known, suitably located storage site. The flooding and drainage problems are of a type that can best be solved on an individual farm basis. For these reasons, there appears to be little opportunity at present for action under P. L. 566 in this watershed.

6. COAST RANGE SUBBASIN

Watershed A, North Yamhill River

Description. The North Yamhill River watershed covers 78,550 acres in northwestern Yamhill County within the Yamhill County Soil Conservation District. The river flows southeasterly from the Coast Range and joins the South Yamhill River about two miles east of McMinnville, Oreg.

Land slopes in the mountain parts are quite steep with channel gradients averaging around 5 percent. The valley area has a level to gentle undulating surface, and the channel gradients average less than one percent. Elevations range from 100 feet at the junction of the rivers to a summit average of around 3,000 feet.

Three main soils groups based on physiographic position can be recognized in the watershed. Residual soils derived from the underlying bedrock occupy the higher areas. Old valley fill slopes comprise a second group and recent alluvium stream bottoms, a third. The residual soils are derived from the igneous and sedimentary rock of the area. The igneous rocks have weathered deeply forming the Nekia and Hembre series. The weakly consolidated sedimentary rocks of the lower hills, in most cases, are not weathered as deeply as the igneous rocks. They give rise to the Astoria, Willakenzie, and Peavine series. Old valley fill soils are developed from transported materials of mixed origin and are of considerable age. Difference in origin and in drainage conditions with consequent differences in color and in character of subsoils have given rise to the moderately well drained Woodburn series and to the imperfectly drained Amity series. Soils of recent alluvial origin, of comparatively small extent, include the Chehalis, Wapato, Reed, and Cove series. They lie only a few feet above the normal flow of the streams and are subject to periodic flooding.

The normal annual precipitation in this watershed varies from 40 inches in the lower reaches to over 100 inches in the mountains.

An estimated 54,150 acres are forested. Most of the mountainous and hilly portions of the watershed are covered with coniferous forests, although hardwoods also occur in some areas. About 20 percent of the forest land has been logged, and about 6,000 acres of the northwestern edge of the watershed are in the Tillamook Burn. Most logged and burned areas are well stocked with young softwoods. There is little current logging activity. About 32 percent of the forest land is grazed. About 74 percent of the forest land is owned by "medium" and "small" private owners; 8 percent is owned by large timber companies; and 18 percent is in public ownership.

The cropland makes up around 19,320 acres of the watershed with hay, pasture, and small grains making up 90 percent of the cropland; other crops include tree fruits, nuts, grass seed, and berries.

Watershed Problems and Needs. Floodwater damage is usually not very extensive. The floodplain area is relatively small and with the exception of the mill at Carlton has no major nonagricultural developments. The largest annual flood damages are to crops and fences on low lying land during short periods of streambank overflow. Some silt and debris are left on cropland whenever overflow occurs. Some water supplies are silty during heavy runoff periods with poor quality of water and silting of the systems.

There is considerable sheet erosion on the grazed forest land, much of which is too steep and erodable for the present intensity of use. Some of the rangeland on steep, highly erodable slopes could be used more profitably for forest production. A minor amount of erosion is occurring on old cutover areas, mainly on skid trails and landings.

The watershed produces sufficient water to irrigate all of the arable land, but there are inadequate flows during the irrigation season. Water right applications have been filed for approximately 2,122 acres in this watershed.

The five storage sites (numbers 1-5) that have been investigated in the upper reaches of the watershed have a combined potential storage of nearly 39,000 acre feet. Combinations of these storage sites would provide adequate water to irrigate a large portion of the potentially arable land.

A drainage problem exists on approximately 9,000 acres of arable land due to soil conditions and lack of natural outlets.

Opportunities under P. L. 566. An application for a plan under P. L. 566 has been received and approved. It would probably not be feasible to completely alleviate the flooding problems. Some flood control as a part of a project which includes irrigation, drainage, and municipal water storage could be feasible. Land treatment measures would also bring substantial benefits. It appears that an overall watershed program would be feasible under P. L. 566.

Watershed B, Chehalem Creek

Description. The Chehalem Creek watershed occupies 26,320 acres in northeastern Yamhill County within the Yamhill County Soil Conservation District. The creek flows in a southeasterly direction from the Chehalem Mountains to its confluence with the Willamette River south of Newberg, Oreg. The watershed is about 10 miles long in a southeast-northwest direction and about 7 miles wide at its widest point in a southwest-northeast direction. It is generally hilly with a large area of nearly level to sloping topography along Chehalem Creek. Elevations range from 75 feet at the mouth of Chehalem Creek to 900 feet in the Chehalem Mountains. Average annual precipitation is 40 to 42 inches.

Soils in the Chehalem Creek drainage area include those occurring on the rolling hills formed from sedimentary rocks, those on outwash fans that overly the recent alluviums along the creek, the recent alluvial soils, and the soils formed on Willamette Valley silts near the mouth of the creek. The well-drained Willakenzie soils cover most of the uplands while the small wet areas are occupied by the imperfectly drained Dupee and the poorly drained Panther soils. The well drained Peavine soils lie on the higher ridges. Small areas of the well drained Nekia soils are on the basalt intrusions in the sandstones and shales. The moderately-well drained Chehalem soils with many rock fragments in the subsoil occupy the outwash fans in the upper valley. The well drained Salem-like soils with mixed gravel and soil substratums occur on outwash fans in the central part of the valley. The recent alluviums are the poorly drained Wapato, the very poorly drained claypan Reed soils, and small areas of dark muck and peat. The well drained Willamette soils, the moderately well drained Woodburn soils with weak fragipan subsoils, and the imperfectly drained Amity soils have formed on the Willamette Valley silts near the mouth of Chehalem Creek.

An estimated 13,340 acres are forested and are owned by farmers and other "small private" owners. The forested acreage is evenly divided between hardwood and coniferous stands; coniferous stands occur on the highest hills and on northerly slopes, and hardwood stands occur along the streams and on southerly slopes. Most of the forest stands are of small sawtimber size or smaller. There has been little timber harvesting recently. About half of the forest land is grazed.

An estimated 18,000 acres in 150 farms are used for agricultural production including 9,380 acres of cropland, 2,400 acres of rangeland, and 6,220 acres of grazed forest land. Approximately 180 acres of cropland are being irrigated including vegetable crops, small berries, and pasture. The 9,200 acres of dryland cropland includes small grains, orchards, berries, grass and legume seed, and pasture. Practically all potential cropland has been developed in this watershed.

Watershed Problems and Needs. Problems on forest land are limited to steep slopes that are grazed by livestock and are susceptible to erosion becuuse of over use. Some steep hill pastures are also susceptible to erosion and should be under forest cover.

An estimated 2,000 acres are flooded to some extent. About 350 acres of pasture are flooded annually. The land is wet and poorly drained so flooding causes very minor damage. Approximately 250 acres of cropland are flooded or in danger of annual flooding. There is some slight annual damage to farm facilities and roads. Channel improvement is needed to relieve the flooding problem.

Estimates show that 5,000 acres of arable land have excessively wet soils and need surface and subsurface drainage.

Approximately 7,500 acres are suitable for irrigation, but development of an adequate water supply is required. Proposals for irrigation development have been made by various agencies. One proposal is to pump water from the Willamette River; others are to divert stored water from adjoining watersheds as there are no adequate storage sites in this watershed. Late season irrigation shortages occur where water is being pumped from small streams.

Opportunities under P. L. 566. An application for a plan under P. L. 566 has been received and approved. Opportunities exist for development of water supplies for irrigation expansion and supplementing late season shortages. Stream channel clearing, enlarging, and shaping would help control flooding and provide drainage outlets. Improved drainage could be accomplished by installing open and closed drains. It appears that a complete watershed program would be feasible; also, a program consisting only of flood control and drainage would be feasible under P. L. 566.

Watershed C_7, Bowers Slough

Description. The Bowers Slough watershed, a tributary of the Willamette River in northwestern Benton County, contains 17,270 acres within the Benton Soil Conservation District. It includes the watersheds of Bowers Slough and Frazier Creek which rise in a mountainous area northeast of Corvallis and join about 1/3 mile before entering the Willamette River about 3 miles west of Albany. The watershed is ovally elongated in a northeast-southwest direction and is about 10 miles long and 3 miles wide. About 50 percent of the watershed is on steep, mountainous terrain west of U. S. Highway 99W. About 25 percent of the watershed is on less steep, though hilly, terrain east of U. S. Highway 99W. About 25 percent of the watershed is level to gently rolling terrain near the main stream channels. Elevations range from 200 to 300 feet in the more level areas to 1,500 feet in the mountains. The average annual precipitation varies from 40 inches in the valley to 50 inches in the mountains.

There are four general kinds of soils in the watershed based on parent material and corresponding elevation, topography, and geology. The western half is composed of hills of basic igneous parent material on which is developed the Nekia series. Approximately a fourth of the watershed is composed of Willakenzie, Peavine, and Sites soils formed on moderately steep hills of sedimentary rock. Almost a fourth of the watershed is Willamette, Woodburn, Amity, Dayton, and Cove series.

Areas of recent alluvial soils of the Chehalis, Newberg, Maytown, Wapato, and Reed series occur along the streams.

An estimated 8,100 acres are forested land, most of which is in the mountainous areas. The lowest ridges are covered with oak stands while Douglas-fir stands are predominant elsewhere. About 31 percent of the forested land is in the McDonald State Forest located in the headwaters of Calloway, Frazier, and Jackson Creeks. About 69 percent of the forested land is in "medium" and "small" private ownership and located on the lower slopes and foothills adjacent to valley bottoms. About 25 percent of the private forest land is grazed by livestock, and most of the merchantable timber stands have been logged.

An estimated 8,170 acres in 35 farms are used for agricultural production including 5,700 acres of cropland, 1,370 acres of rangeland, and 1,100 acres of grazed forest land. About 300 acres are irrigated and used for pasture, orchard, and row crops. The nonirrigated crops are pasture, grain, and grass for seed.

Watershed Problems and Needs. Most of the forest land is in good condition from a watershed management standpoint. However, some of the hill land is experiencing heavy livestock grazing and some sheet erosion. Some of the cutover forest land supports poor quality hardwood stands and needs to be restocked to a more productive condition.

Flooding and erosion damage affect approximately 400 acres of cropland and 100 acres of pasture land. There is a minor damage to farm facilities and some damage, although not serious, to roads, bridges, and urban development. Some channel improvement has been made in past years, but additional channel clearing, shaping, and enlarging would greatly reduce flooding and erosion problems. Approximately 700 acres of arable land have excessively wet soils and are in need of surface and/or subsurface drainage. Channel improvement, land shaping, diversions, and grassed waterways would lessen the surface drainage problem. Improved outlets and drainage systems using both open and closed drains, where applicable, need to be installed.

Approximately 300 acres are being irrigated with water shortages experienced late in the season. An estimated additional 5,000 acres are suitable for irrigation. Of this acreage 2,700 acres would need additional water development for the full irrigation season while the remaining 2,300 acres plus the presently irrigated 300 acres need supplemental water for a period of approximately two months. There were no storage sites noted on this watershed, but adequate water could be obtained from the Willamette River.

Opportunities under P. L. 566. Channel improvement would greatly reduce flooding and would also lessen drainage problems. Irrigation storage development does not appear to be feasible within the watershed. Adequate water is available from the Willamette River and its storage facilities.

Specific cost and benefit figures were not developed, but it appears that a program of flood prevention, land treatment, and drainage would be feasible under P. L. 566.

Watershed E, Panther Creek

Description. The Panther Creek watershed occupies 18,510 acres northwest of McMinnville in central Yamhill County within the Yamhill County Soil Conservation District. The creek flows southeast out of the mountains which form the boundary of the Middle Willamette River Basin and enters the North Yamhill River two miles north of McMinnville, Oreg.

The configuration is an irregular oval about eleven miles long in a northwest-southeast direction and three miles wide in a northeast-southwest direction. Elevations vary from 2,159 feet at the extreme northwest to 100 feet at the junction with the North Yamhill River.

The average annual precipitation is 65 inches, approximately 98 percent of which occurs as rain from September through June. The two-year frequency 24-hour precipitation is about 4.0 inches. The climate is mild with an average annual frost-free period of about 165 days.

Three main soils groups, based on physiographic position, are recognized in the watershed. These are residual soils derived from underlying bedrock occupying the higher areas, old valley fill soils, and recent alluvial stream bottom soils. The residual soils are derived from either igneous or sedimentary rock. The igneous rocks have weathered deeply forming the Nekia and Hembre series. The weakly consolidated sedimentary rocks of the lower hills, in most cases, are not weathered as deeply as the igneous rocks. They give rise to the Astoria, Willakenzie, and Peavine series. Old valley fill soils are developed from transported materials of mixed origin and are of considerable area. Difference in origin and in drainage conditions with consequent differences in color and in character of subsoils have given rise to the moderately well drained Woodburn series and to the imperfectly drained Amity series. Soils of recent alluvial origin are of comparatively small extent. They lie only a few feet above the normal flow of the streams and are subject to periodic flooding. Recent alluvial soils include the Chehalis, Wapato, Reed, and the Cove series.

An estimated 14,310 acres are forested. Most of the western half of the watershed and much of the hilly areas in the eastern half of the watershed are covered with coniferous stands. Young stands of Douglas-fir and hemlock predominate, and about 40 percent of the area has been logged in the past. There is presently little logging activity. About 12 percent of the forest land is grazed. About 18 percent of the forest land is in public ownership; 14 percent is owned by large timber companies; and 68 percent is owned by "medium" and "small" private owners.

Approximately 3,000 acres of cropland lie within the watershed. These lands are devoted primarily to small grains. Small acreages of

orchard crops, seed clover, and row crops are also being grown. An estimated 1,000 acres are devoted to rangeland.

Watershed Problems and Needs. Overflow of the channel and flooding of the adjacent lands occurs annually on approximately 150 acres of bottom land pasture. The cause of flooding appears to be inadequate channels restricted by vegetation and debris. Damage is minor and monetary loss is slight.

It is estimated that 2,000 acres of arable land have excessively wet soils. The majority of this land need some type of closed drains; a small acreage could be remedied by land shaping to improve surface drainage. At present, only 270 acres are under irrigation, but estimates show an additional 2,500 acres of land suitable for irrigation. To accomplish this, storage would be necessary. One reservoir site (number 7) was investigated that could furnish a portion of the required water. There are no significant problems on the forested land in the watershed.

Opportunities under P. L. 566. Clearing and improving of channels would greatly reduce the flooding problems. Land treatment in the upper watershed would also have some effect on flooding. Drainage and irrigation benefits would be greater with a more intensive cropping pattern than is now practiced in the watershed.

It appears that an overall watershed program including flood protection, drainage, irrigation, land treatment, and municipal water development would be feasible under P. L. 566.

Watershed F, Baker Creek

Description. The Baker Creek watershed covers an area of 16,860 acres in central Yamhill County within the Yamhill County Soil Conservation District. The creek flows southeast from Bald Mountain in the Coast Range to its junction with Panther Creek two miles north of McMinnville, Oreg. The watershed is about 10 miles long and 2 to 4 miles wide. About three-fourths of the watershed is hilly or mountainous terrain in the Coast Range. An area of valley bottom land extends from the mouth of the creek upstream for about 8 miles gradually narrowing from 2 miles to about one-quarter mile wide. Elevations in the valley are from 100 to 250 feet and are as high as 2,300 feet in the mountains. The average annual precipitation increases from about 44 inches on the east boundary of the watershed to about 70 inches on the west boundary.

There are three main soils groups based on physiographic position recognized in this watershed. Residual soils derived from the underlying bedrock occupy the higher areas. These are derived from two groups of rock of the area, those of igneous rock or volcanic origin forming the Nekia and Hembre series and those of sedimentary origin giving rise to the Astoria, Willakenzie, and Peavine series. Old valley fill soils are developed from transported materials of mixed origin and are of considerable age. These soils are the moderately well drained Woodburn series and the imperfectly drained Amity series. Soils of

recent alluvial origin are of comparatively small extent. They include the Chehalis, Wapato, Reed, and the Cove series.

An estimated 9,980 acres are forested. Softwood stands are common in the west half of the watershed, and hardwood stands are common in the east half. There has been logging activity throughout the watershed, though there has been little logging during the past 5 years. About 16 percent of the forest land is grazed. About 82 percent of the forest land is owned by "medium" and "small" private owners; 2 percent is owned by large timber companies; and 16 percent is in public ownership.

An estimated 8,180 acres in 90 farms are used for agricultural production including 4,580 acres of cropland, 2,000 acres of rangeland, and 1,600 acres of grazed forest land. More than half of the cropland is used for grain production. Smaller acreages are used for pasture, orchard, and production of row crops. About 480 acres are irrigated.

Watershed Problems and Needs. Approximately 50 acres of cropland and 150 acres of pasture land are subject to annual flooding. Damage is slight in most years, but occasionally flooding causes sheet erosion and deposition of logs and debris. Some bank erosion occurs on roads, but damage is slight. Irrigation sumps are often filled with deposited sediment. Channel clearing and enlarging along with land treatment on the upper watershed would reduce the flooding problem.

It is estimated that 3,000 acres of arable land having excessively wet soils are in need of either surface drainage, subsurface drainage, or a combination of both. Additional irrigation water is needed on land presently irrigated late in the season and to irrigate the estimated 3,500 acres of additional irrigable land. Two reservoir sites (numbers 8 and 9) were investigated, but they would not have adequate storage to supply all of the potentially irrigable land.

There are no significant watershed problems on forest land.

Opportunities under P. L. 566. Opportunities exist for water development and drainage to increase the area irrigated and permit more intensive land use. Some flood control benefits would be realized through water storage development, but channel work would also be required. Land treatment measures are needed to reduce damage from flooding, erosion, and sedimentation. It appears that an overall watershed project under P. L. 566 would be feasible.

Watershed G, Deer Creek

Description. The Deer Creek watershed covers an area of 34,750 acres in southwestern Yamhill County within the Yamhill County Soil Conservation District. Deer Creek flows south from Bald Mountain in the Coast Range and then east to enter the South Yamhill River six miles southeast of McMinnville, Oreg. Muddy Creek, a tributary, flows south and enters Deer Creek in Section 22, T-5-S, R-5-W. The watershed is about 13 miles long and 4 to 8 miles wide. Elevations in the watershed range from 140 feet to 2,200 feet with most of the cultivated

land below 380 feet. The annual precipitation in the lower watershed is about 46 inches and increases to over 70 inches in the higher elevations.

Three main groups of soils based on physiographic position make up the area. Residual soils derived from the underlying bedrock occupy the higher areas. Old valley fill soils comprise the second group, and the third consists of recent alluvial stream bottoms. The residual soils are derived from the igneous and sedimentary rock of the area. The igneous rocks have weathered deeply forming the Nekia and Hembre series. The weakly consolidated sedimentary rocks of the lower hills in most cases are not weathered as deeply as the igneous rocks. They give rise to the Astoria, Willakenzie, and Peavine series on the upper slopes. The moderately well drained Hazelair and poorly to very poorly drained Panther series occur on the lower slopes. Old valley fill soils are developed from transported materials of mixed origin and are of considerable age. Difference in origin and in drainage conditions with consequent differences in color and in character of subsoils have given rise to the moderately well drained Woodburn series and to the imperfectly drained Amity and the poorly drained Grand Ronde series. Soils of recent alluvial origin, of comparatively small extent, lie only a few feet above the normal flow of the streams and are subject to periodic flooding. Recent alluvial soils include the Chehalis, Wapato, Reed, and the Cove series.

An estimated 21,220 acres are forested. Most of the forest land has been logged or burned and now support stands of brush and young conifers, although oak stands occur in some areas. There is little chance of logging activity in the near future because there is little merchantable timber. About 84 percent of the forest land is in "medium" and "small" private ownerships; 10 percent is owned by large timber companies; and 6 percent is in public ownership. About half of the forest land in "medium" and "small" private ownership is grazed by livestock.

An estimated 21,600 acres in 130 farms are used for agricultural production including 11,550 acres of cropland, 1,340 acres of rangeland, and 8,710 acres of grazed forest land. The principal crops produced are grain and fruit, though some land is used for pasture and for production of grass for seed, row crops, and berries. About 720 acres are irrigated. Most cultivated land is in the extreme lower part of the watershed and in Gopher and Muddy Valleys.

Watershed Problems and Needs. Approximately 1,000 acres are flooded along Deer and Muddy Creeks damaging late fall crops and early spring crops.

There is slight streambank erosion on the upper reaches of the streams. It is estimated that 12 acres of cropland are lost each year near the confluence of Deer Creek and the South Yamhill River.

Flood problems could be controlled through installation of flood control structures, channel clearing, enlarging, and shaping.

Much of the range and grazed forest land is on steep terrain with erodible soils. Considerable sheet and gully erosion is occurring under the present grazing use. Many burned over hill slopes adjacent to Gopher and Muddy Valleys are used for supplemental pasture for livestock that cannot be supported by the limited improved pasture in the valleys. Much of the burned over forest land supports stands of brush with little chance of adequate stocking of desirable species through natural seeding. Reforestation of unproductive lands depends upon significant changes in the land use pattern to allow exclusion of livestock from hill lands and would require considerable site preparation to control brush.

Approximately 720 acres of cropland are irrigated, and an estimated additional 7,450 acres could be developed for irrigation. Development of the six reservoir sites (numbers 12 through 17) investigated within the watershed would add materially to the irrigation water supply.

Drainage problems occur on approximately 4,000 acres of arable land. Improved surface drainage and/or subsurface drainage are needed.

Opportunities under P. L. 566. Channel improvement measures are both desirable and practical, but complete flood prevention would also require storage. Channel improvement and installation of drainage measures would improve both surface and subsurface drainage, permitting increased yields and more intensive land use.

Development of reservoir sites would greatly benefit the irrigation potential in the area and provide considerable flood control. It appears that an overall watershed program might be feasible under existing conditions and laws if agricultural land use becomes more intensive.

Watershed H, Willamina Creek

Description. The Willamina Creek watershed occupies an area of 52,230 acres in Yamhill and Tillamook Counties. Approximately 5,000 acres of the upper watershed is in Tillamook County. It is entirely in the Yamhill County and South Tillamook Soil Conservation Districts. The creek flows south from the slopes of the Coast Range and enters the South Yamhill River at Willamina, Oreg.

Elevations in the watershed range from 220 feet to 2,600 feet with the cropland below 400 feet. The average annual precipitation is about 50 inches in the lower watershed and increases to 80 inches at the higher elevations.

This area has a mild climate with an average maximum temperature of 63° F. and average minimum of 40° F. The average frost-free period is 170 days.

The soils of the area consist mainly of three groups based on physiographic position. Residual soils derived from the underlying bedrock occupy the higher areas. Old valley fill soils comprise the second group, and the third consists of recent alluvium. The residual

soils are derived from the igneous and sedimentary rock of the area. The igneous rocks have weathered deeply forming the Nekia and Hembre series. The weakly consolidated sedimentary rocks of the lower hills, in most cases, are not weathered as deeply as the igneous rocks. They give rise to the Astoria, Willakenzie, and Peavine series on the upper slopes. The moderately well drained Hazelair and poorly to very poorly drained Panther series occur on the lower slopes. Old valley fill soils are developed from transported materials of mixed origin and are of considerable age. Difference in origin and in drainage conditon with consequent differences in color and in character of subsoils have given rise to the moderately well drained Woodburn series and to the imperfectly drained Amity and the poorly drained Grand Ronde series. Soils of recent alluvial origin of comparatively small extent lie only a few feet above the normal flow of the streams and are subject to periodic flooding. Recent alluvial soils include the Chehalis, Wapato, Reed, and the Cove series.

An estimated 47,860 acres, or 92 percent of the area, are forested. A majority of the watershed has experienced large fires within the past 80 years. Most of the oldest burned areas are well stocked with either conifers or alder, but a large recently burned area in the East Fork is mainly stocked with brush. There has been limited logging in large young-growth stands and salvage logging in burned areas. About 4 percent of the forest land adjacent to agricultural areas is grazed by livestock. About 38 percent of the forest land is in public ownership; 26 percent is owned by large timber companies; and 36 percent is owned by "medium" and "small" private owners.

About 5,670 acres in 220 farms are used for agricultural production including 3,190 acres of cropland, 480 acres of rangeland, and 2,000 acres of grazed forest land. Cropland uses include pasture and hay, small grains, and to a minor extent, row crops. About 550 acres are irrigated by sprinkler application or water pumped from streams.

Watershed Problems and Needs. Most of the forested part of the watershed is in good condition, though much of the forest cover consists of low value tree species and brush.

Annual overflow from the channel floods approximately 400 acres of cropland. Fall grain crops have been drowned out, and both spring and fall grain suffered from seepage and wet spots. Roads are undercut, and some damage to bridge abutments occurs. Floodwater damage to buildings and urban areas is very minor. Streambank erosion is a problem in some areas along the main creek. Excessive use of soil depleting crops on hill land has resulted in accelerated runoff and erosion on steeper slopes.

Channel clearance, shaping, and enlargement is needed on sections of the main channel. This would reduce the frequency of flooding and with upstream detention would virtually eliminate the overflow of the creek on the bottom lands.

Approximately 2,000 acres of arable land have excessively wet soils and are in need of either surface drainage, subsurface drainage, or a combination of both.

Channel shaping and clearance, land shaping, diversions, and grassed waterways would reduce the surface drainage problem. Improved outlets and drainage systems using both open and closed drains, where applicable, need to be installed.

There are irrigation water rights filed for 7.98 cfs. covering 700 acres, but only about 550 acres are being irrigated. With additional water development, 1,500 acres of cropland could be irrigated. Two possible dam sites (numbers 18 and 19) on Willamina Creek, one on Tindle Creek (number 21), and one on Coast Creek (number 20) would provide ample storage capacity to supply the irrigation water requirements for all the potentially irrigable land in the watershed.

Opportunities under P. L. 566. The problems in this watershed are of the type that apply to P. L. 566, but it appears the drainage area and water yield is large in comparison to the agricultural land damaged. Other damages are also quite minor in nature. It, therefore, appears a project would not be feasible under existing conditions and laws.

Watershed I, Cosper Creek

Description. The Cosper Creek watershed covers an area of 6,370 acres in southwestern Yamhill County in the Yamhill County Soil Conservation District. Cosper Creek flows southeast from the Coast Range to the South Yamhill River at Valley Junction, Oreg. The watershed is about 8 miles long and averages about 1 mile wide.

Elevations in the watershed range from 300 feet to 1,600 feet with most of the cropland below 500 feet. The average annual precipitation is about 68 inches. The climate is mild with an average temperature of about 52° F. and an average growing season of 170 days.

The soils of the watershed consist of three groups based on the physiographic position. Residual soils from the underlying bedrock occur on the higher areas. Soils developed on old terraces in the valley comprise the second group, and the third consists of soils developed on the recent alluvial terrace deposited by the streams. On the higher areas, basic igneous rock has weathered forming the Nekia and Hembre series. The sedimentary rock of the lower hills has weathered forming the Astoria, Willakenzie, and Peavine series on the upper slopes and Hazelair and Panther series on the lower slopes. The Woodburn, Amity, and Grand Ronde series have developed on the old valley terrace. The Chehalis, Wapato, Reed, and Cove series have developed on the recent alluvial terrace.

An estimated 3,930 acres are forested mostly with Douglas-fir and alder stands younger than 50 years. About 45 percent of the forest land is in public ownership administered by the Bureau of Land Management. About 49 percent is owned by one large timber company, and 6

percent is owned by farmers. There has been little logging recently, but about 25 percent of the forest land is grazed.

An estimated 3,360 acres in 10 farms are used for agricultural production with 2,000 acres of cropland, 360 acres of rangeland, and 1,000 acres of grazed forest land. The principal crops produced are pasture, hay, and grain. There is no irrigation in this watershed at present.

Watershed Problems and Needs. Very little flood related damage occurs in this watershed. Some streambank erosion occurs, but damage is slight. Approximately 180 acres are flooded along the lower reaches of the channel. This area is in pasture and hay crops so the damage is minor. Drainage is not a major problem in the Cosper Creek watershed.

There is an estimated 1,320 acres that are suitable for irrigation. Existing water supply is adequate for only about 100 acres. One reservoir site (number 22) was investigated. At the present time, there appears to be no interest in irrigation.

There are no significant watershed problems on the forest land.

Opportunities under P. L. 566. Under existing conditions and laws, there are insufficient benefits from flood control and erosion to justify the costs of a watershed protection project. Development of an irrigation system to provide an adequate water supply might be possible if land use becomes more intensive. It appears that a project under P. L. 566 would not be feasible under existing conditions and laws.

Watershed J, Agency Creek

Description. The Agency Creek watershed, a tributary of the South Yamhill River in southwestern Yamhill County, covers 16,660 acres. It is entirely in the Yamhill County Soil Conservation District. It flows in a southeasterly direction from the summit of the Coast Range Mountains to a point one mile north of Grand Ronde, Oreg., where it enters the South Yamhill River. The watershed is about 10 miles long and 2 to 3 miles wide. Elevation varies from 320 feet at the confluence of Agency Creek with the South Yamhill River to 2,900 feet on the highest peak in the northern end of the watershed. The rainfall varies from 100 inches in the upper watershed to 64 inches in the lower reaches.

The soils of the watershed consist of three groups based on physiographic position. Residual soils from the underlying bedrock occur on the higher areas. Soils developed on old terraces in the valley comprise the second group, and the third consist of soils developed on the recent alluvial terrace deposited by the streams. On the higher areas, basic igneous rock has weathered forming the Nekia and Hembre series. The sedimentary rock of the lower hills has weathered forming the Astoria, Willakenzie, and Peavine series on the upper slopes and Hazelair and Panther series on the lower slopes. The Woodburn, Amity,

and Grand Ronde series have developed on the old valley terraces. The Chehalis, Wapato, Reed, and Cove series have developed on the recent alluvial terrace.

An estimated 12,960 acres are forested with Douglas-fir and alder stands younger than 50 years. About 61 percent of the forest land is in public ownership, and 39 percent is owned by large timber companies. There has been little logging or grazing on forest land recently.

An estimated 4,000 acres in 55 farms are used for agricultural production including 1,500 acres of cropland, 2,000 acres of rangeland, and 500 acres of grazed forest land. Principal crops being produced in the watershed include pasture, small grain, and grass seed. Only 20 acres are irrigated, and they are devoted to pasture.

Watershed Problems and Needs. Flooding occurs annually on approximately 400 acres; most of this land is in pasture and hay crops. There is some bank cutting and erosion in the watershed. Channel clearing and shaping is needed to eliminate the major portion of this problem.

Approximately 2,000 acres of arable land in this watershed have excessively wet soils and are in need of drainage. It is estimated that there are 1,500 acres of land that are suitable for irrigation. The majority of the water required must be stored; one reservoir site (number 23) was investigated that could store enough water to irrigate more than 90 percent of land suitable for irrigation. There appears to be no interest in irrigation development at the present time.

There are no significant problems on the forested lands in this watershed.

Opportunities under P. L. 566. The benefits derived from flood protection and erosion alone would not justify the cost of protective measures. However, drainage and irrigation improvements might be practical if a more intensive agriculture program were adopted.

It appears that any watershed program combining all needs of the watershed might be feasible.

Watershed K, Upper South Yamhill

Description. The Upper South Yamhill watershed is in northwestern Polk County and southwestern Yamhill County. It covers an area of 67,650 acres and is the upstream portion of the South Yamhill River and is partly in the Yamhill County Soil Conservation District. It extends from the Coast Range summit to about two miles east of Willamina, Oreg. Agency, Cosper, and Willamina Creeks are excluded and studied as separate watersheds.

The area consists of hill land with steep slopes surrounding a narrow floodplain and terrace. The hills are made up of residual soils of both sedimentary and basic igneous origin. The Astoria and Blachly series are formed from sedimentary rock in the higher hills, and Nekia is formed from basic igneous rock. The Willakenizie and Peavine soils

are formed on sedimentary rock on the eastern lower hills. A combination of Salkum, Woodburn, Amity, and Holcomb is found on the terrace. Chehalis, Maytown, and Wapato soils are found on the floodplain.

The average annual precipitation varies from 46 to 100 inches. Elevations vary from 200 feet to 3,400 feet, although most agricultural land is below 400 feet.

Agricultural land use involves a comparatively small part of the watershed. The 5,200 acres of cropland include 2,000 acres of grain and 3,000 acres of pasture. About 200 acres of pasture are irrigated.

About 88 percent of the watershed, or 59,910 acres, is forested. The ownership is 16 percent public, 72 percent "large private", and 12 percent "medium and small private". Most of the forest land is covered with young alder or Douglas-fir stands, and there is little grazing or logging activity.

Watershed Problems and Needs. There is a slight problem of flooding on the lowlands during spring runoff with approximately 400 acres being flooded annually. Some streambank erosion also exists. Channel clearing and shaping would partially, if not completely, remedy this problem. A problem of severe erosion exists on the steeper pastureland and cropland. Land treatment measures and changes in land use are needed to correct this problem. Approximately 2,000 acres are in need of improved drainage which could be corrected through the installation of drainage systems.

It is estimated that 4,500 acres of additional land is suitable for irrigation. Storage is needed to irrigate this acreage as well as to supplement supplies for presently irrigated land during late summer. One reservoir site (number 25) was investigated, but due to location it would probably have no effect on flooding and is not adequate to provide water for all irrigable land.

There are no significant watershed problems on forest land.

Opportunities under P. L. 566. It appears that benefits from correcting the problems of this watershed are not large enough to justify the expenses necessary to control the water from such a large watershed. There is very little chance for a project under P. L. 566 for the entire area under present conditions and laws. It is possible some portions of the watershed would prove more favorable than the entire area.

Watershed M, Palmer Creek

Description. The Palmer Creek watershed occupies an area of 21,380 acres in southeastern Yamhill County in the Yamhill County Soil Conservation District. The creek flows north from the Eola Hills and enters the Yamhill River at Dayton, Oreg. The watershed is 11 1/2 miles long and is 4 1/4 miles wide at the widest point.

Elevations in the watershed range from 80 feet to 1,100 feet with most of the cropland below 200 feet. The average annual precipitation in the watershed is about 34 inches.

The climate of the area is mild with an average temperature of 52° F. The average frost-free period is 170 days.

The upper portion of the watershed is hill land comprised of about 6,000 acres of Nekia and Melbourne soils. Of this area roughly 1/2 of the land is cultivated, and the remainder is in brush, native grass, and timber. The lower portion is valley comprising about 15,400 acres. Twelve percent of this is very flat Dayton soil; 73 percent has very gentle slopes of 1 percent to 2 percent; and 15 percent are the steep slopes of Palmer Creek and its tributaries. The majority of this land is of the Willamette, Woodburn, and Amity series. Almost all is cultivated with the exception of the steep slopes near the creeks.

An estimated 3,700 acres are in forest stands of mixed hardwood and softwood species occurring in small tracts intermingled with agricultural land. Most of the forest land is owned by farmers, and almost half is grazed by livestock. Much of the forest land has been cutover and is in young-growth stands.

An estimated 18,780 acres in 150 farms are used for agricultural production including 14,370 acres of cropland, 2,610 acres of rangeland, and 1,800 acres of grazed forest land. The principal crops produced are grain, clover seed, row crops, berries, and orchards. About 3,070 acres are irrigated.

Watershed Problems and Needs. Approximately 580 acres of bottom lands are flooded annually. There is annual damage from high water to several roads crossing Palmer Creek. About 700 acres of cropland need surface drainage to provide for earlier planting of spring crops. Approximately 4,000 acres of arable land need open and closed subsurface drainage.

Approximately 200 acres of additional land are suitable for cropland development.

It is estimated that 12,500 acres of land are suitable for irrigation with water being available for early season irrigation on 1,000 acres without storage. Storage would be required to supply late season needs and to irrigate the remaining 11,500 acres. One reservoir site (number 10) has been investigated, and its development could add materially to the irrigation water supply.

Opportunities under P. L. 566. Opportunities exist for some channel improvement measures to relieve flooding and help improve drainage outlets. Other drainage measures would permit more intensive land use and increased yields.

The development of the reservoir site would supply irrigation water for a large section of the potentially irrigable land. Benefits could

also be credited for reduced flooding. Irrigation would permit more intensive land use and increased yields.

It appears that a multiple-purpose project including flood control, irrigation, drainage, and land treatment would be feasible under P. L. 566.

Watershed P, Mill Creek

Description. The Mill Creek watershed is located in northwestern Polk County. It contains 33,930 acres and originates near the summit of the Coast Range and extends northeast to enter the South Yamhill River three miles east of Willamina, Oreg. It is 15 miles long and varies in width from 1 1/2 to 5 miles.

It has an area of relatively high hills in the southwestern part reaching elevations of 3,400 feet. Toward the northeast the hills are lower in elevation. The drainage of Mill Creek has incised itself into this formation and has a floodplain and a second terrace bordering it. The lowest elevation is 200 feet on the floodplain at the mouth of Mill Creek.

The hills in the southwest portion contain soils of both sedimentary and basic igneous rock. These are the Astoria and Blachly soils on the sedimentary rock and Nekia on the basic igneous rock. The lower hills in the northeast part of the watershed are of sedimentary rock, and the soils formed on it are the Willakenzie and Peavine. The largest area of terrace soils are developed from gravelly sediments forming the Salkum series. There is, also, a small area of the Woodburn and Amity series. The floodplain soils are the Chehalis, Maytown, and Wapato group.

The average annual precipitation varies from 46 inches in the northeast to 100 inches in the higher hills in the southwest.

Approximately 5,090 acres in 100 farms are used for cropland. The majority of this land is in grass, forage crops, and grain. A small area is in orchards, and about 160 acres are irrigated pasture.

Approximately 28,160 acres are forested with 1,020 acres being grazed. Coniferous forest stands are predominant except at low elevations where oak stands are common. About 50 percent of the coniferous stand has been logged including about 6,000 acres at the head of Mill Creek. Forest landownership is 36 percent public, 31 percent "large private", and 33 percent "small private".

Watershed Problems and Needs. There is minor lowland flooding after heavy winter rains. Some streambanks are composed of gravelly material susceptible to undercutting and caving. Channel alignment and shaping with some bank protection at critical locations is needed on this creek.

Approximately 2,000 acres have excessively wet soils. Surface drainage does not seem to be a problem but subsurface drainage is need-

ed to allow more intensive land use. There is a shortage of irrigation water for the land presently irrigated. Also, it is estimated that an additional 4,000 acres of land is suitable for irrigation. A good reservoir site exists on Mill Creek for irrigation water and is reported feasible by the Bureau of Reclamation. This is the proposed storage site of the Red Prairie Irrigation Project studied by the Bureau of Reclamation. This project includes the irrigable land in the Mill Creek watershed and also a considerable area in Watershed L, South Yamhill River and Watershed O, Salt Creek for which no summary reports were written.

Intensive timber harvesting and road construction have resulted in some areas of serious erosion. Log jams have developed in upper Mill Creek causing some streambank erosion. A limited amount of land treatment is needed to lessen these problems.

Opportunities under P. L. 566. Damages from flooding are not great enough to produce sufficient benefits to justify the cost of protective measures. Drainage, land treatment, and irrigation development are practical but not feasible until such time as the land use becomes more intensive. A project does not appear to be feasible for the area included within the present boundaries but might be if other lands showing benefits were included.

Watershed R, Rickreall Creek

Description. The Rickreall watershed is located in the central part of Polk County and extends from the summit of the Coast Range to the confluence of Rickreall Creek and the Willamette River. It covers 41,120 acres and is approximately 25 miles long varying from one to four miles in width. Rickreall Creek and its tributaries which drain the watershed empties into the Willamette River three miles west of Salem.

The higher hills on the western end of the watershed vary in elevation of from 1,000 feet to 3,000 feet and vary in annual rainfall of from 70 inches to 100 inches. The western part which is the highest is of a sedimentary rock formation with the Astoria and Blachly soils being formed from it. The area just to the east is of a basic igneous rock formation, and the Nekia soil has been developed on it. The whole area is characterized by steep slopes and deep and narrow drainage ways.

The central portion of the watershed just west of Dallas is composed of sedimentary rock. The Willakenzie and Peavine soils have been formed from this rock. The elevation has a range of 400 to 1,000 feet, and the annual rainfall ranges from 50 inches to 70 inches.

The terrace area beginning near Dallas and extending to the Willamette River is composed of an old gravelly sediments formation and the Willamette Silts formation. The soils are the Salkum soil on the gravelly terrace and Woodburn, Amity, and Dayton on the Willamette Silts terrace. The elevation ranges from 150 feet to 400 feet, and the annual rainfall ranges from 32 inches to 50 inches.

The floodplain traverses the entire watershed with corresponding changes in elevation and rainfall. The soils are Chehalis, Maytown, Wapato, and Reed.

Almost a third of the watershed is cropland mostly in the eastern portion of the watershed, and the remainder is located near the streams farther west. It includes 300 acres of orchard, 1,350 acres of grain and forage, 12,150 acres of grain, 500 acres of pasture, and 100 acres of cannery crops. The 100 acres of cannery crops and 500 acres of pasture are irrigated by sprinkling water pumped from streams. It is estimated that an additional 500 acres could be developed for cropland.

An estimated 23,850 acres are forested. Most of the watershed west of Dallas is covered with coniferous forests that are either publicly owned or owned by large timber companies. A minor portion of the watershed east of Dallas is forested, mostly with hardwoods and is in "medium" and "small" private ownership. Overall, 18 percent of the forest land is publicly owned; 56 percent is owned by large timber companies; and 26 percent is owned by "medium" and "small" private owners. About 60 percent of the forest land has been cutover by clear-cutting methods during the past 30 years. Most logged areas are re-stocked.

Watershed Problems and Needs. Considerable damage occurs annually from floods caused by above normal rainfall. There is severe damage to fields from gully, rill, and bank erosion along Rickreall Creek below Dallas. Floods cause damage annually to buildings, fences, roads, and bridges on the floodplain. Approximately 700 acres are inundated for extended periods each year causing damage to crops and creating drainage problems.

The forest land presents few watershed problems. There is some sheet erosion for one to two years after logging; some skid roads, landings, and spur truck roads that have been abandoned are subject to gully erosion.

Approximately 2,000 acres of arable land have excessively wet soils and are in need of drainage. This could be accomplished with either closed or open drains.

It is estimated that 13,000 acres of additional land are suitable for irrigation, but water from storage is needed. One reservoir site (number 32) on Ellendale Creek was investigated in connection with this report, and another has been proposed by the Corps of Engineers, U. S. Army on Rickreall Creek. These storage sites could supply water for a large portion of the irrigable land. The Bureau of Reclamation is working on a proposed irrigation project called the "Monmouth-Dallas Project" that would include a majority of the irrigable land in the watershed.

Opportunities under P. L. 566. There are opportunities in this watershed for project action to reduce the flooding and improve subsurface drainage. A stream channel program involving clearing of debris and gravel bars, realignment, and bank protection would greatly reduce

the damage resulting from flooding. Further irrigation development would probably increase drainage problems which could be considered in an overall program. It appears that a program of flood control, drainage, and land treatment would be feasible under P. L. 566.

Watershed T, Little Luckiamute River

Description. The Little Luckiamute River watershed, a tributary of the Luckiamute River, covers an area of 52,640 acres in southwestern Polk County. The watershed is about 5 miles wide and 18 miles long from the summit of the Coast Range to the confluence of the Little Luckiamute River and the Luckiamute River.

The upper half of the watershed, west of Falls City, is in the Coast Range with topography characterized by deep, steep drainage ways and narrow ridgetops and elevations ranging from 380 feet at Falls City to 3,300 feet on the highest summits. This portion of the watershed is composed of two major formations; the western area is sedimentary rock, and the eastern area is basic igneous rock. Astoria and Blachly soils have formed on the sedimentary rock, and Nekia soil has formed on the basic igneous rock. The average annual precipitation in the upper watershed varies from 70 inches on the east to 135 inches on the west.

The lower half of the watershed, east of Falls City, has generally hilly topography with a nearly level terrace and floodplain along the Little Luckiamute and its tributaries. Elevations vary from 250 to 400 feet along the river and 500 to 1,500 feet on the hill tops. The hills are formed from sedimentary rock and are characterized by rounded tops and moderately steep slopes. Soils are of the Willakenzie-Peavine-Sites association. The average annual precipitation varies from 50 to 70 inches.

There is a small terrace area of Woodburn, Amity, and Dayton soils lying at elevations of 250 to 400 feet. A floodplain lies along the Little Luckiamute below Falls City and is composed of Chehalis, Maytown, Wapato, and Reed soils. Average annual precipitation in the terrace and floodplain areas is 40 to 50 inches.

An estimated 43,160 acres are forest land. Forests cover most of the western half of the watershed and about half of the hill and floodplain lands in the eastern half of the watershed. Coniferous forests are predominant in the western half of the watershed while oak and other hardwoods are most common east of Falls City. About 30 percent of the upper watershed has been logged by clearcutting methods since 1940, and there is some current logging activity in this area. Less than 10 percent of the forest land, mostly adjacent to pasture land in the eastern half of the watershed, is grazed. Many areas near Falls City that were farmed or grazed have been abandoned and have reforested naturally. About 58 percent of the forest land is owned by "medium" and "small" owners; 36 percent is owned by large timber companies; and 6 percent is in public ownership. The forest land west of Falls City is mostly owned by large timber companies while that east of Falls City is owned by "medium" and "small" private owners.

An estimated 11,020 acres in 30 farms are used for agricultural production including 5,260 acres of cropland, 2,630 acres of rangeland, and 3,130 acres of grazed forest land. Most of the agricultural land is located in the eastern half of the watershed, primarily on the terrace and floodplain. The cropland consists of 2,530 acres of pasture, 2,330 acres of grain, 300 acres of orchard, and 100 acres of row crops. At present, 100 acres of row crops and 200 acres of pasture are irrigated. It is estimated that an additional 500 acres could be developed as cropland.

Watershed Problems and Needs. Considerable damage is caused by flooding annually. An estimated 1,500 acres is inundated for extended periods of time causing crop damage and drainage problems. There is deposition of debris on the pasture lands near the streams. Serious erosion and sedimentation occurs on cropland. There is a small amount of damage to structures, particularly accumulation of flood debris on the fences.

Erosion problems on forest land are mostly confined to roads and recently logged areas. Some logging roads, abandoned without construction of adequate drainage ways, are subject to gully erosion; and unprotected cut and fill slopes are subject to sheet and rill erosion. Sheet erosion occurs on recently cutover land, but vegetation usually becomes re-established within 1 to 3 years.

Approximately 3,000 acres of arable land have a wetness problem and are in need of drainage. This could be accomplished with closed drains.

Approximately 4,000 acres are suitable for irrigation. It would be necessary to store water to irrigate this land.

There is need of water development for domestic, municipal, and industrial use in the vicinity of Monmouth and Independence.

Several reservoir sites have been investigated by other agencies that have possibilities for multiple-purpose development.

Opportunities under P. L. 566. The problems of this watershed are applicable to P. L. 566. It has promise of showing high benefits from agricultural, domestic, municipal, industrial, and recreation uses; for this reason, a project might prove feasible despite four-fifths of the drainage area being forested.

Watershed U, Luckiamute River

Description. The Luckiamute River watershed includes 113,900 acres located in southwestern Polk County and northwestern Benton County. It is partly in the Benton Soil Conservation District. It is somewhat triangular in shape with the wide end on the west near the summit of the Coast Range. This is caused by the direction that the Luckiamute River flows - first, in a southeasterly direction from the summit, then

in a northeasterly direction, and again in a southeasterly direction to where it flows into the Willamette River about 9 miles downstream from Albany.

The watershed divides into three general areas on the basis of elevation, topography, and geology.

The central area of the watershed is composed of hills formed on sedimentary rock with moderately steep topography. The soils are of the Willakenzie-Peavine-Sites association. The elevation ranges from 400 feet to 1,000 feet, and the annual rainfall ranges from 50 to 70 inches.

The most westerly and highest portion of the watershed is rugged and has sharply incised drainages with narrow ridgetops and floodplains. The elevation varies from 1,000 feet to 3,300 feet above sea level, and the annual rainfall varies from 60 to 135 inches. The soils on most of the area are Astoria and Blachly formed on sedimentary formations, except for a small part of the east side where Nekia soils are formed from basic igneous rock.

There is a relatively large area of terrace soils in the eastern end of the watershed lying on both sides of U. S. Highway 99W and extending beyond Parker to the Willamette River. The soils are the Woodburn, Amity, Holcomb, and Dayton series. The elevation varies from 200 to 400 feet. The annual rainfall varies from 32 to 50 inches.

A floodplain dissects the entire length of the watershed with corresponding changes in elevation and rainfall. It is rather narrow in the western part but becomes wide near the Willamette River. The soils are Chehalis, Maytown, Wapato, and Reed series.

An estimated 87,330 acres are forested. Most of the hill and mountainous areas are forested with coniferous stands, although hardwoods occur along stream courses and on low hills in the central and eastern parts of the watershed. About 50 percent of the forest stands have been cutover by clearcutting methods including most of the central part of the watershed. There is currently considerable timber harvesting activity in the western portion. About 10 percent of the forest land is grazed by livestock. About 55 percent of the forest land is owned by "medium" and "small" private owners; 40 percent is owned by large timber companies; and 5 percent is in public ownership.

Approximately 15 percent of the watershed area is cropland. Most of this is in the east portion on the terrace soils. The cropland includes 6,300 acres of grass and forage, 11,220 acres of grain, 50 acres of orchards, 650 acres of pasture, and 270 acres of row crops. The latter two are usually irrigated by pumping directly from streams. It is estimated that an additional 1,500 acres could be developed for cropland. There are an estimated 5,000 acres of rangeland and 8,890 acres of grazed forest land.

Watershed Problems and Needs. Considerable damage is caused by flooding each year. An estimated 6,000 acres are flooded for extended

periods, causing damage to crops, fences, roads, streambanks, and fields. There is also severe damage from erosion, debris deposition, and sedimentation in the downstream portion of the watershed.

There is considerable gully erosion on abandoned logging roads in the central part of the watershed. Most cutover areas are well covered with soil-protecting vegetation so are not subject to erosion. A limited amount of grazed forest land on steep slopes has active sheet and gully erosion.

An estimated 7,000 acres of arable land have a wetness problem and are in the need of drainage which could be accomplished with open or closed drains.

An estimated 17,000 acres of additional land are suitable for irrigation. To develop this potential, storage facilities will be needed. Seven reservoir sites (numbers 34, 36, 37, 39, 40, 41, and 43) were investigated in connection with this report, and several others have been investigated by other agencies. There is sufficient storage represented by these sites to provide irrigation water for all of the arable acreage.

Opportunities under P. L. 566. The total flood control problems probably are beyond the scope of P. L. 566; but some improvements could be made to greatly reduce flooding in certain areas. There is need for channel improvement such as alignment and clearing. Land treatment measures would reduce erosion and sedimentation problems. Drainage improvement and irrigation development would probably be feasible if more intensive use is made of the land. It appears that at this time a project on the total area would not be feasible, but projects involving portions of the watershed might be feasible; or an overall project might be feasible in cooperation with the Corps of Engineers, U. S. Army.

7. PUDDING SUBBASIN

Watershed B, Champoeg Creek

Description. The Champoeg Creek watershed is a tributary of the Willamette River in northwestern Marion County in the Mt. Angel Soil Conservation District. It contains 29,680 acres lying in a generally north-south direction roughly paralleling the Willamette River. It includes Champoeg Creek and its tributaries, Mission Creek, West Champoeg Creek, East Champoeg Creek, and Case Creek.

The watershed is composed of two physiographic units which have different origin, geology, and soils. About 97 percent of the area is the Willamette Silts terrace. The Willamette, Woodburn, Amity, Concord, and Dayton soils have formed on this terrace. The elevation is 115 to 184 feet with level to gently sloping topography. The average annual precipitation is 40 inches.

The floodplain of recent alluvial soils follows the drainage ways throughout the length of the watershed. The soils are Chehalis, New-

berg, and Wapato series. The elevation is 95 to 125 feet, and the topography is level to gently sloping.

An estimated 4,850 acres are forested. Most of it is composed of hardwoods that parallel the streams. Approximately 550 acres are grazed.

There are about 22,520 acres of cropland in 150 farms. A wide variety of crops are grown. An estimated 4,000 acres is irrigated including 1,050 acres of pasture and 2,950 acres of row and specialty crops. About two-thirds of the nonirrigated cropland is used to produce grain, and one-third is used to produce pasture, grass seed, and orchards.

Watershed Problems and Needs. Minor to moderate damage occurs annually from floods caused by rains of longer duration and greater intensity than normal. Annual flooding for extended periods occurs on about 300 acres. There is minor to moderate damage from erosion and deposition of debris and silt to crops, fields, farm facilities, irrigation structures, ditches, and fences. Minor damage occurs to roads, bridges, and urban areas. Channel shaping, clearing, straightening, and enlargement are needed to reduce flooding.

Approximately 9,000 acres of arable land have excessively wet soils that could be improved with subsurface drainage.

An estimated additional 19,000 acres are suitable for irrigation. It is estimated that there is a source of water from natural streamflow and underground water to irrigate an additional 3,000 acres. A water supply from outside the watershed would be needed to permit irrigation of the remainder.

Opportunities under P. L. 566. The problems of this watershed are applicable to P. L. 566. There is intensive agricultural land use and a need for expansion of irrigation; but with the additional water supplies limited within the watershed an irrigation, flood control, drainage, and land treatment project may not be possible unless water from the Willamette River or another watershed could be used.

Watershed C, Lower Pudding River

Description. The Lower Pudding River watershed is located in northwestern Marion County and Clackamas County within the Mt. Angel and South Clackamas Soil Conservation Districts. It includes the downstream portion of Pudding River from its confluence with Butte Creek to the Willamette River. It contains 35,310 acres and lies in a generally north-south direction. The drainages include Deer Creek, Seven-up Creek, Mill Creek, and Senecal Creek.

The watershed is separated into two physiographic units having different origin, geology, and soils. About 90 percent of the watershed is composed of the Willamette Silts terrace including the soils of the Willamette, Woodburn, Amity, Concord, Dayton, and Holcomb series. About 10 percent of the area is a recent alluvial terrace adjacent to

the streams composed of soils of the Chehalis, Newberg, and Wapato series with small areas of peat. The topography is level to gently sloping with terrace escarpments having steeper slopes. The elevation varies from 90 to 185 feet. The average annual precipitation is 40 inches.

A wide variety of crops are grown on the 24,060 acres of cropland. About 3,500 acres are irrigated and used to produce vegetables, berries, pasture, and specialty crops. The dryland crops include pasture, grain, grass seed, and berries.

There are about 6,800 acres of hardwood forest paralleling the streams. Approximately 1,800 acres of the forested land are grazed with varying degrees of management.

Watershed Problems and Needs. Considerable damage occurs annually along the streams and floodplains. An estimated 600 acres are flooded annually for extended periods because of rains of longer duration and greater intensity than normal. Pasture and cropland incurs minor to heavy damage annually from flooding and the deposition of debris and sediment. There is moderate to heavy damage to irrigation ditches and bridges. Minor to moderate damage occurs to fences, roads, bridges, and urban areas. Channel shaping, clearing, straightening, and enlargement are needed to prevent overflow and provide outlets for drainage. Approximately 9,000 acres are excessively wet and could be improved with subsurface drainage.

It is estimated that 20,000 acres of additional land are suitable for irrigation. Water from natural streamflow and underground water is sufficient to irrigate 1,250 acres. The remaining 18,250 acres would need water from another source. No reservoir sites were studied in the watershed.

Opportunities under P. L. 566. The problems and needs of this watershed are applicable to P. L. 566; but the opportunity for their solution will be affected by watershed development in the Upper Pudding River watershed. An application has been filed for a watershed project in the Upper Pudding River watershed; but the lower part of Pudding River could not be included because of acreage limitations under the law. It would be very desirable if the needs of the Lower Pudding River watershed could be considered in the planning of the Upper Pudding River watershed. For instance, the upper watershed has several promising storage sites whose development could help meet flood control and water supply needs of the lower watershed. The Lower Pudding River watershed lacks storage sites and presents little opportunity for flood control on the main river or development of water for irrigation. A project including flood control, drainage, land treatment, and irrigation development would probably not be practicable in the Lower Pudding River watershed alone.

Watershed D, Rock Creek

Description. The Rock Creek watershed, a tributary of the Pudding River, contains 40,680 acres in southwestern Clackamas County in the

South Clackamas Soil Conservation District. Rock Creek and its tributaries flow in a north to northwesterly direction from the foothills of the Cascades. The watershed is 13 miles long and 3 to 7 miles wide. The northwestern half of the watershed is in the Willamette Valley with elevations of 150 to 300 feet. The southwestern half of the watershed is in the foothills of the Cascades with elevations as high as 2,000 feet. Average annual precipitation ranges from 45 to 50 inches.

The watershed contains three general areas of soils based on physiographic position. The southeastern half is composed of residual soils on the uplands. There are the residual soils of basic igneous material which form the McCully, Nekia, and Viola series and the residual soils of sedimentary material which form the Steiwer and Hazelair series. The northwestern half is the Willamette Silts formation on which has formed Willamette, Woodburn, Amity, Holcomb, and Dayton series. The floodplain, lying adjacent to streams throughout the watershed, contains Maytown and Wapato series.

An estimated 12,800 acres are forested. Most of the forest land is in the foothills of the Cascades. The original stands were logged more than 20 years ago, and the land now supports well stocked stands of Douglas-fir and Western hemlock. Forest stands in the valley grow on creek bottoms and poorly drained areas that support hardwood and mixed hardwood and Douglas-fir stands. Most of the forest land in the valley and some forest land in the Cascade foothills is grazed by livestock. About 96 percent of the forest land is owned by "medium" and "small" private owners; 1 percent is owned by "large" private owners; and 3 percent is federally owned.

An estimated 32,870 acres in 480 farms are used for agricultural production including 21,870 acres of cropland, 4,000 acres of rangeland, and 7,000 acres of grazed forest land. About 800 acres of cropland are irrigated including 300 acres of pasture and 500 acres of row crops and berries. The 21,070 acres of dryland cropland include 10,500 acres of corn and grains, 7,270 acres of pasture and hay, 500 acres of row crops and berries, and 2,800 acres of specialty crops. Approximately 3,100 acres of additional land could be developed as cropland.

Most of the row crops, berries, and specialty crops are grown on the floodplains and terraces while the grain and forage crops are usually on the hill land. Some cutover hill land is being converted to range by repeated burning while some range is permitted to revert to forest.

Watershed Problems and Needs. There is practically no timber harvesting activity on forest land at present. Some erosion occurs on approximately 500 acres of forest land that are currently being converted to range.

Approximately 1,750 acres involving 35 farms are subject to flooding and have problems of sedimentation and debris deposition. There is some damage to buildings and fences adjacent to streams. Channel work is needed to remove log jams and vegetation that restrict stream-

flows and cause flooding. Beaver dams also contribute to flooding problems.

Around 7,000 acres of arable land have excessively wet soils; subsurface drainage, particularly closed drains, is needed.

Additional irrigation water is needed. Some late season shortages occur where streamflow is used for irrigation. An additional 20,000 acres are suitable for irrigation development with approximately 15,150 acres dependent on development of storage. Three reservoir sites (numbers 6, 7, and 8) were investigated in connection with this study, but their combined storage would only irrigate about 3,000 acres.

Opportunities under P. L. 566. Channel clearing and alignment would probably have the most beneficial effect on flood control. The lower channels are congested and have fairly flat gradients. The flood control benefits from storage alone probably would not justify the cost of construction so drainage could be improved through installation of closed and open drains. Some land shaping would reduce localized surface ponding. Development of irrigation water would permit more intensive land use and greater crop yields. The watershed yield is adequate to supply the needed water, but a thorough study would be required to determine additional storage sites. It appears that a program of flood control, drainage, land treatment in the upper watershed, and/or irrigation development could be feasible under existing conditions and laws.

Watershed E, Bear Creek

Description. The Bear Creek watershed, a tributary of Rock Creek in southwestern Clackamas County, contains 13,080 acres. It is in the South Clackamas Soil Conservation District. The creek rises near Molalla, Oreg., and flows northwest to join Rock Creek. The watershed is about 11 miles long and 1 to 3 miles wide. The elevation ranges from 125 to 600 feet with an average annual precipitation of about 45 inches.

The watershed contains three general areas of soils based on physiographic position. The east end of the watershed is an area of high terraces of mixed origin containing soils of the Cazadera and Cottrell series. A large portion of the watershed is on the Willamette Silts formation on which have formed the Willamette, Woodburn, Amity, Dayton, and Concord series. The floodplain through the area contains soils of the Chehalis, Newberg, Maytown, Wapato, and Reed series.

About 2,320 acres are forested of which 1,100 acres are grazed. The forested land is in scattered tracts, usually smaller than 100 acres, owned by farmers and ranchers.

Approximately 10,960 acres in 180 farms are used for agricultural production including 8,810 acres of cropland, 1,050 acres of rangeland, and 1,100 acres of grazed forest land. About 350 acres of cropland are irrigated including vegetables, berries, and pasture. Such

crops as grain, corn, grass seed, pasture, hay, and legume seed are produced on nonirrigated cropland. Approximately 800 acres of additional land could be developed for cropland.

Watershed Problems and Needs. There are no significant watershed problems on forest land. Annual flooding damages about 20 acres of land. Some debris deposition occurs along the main channel of Bear Creek. There is slight damage to bridges on farm roads. The channel is badly congested with vegetation and beaver dams. Channel clearing and shaping would greatly reduce flooding.

Approximately 3,000 acres of arable land have excessively wet soils. Improved outlets along with additional subsurface drainage practices are needed. Channel clearing would also have a beneficial effect on drainage problems.

Estimates show that an additional 8,200 acres are suitable for irrigation. Water is available for about 15 percent of this land with storage being required for the remaining 85 percent. Two reservoir sites (numbers 4 and 5) with a combined storage of 3,300 acre feet were investigated.

Opportunities under P. L. 566. Stream channel improvement would alleviate most of the minor flooding problem and also provide improved drainage outlets. Improved surface drainage through tile installation is also needed. An adequate water supply for irrigation development is probably the major need in this watershed. A thorough study of the possibilities of outside water being brought in as compared to storage within the basin would be necessary to determine the most economical source. It appears that a watershed project including flood control, drainage, and irrigation development might be feasible.

Watershed F, Gribble Creek

Description. The Gribble Creek watershed, a tributary of the Molalla River, contains 10,590 acres in southwestern Clackamas County. It lies within the boundaries of the South Clackamas Soil Conservation District. Gribble Creek and Creamery Creek, its principal tributary, rise near Molalla and flow northwest to enter the Molalla River about 5 miles upstream from its confluence with the Willamette River. The watershed is about 9 miles long and 1 to 3 miles wide. The topography varies from level to gently sloping valley bottom with elevations ranging from 125 to 400 feet. The average annual precipitation is about 44 inches.

The watershed contains three general areas of soils based on physiographic position. About 14 percent of the watershed is on high terraces of mixed origin containing the Cazadera and Cottrell soil series. Approximately 80 percent of the watershed is on the Willamette Silts formation with Willamette, Woodburn, Amity, Dayton, and Concord soil series. A floodplain cuts through the area and contains the Chehalis, Newberg, Maytown, Wapato, and Reed series.

The 1,100 acres of forest land is in small scattered tracts of less than 100 acres, usually in poorly drained areas. More than half of it is grazed.

About 9,530 acres in 160 farms are used for agricultural production including 8,280 acres of cropland, 650 acres of rangeland, and 600 acres of grazed forest land. About 500 acres of cropland are irrigated including about 250 acres of row crops and berries, 150 acres of pasture, and 100 acres of nursery crops. Other cropland includes 3,600 acres of corn and grain, 2,500 acres of pasture, 980 acres of specialty crops, 600 acres of grass seed, and 100 acres of row crops and berries. An additional 650 acres could be developed for cropland.

Watershed Problems and Needs. There are significant watershed problems on forest land. Flooding is a minor problem in this watershed with only about 100 acres of pasture land being affected. There is some damage to farm fences from debris deposition. Flooding is largely a result of numerous beaver dams and vegetative growth in the channels, conditions that also reduce the adequacy of the channel as a drainage outlet. Channel clearing would eliminate annual flooding and improve existing drainage outlets. Additional subsurface drainage is required on about 2,000 acres.

An estimated additional 6,000 acres are suitable for irrigation, but an adequate supply of irrigation water needs to be developed. There is a late season shortage where water is pumped from streams. No reservoir sites for the storage of irrigation water were studied within the boundaries of the watershed. Water could possibly be obtained from the Molalla River.

Opportunities under P. L. 566. There would be limited benefits from elimination of annual flooding, but the cost of channel improvement might be justified in conjunction with improved drainage outlets. Open and closed subsurface drainage systems would benefit cropland and improve the possibilities of more intense cropping on the wet lands. Opportunities for development of irrigation would depend on location of storage sites or an adequate source of water outside the watershed. It appears that a program of flood control, drainage, and land treatment could be feasible under existing conditions and laws.

Watershed G, Molalla River

Description. The Molalla River watershed, as described in this study, includes the Molalla River and its tributaries except Milk Creek and Gribble Creek which are discussed separately. The remaining Molalla River watershed includes 150,600 acres in southwestern Clackamas County within the boundaries of South Clackamas Soil Conservation District. The Molalla River and its tributaries rise in the western Cascade Range and flow generally northwest through the western Cascades and Willamette Valley to the Willamette River near Canby. The watershed within the Cascades is roughly rectangular; it is about 16 miles long and 12 to 15 miles wide. The watershed within the valley is long and narrow; it is about 16 miles long and 1 to 2 miles wide.

Elevations in the level to gently sloping lower portion of the watershed are from 70 to 400 feet. Elevations in the mountainous upper portion of the watershed range from 400 feet to nearly 5,000 feet. Average annual precipitation ranges from 40 to 50 inches in the valley to about 130 inches at the headwaters.

There are four general areas of soils based on physiographic position. The upper watershed, occupying about 70 percent of the area, has the Kinney series and lithosols developed from basic igneous material. The central part of the watershed is composed of residual soils of both basic igneous material, which form the McCully, Nekia, and Viola series, and sedimentary material, which form the Steiwer and Hazelair series. The western end of the watershed is the Willamette Silts formation on which have developed Hillsboro, Willamette, Woodburn, Amity, Concord, Holcomb, and Dayton series. The floodplain, adjacent to the streams, contains the Chehalis, Maytown, Newberg series and a small amount of the Wapato and Reed series.

About 132,900 acres are forested. Most of the mountainous upper watershed is forested with stands of mixed conifers. Most of the land immediately adjacent to the Molalla River in the Willamette Valley is forested with hardwoods. About 20 percent of the forest land has been logged by clearcutting methods since 1930, and there is currently considerable logging activity in the upper watershed. About 27 percent of the forest land is in public ownership; 56 percent is owned by large timber companies; and 17 percent is owned by "medium" and "small" private owners.

An estimated 17,630 acres in 350 farms are used for agricultural production including 15,170 acres of cropland, 1,340 acres of rangeland, and 1,120 acres of grazed forest land. About 2,570 acres of cropland are irrigated including 1,670 acres of pasture and 900 acres of row crops and berries. The 12,600 acres of nonirrigated cropland include 5,200 acres of grain, 4,800 acres of pasture, 2,200 acres of grass for seed, and 400 acres of row crops and berries. Approximately 500 acres of additional land are suitable for cropland development.

Watershed Problems and Needs. All but the most recently cutover forest land is well stocked with trees and other vegetation. Cutovers usually become restocked within 1 to 3 years so present only minor erosion problems. Considerable erosion is occurring on roads, particularly those with inadequate drainage, or those without adequate maintenance. Logging slash has formed large jams in the channels of several tributaries causing bank erosion and blocking fish migration. Logging debris carried downstream during floods has caused considerable property damage along the lower Molalla River.

There is considerable flooding along the lower reaches of the Molalla River. Approximately 2,000 acres of land adjacent to the river are subject to frequent flooding. Flood damage is mainly from inundation and streambank erosion. Residences in the Shady Dell Area and some irrigation pumping sites along the river have been damaged by high water and bank erosion. Dikes have been built by the Corps of Engineers, U. S. Army to reduce flooding in some areas. It appears

that removal of log jams and other obstructions would further aid in reducing flooding. The Corps of Engineers has investigated two upstream sites for flood control storage and also are studying the possibility of additional diking and bank revetment. One reservoir site (number 12) was investigated in connection with this report, but because of the volume of runoff, it would have little value for flood control.

It is estimated that 1,500 acres of arable land have excessively wet soils and are in need of improved subsurface drainage.

Approximately 12,500 acres of additional land are suitable for irrigation. Water is available from underground storage for about 2,500 acres. At present, there is some seasonal shortage of surface flows for irrigation.

Opportunities under P. L. 566. The flood control problem is too large to consider under P. L. 566. The Corps of Engineers, U. S. Army has been working on plans to solve this problem. Drainage problems could probably best be solved by individual or small group projects under other programs. Irrigation development and land treatment measures could be provided under P. L. 566, but a project of such limited objectives would probably not be feasible. A joint project with the Corps of Engineers, U. S. Army that would include flood control, land treatment, and irrigation might be feasible.

Watershed H, Milk Creek

Description. The Milk Creek watershed, a tributary of the Molalla River, contains 65,790 acres in southwestern Clackamas County between the Clackamas and Molalla Rivers. It is in the South Clackamas Soil Conservation District. Milk Creek and its tributaries rise in the Cascade foothills and flow in a generally westerly direction to enter the Molalla River about 13 miles upstream from its confluence with the Willamette River. The watershed is about 14 miles long and 6 to 10 miles wide. Most of the watershed has hilly topography, but there are several large level to sloping areas along Milk Creek and on ridgetops in the eastern part of the watershed. A few steep slopes occur in some small tributaries and on Green Mountain in the southeastern part of the watershed. Elevations range from 125 feet at the mouth of Milk Creek to 3,575 feet on Green Mountain. The average annual precipitation is 40 to 70 inches.

Four general areas of soils are found in the watershed based on physiographic position. Almost 80 percent is high terraces of mixed origin and contains the Cazadero and Cottrell series. East of this area of high terraces is an area of residual soil of the Kinney series formed on basic igneous material. A small area west of the high terraces is occupied by the Woodburn and Amity series formed on the Willamette Silts deposit. A floodplain dissects the area and contains Chehalis, Newberg, Maytown, Wapato, and Reed series.

An estimated 45,460 acres are forested. Coniferous stands are predominant. About half of the forest land has been cutover; but it

is well stocked except where regeneration has been discouraged to keep areas open for livestock grazing. There has been little logging activity during the past five years. About half of the forest land is grazed. About 79 percent of the forest land is owned by "medium" and "small" private owners. Large timber companies own 13 percent, and 8 percent is in public ownership.

An estimated 41,330 acres in 585 farms are used for agricultural production including 15,330 acres of cropland, 3,000 acres of rangeland, and 23,000 acres of grazed forest land. About 1,850 acres of cropland are irrigated including 970 acres of pasture and 880 acres of row crops and berries. The 13,480 acres of dryland cropland include 7,000 acres of pasture, 4,400 acres of grain, 1,640 acres of grass seed, and 440 acres of specialty crops.

Watershed Problems and Needs. Most forest land is well stocked with trees or brush species that adequately protect watershed values. Some abandoned skid roads and logging roads are sources of erosion.

Flood damage is quite severe at times in the Milk Creek watershed. It is estimated that 2,750 acres are flooded and are subjected to varying degrees of damage. The primary cause of flooding is channel congestion from log jams and other obstructions. Severe bank erosion has occurred along lower sections of the main channel with losses of cropland. There has been considerable sedimentation and erosion damage to cropland from flooding. Some farm facilities and urban developments have also been damaged. Channel clearance would correct many flooding problems and reservoirs on the headwaters could be beneficial in controlling peak discharges.

An estimated 8,000 acres of arable land have excessively wet soils. Some of this land needs improved surface drainage as well as subsurface drainage.

About 17,500 acres of additional land are suitable for irrigation. Ground water is adequate to irrigate about 1,200 acres. The remaining 16,300 acres would need to be supplied from stored water. Three reservoir sites were investigated in connection with this report. They include one on Buckner Creek (number 1) and two on Cedar Creek (numbers 2 and 3) with a combined storage of 6,500 acre feet. Additional sites might be located with further study.

Opportunities under P. L. 566. Opportunities for flood control and drainage depend on channel clearance. Construction of reservoirs would also help control floods as well as store water for irrigation. Land treatment to reduce erosion, provide drainage, and improve irrigation is also necessary. It appears that a program of flood control, drainage, land treatment, and irrigation would be feasible under existing conditions and laws.

MEANS TO ACCOMPLISH NEEDED WORK

PROGRAMS OF USDA

Several agencies within the U. S. Department of Agriculture administer programs that are directly concerned with various aspects of water and related land resources. Many of the department's activities and programs are, or can be, helpful in the solution of problems and the accomplishment of needed work in the Middle Willamette River Basin.

COORDINATION OF USDA PROGRAMS AND OTHER BASIN ACTIVITIES

In general, the forestry and agricultural aspects of water and related land resource problems are often intimately connected with uses of land and water for other purposes such as cities and towns, recreation, navigation, industry, and highways. The degree of relationship varies between geographic areas depending primarily upon the resource base available and pressures upon that base.

The U. S. Department of Agriculture is concerned with all agricultural and forest land in the basin and is responsible for the administration of the 14 percent of the basin that is in national forests. The Bureau of Land Management of the U. S. Department of Interior is responsible for the administration of about 6 percent of the area. Therefore, the federal government is directly responsible for the administration of approximately 20 percent of the Middle Willamette River Basin. The management of this land is an important factor in the economy of the basin and influences the timing of water flows and the quality of water flowing from the upper watersheds.

The Corps of Engineers, U. S. Army under assignment by Congress is charged with the public civil works program to control, regulate, and improve river and harbor resources, to administer the laws pertaining to the preservation of navigable waters, and to plan, construct, and operate flood control works. Many of the existing and possible future projects under the Corps' jurisdiction affect agricultural lands. Substantial assistance in the solution of basin agricultural problems has and will accrue from the coordination of the Corps' work and that of other interests in the basin.

Private and municipal water developments for power and industrial uses in some instances affect agricultural and forest lands. In many cases, substantial mutual benefits can result from the coordination of projects so as to solve or mitigate existing problems.

From an agricultural standpoint, there is a need for coordination of effort on present and future problems on an individual, group, and project basis. In turn it is important that agricultural water control and utilization developments recognize to the extent feasible all other land and water uses and values. Such coordination is necessary to a secure a diminishment of mutual problems instead of their compoundment. Notable coordination has occurred and should be continued. This co-

ordination ranges from informal contacts on individual problems to formal liaison between organizations and agencies on the inter-relationship of major projects.

Future small watershed projects need to be coordinated to insure the inclusion of all feasible features to enhance the use of both the watershed and its waters for all worthwhile purposes. In addition, small watershed projects need to complement other major water projects in the basin and make the best use of improvements provided under other programs.

It is hoped that the information in this report and the data gathered for its preparation will be of assistance to others in future coordination of the water and related land resources in the Middle Willamette River Basin.