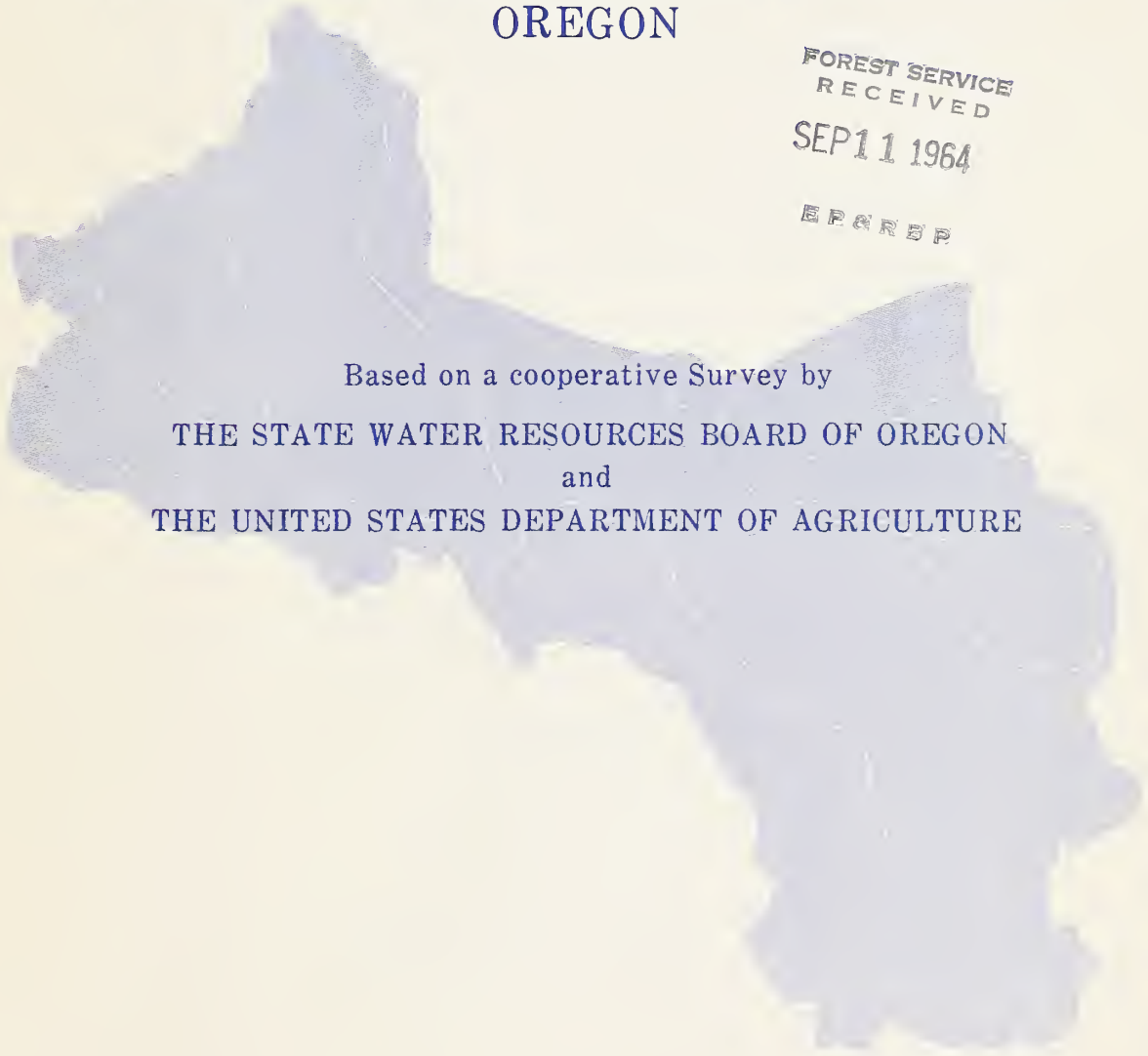
USDA Report on
WATER and RELATED LAND RESOURCES

LOWER 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 September 1963

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Report Prepared by

USDA Oregon River Basin Survey Party, Salem, Oregon

H. H. Ralphs, Soil Conservation Service, Leader
D. D. Raitt, Economic Research Service
J. H. Poppino, Forest Service
H. E. Carnahan, Soil Conservation Service
D. G. Price, Soil Conservation Service
K. K. Smith, Soil Conservation Service, Typist

Under Direction of

USDA Field Advisory Committee

T. P. Helseth, Soil Conservation Service, Chairman
C. E. Stewart, Economic Research Service
K. W. Linstedt, Forest Service

September 1963

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INTRODUCTION

This report presents information concerning the water and related land resources of the Lower 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 Lower 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: (1) the kind and location of desirable water resource developments; (2) the amounts and quality of water required; (3) the physical opportunities for developments 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 data and 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.

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 Oregon River Basin Survey Party made limited surveys to gather basic information that was not otherwise available including 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 Survey Party.

Several agencies and organizations provided helpful assistance in making this survey. The field offices of the Soil Conservation Service furnished much of the basic information concerning reservoir sites and tributary watersheds. The County Extension Service also assisted in the collection of 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 Forest Service, the Pacific Northwest Forest and Range Experiment Station, the Bureau of Land Management, the Fish and Wildlife Service, the Oregon State Game Commission, the Fish Commission of Oregon, and the State Forester of Oregon. Some of the agricultural data were obtained from publications of the 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 maps.

SUMMARY

GENERAL DESCRIPTION OF THE BASIN

The Lower Willamette River Basin encompasses an area of 1,748,800 acres, 2.8 percent of the state, and includes the area drained by the Willamette River from river mile 32.7 to its mouth, the Sandy River, and several minor tributaries of the Columbia River. The basin has a temperate maritime climate with dry, moderately warm summers and wet, mild winters. The basin is a generally broad, northerly sloping trough with the Coast Range on the west and the Cascade Mountains on the east. Elevations range from 10 to 11,245 feet. There are three geologic provinces, the Coast Range uplift, the Willamette trough, and the western and high Cascades. Most of the soils in the agricultural areas were derived from transported materials while the soils in the Cascades and higher Coast Range are residual and were derived from igneous and sedimentary materials.

Settlement, which began in 1835 by retired Hudson Bay Company employees, increased rapidly after 1840 as emigrants arrived to farm the fertile valley. By 1855, most of the valley was taken up in donation land claims. Although the economy of the basin was at first largely based on agriculture, logging, manufacturing, and services have since become important sources of income. Only 15 percent of the 723,000 people in the basin live on farms or in rural nonfarm areas.

Fifty-six percent of the basin is privately owned, and 44 percent is publicly owned. Sixty-eight percent is forest; 19 percent is cropland; and 13 percent is devoted to other uses. Most of the publicly owned land is forest.

FORESTRY

The major uses of forest land are for production of timber, water, and outdoor recreation.

? See p. 33

There is an estimated 1,149,000 acres of commercial forest land with an estimated 25.5 billion board feet of softwood timber in the basin. The most productive areas are in the Coast Range and from 1,500 to 3,000 feet in the Cascades. Logging and milling began at the time of settlement, and timber harvest increased to almost 600 million board feet annually by the late 1940's. It is estimated that the sawmills, veneer, and plywood plants require an annual supply of 800 million board feet to operate at full capacity. Based on the sustained yield potential the potential allowable annual cut for the basin is estimated to be 448.8 million board feet.

The general trend in recreational visits is toward one day round trips with only a moderate increase in the number of overnight visitors. As the Willamette Valley and other areas of Oregon become more heavily populated, forested areas available for recreation will become increasingly important. All agencies managing public land are planning to provide more facilities as needed to meet future demand.

The most numerous big game animal in the basin is the Columbian black-tailed deer. There are several game bird species including ring-necked pheasants, valley quail, bobwhite quail, mourning doves, and band tailed pigeons. Migratory waterfowl are abundant during the migration period.

All of the major streams and many of the minor streams maintain runs of anadromous fish. The streams, lakes, and reservoirs contain nearly all of the species of game fish found in Oregon. Native fish populations have been difficult to maintain in several streams because of siltation, pollution, high water temperatures, and physical barriers to fish movement.

It is estimated that 80 percent of the annual water yield from the Lower Willamette River Basin comes from forest land.

AGRICULTURE

The land base for agriculture consists of 268,000 acres of cropland, 55,300 acres of rangeland, and 52,850 acres of grazed forest land. The major uses of cropland are for the production of small grains and forage crops. The more intensive crops such as fruits, nuts, and vegetables account for a minor part of the cropland but are important sources of farm income. Although a considerable amount of farmland has been shifted to other uses such as residences and roads, acquisition and clearing of land by farmers for agricultural purposes has evidently more than compensated for this loss.

The 6,492 farms in the basin average 76 acres in size, with 39 acres of cropland, and represent investments of about $29,340 per farm. Farm numbers are decreasing; farm size is increasing; and part-time farming is becoming more popular.

Milk cows and poultry are the most important types of livestock raised in the basin accounting for 28 percent of the agricultural income. Fruits, nuts, and horticultural specialties are the most important crops and were the source of 41 percent of the agricultural income. Since 1939, income from the sale of crops has increased at a higher rate than income from the sale of livestock.

In 1963, 34,810 acres were irrigated in the basin. The major irrigated crops were pasture, hay, vegetables, and fruits. Streams are the direct source of water for 71 percent of the irrigated acreage; ground water is the source for 19 percent; and stored ground and surface water are the sources for 10 percent. Sprinkler irrigation is used on 97 percent of the irrigated land. Irrigated acreage has increased to a magnitude that is 6 times the 1939 level while the percentage of farmers irrigating has increased from 3 percent to 18 percent.

There are adequate land and water resources to irrigate an additional 160,700 acres. However, the degree to which irrigation expands will depend on several social and economic factors. One of the most important factors is the expanding population of the basin.

WATER RELATED PROBLEMS, NEEDS, AND OPPORTUNITIES

Land use influences the quantity, quality, and use of water. The basin has a summer period of water shortages and then a winter period of excessive water, both affecting water quality and efficiency of all areas of use. The total water resources are more than adequate for present and future agricultural needs. The average annual yield after current consumptive use withdrawals is about 44 inches, which is equal to about 6 million acre feet.

Approximately 84,000 acre feet, or about 10 percent of the surface water yield during the irrigation season, are used to irrigate 34,810 acres of land. However, water supplies are inadequate during the irrigation season in 16 of the 22 tributary watersheds. There are about 160,700 acres of potentially irrigable land, nearly 5 times that irrigated at present.

There is usually an adequate water supply for consumptive use by livestock.

Water supply problems on forest land are few but are expected to increase. In general, the best watershed conditions will prevail when all resources are managed in a manner that insures the optimum sustained production.

The increasing population and the accompanying industrial and urban developments are increasing the competition for land and water resources. As competition becomes keener, water resource developments will be necessary to meet all of the demands.

Flood problems result from both natural factors and human management of the land. The flood season from Willamette Valley precipitation is from November through April, but more than two-thirds of the recorded floods have occurred from December through February. Major floods result from a combination of snow on saturated soil followed by warm rain, occurring about every four or five years. The floods from the Columbia River occur in June and affect the low areas near the rivers below Oregon City. Spring and summer floods from cloudbursts are practically unknown. Agricultural damages consisting primarily of crop and property losses usually account for much of the total evaluated flood damage; however, land damage from erosion and deposition is significant but is difficult to evaluate and probably inadequately appraised.

About 97 percent of the irrigated land is irrigated by the sprinkler method which is easiest to manage for proper and best use of water under existing conditions. In the past irrigation has been developed by individuals. In the future most irrigation must be developed and managed as group projects because most of the land and water that can be easily developed by individual efforts is now in use.

Approximately 172,800 acres, or about 23 percent of the arable soils in the basin, have a major problem of excessive wetness. The elimination of prolonged flooding is often a prerequisite to successful drainage. The specific drainage treatment needed varies widely depending principally upon the soil involved. Since soluble salts are not a problem, the water drained from the land can be used for irrigation.

Improper management of forest resources can produce or intensify flood, erosion, and sedimentation problems. Many of the forest land ownerships are too small for efficient, profitable management on an individual basis.

There is a great potential for development of water resources of the Lower 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. Most future reservoirs will need to be multipurpose in nature. There are many potential water storage sites, both large and small, throughout the basin. Many of them are needed for future development and growth of the area.

OPPORTUNITIES FOR WATERSHED PROTECTION AND FLOOD PREVENTION PROJECTS

The USDA Oregon River Basin Party made a survey of the potential for P. L. 566 work in the Lower Willamette River Basin to provide information as a guide to long range coordination and planning of possible future projects. The basin was divided into 22 small watersheds, and a study and summary report was made on each of them. It was concluded that 7 projects appear to be feasible, and 7 additional ones might be feasible under existing conditions and laws. 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 forest land, a large water yield, 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 Lower Willamette River Basin is located in the northern portion of western Oregon and includes the watersheds of the Willamette River and its tributaries from its confluence with the Columbia River to approximately river mile 32.7 and the Sandy River and other minor drainages of the Columbia River from the town of Bonneville to the city of St. Helens. The basin is bounded by the North Coast Basin on the west, the Middle Willamette Basin on the south, the Deschutes River and Hood Drainage Basins on the east, and the Columbia River on the north (fig. 1). The basin has a total area of 1,748,800 acres, about 23 percent of the entire Willamette Basin and 2.8 percent of the total area of Oregon. The basin includes a major portion of three counties - Clackamas, Multnomah, and Washington - and a minor portion of four counties - Columbia, Marion, Tillamook, and Yamhill.

For the purpose of this report, the Lower Willamette River Basin is divided into four subbasins which are numbered 8 through 11. This numbering is an extention of a system that includes the entire Willamette River Basin. Subbasin 8, the Tualatin Subbasin, lying west of the Willamette River and south of the Portland Hills divide, has an area of 700 square miles and includes all of the drainage of the Tualatin River and its tributaries. Subbasin 9, the Clackamas Subbasin, lying east of the Willamette River, has an area of 1,021 square miles and includes all of the drainage of the Clackamas River and its tributaries and some smaller tributaries of the Willamette River south of its confluence with the Clackamas River. Subbasin 10, the Columbia Subbasin, has an area of 428 square miles and includes all of the basin north of the divide of the Portland Hills and the Clackamas drainage and west of the divide of the Sandy drainage. Subbasin 11, the Sandy Subbasin, is in the northeastern section of the basin, has an area of 583 square miles and includes all of the drainage of the Sandy River and its tributaries and some smaller tributaries of the Columbia River between the Sandy River and the town of Bonneville.

PHYSICAL ASPECTS

Climate

The Lower 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 36 inches in the Willamette Valley but increases rapidly with elevation to 100 inches in parts of

FIGURE 1

LOCATION MAP

LOWER WILLAMETTE RIVER BASIN

OREGON

SEPTEMBER 1963

USDA SCS-PORTLAND, OREG. 1961

FIGURE 2

PRECIPITATION MAP
LOWER WILLAMETTE RIVER BASIN
OREGON

SEPTEMBER 1963

SCALE IN MILES

RIVER BASIN LOCATION

SUBBASINS

8 TUALATIN
9 CLACKAMAS
10 COLUMBIA
11 SANDY

COUNTY LOCATION

LEGEND

- Normal Annual Precipitation in Inches
- River Basin Boundary
- Subbasin Boundary
- National Forest and/or Indian Reservation Boundary

Source: Isohyetal Map, Western Oregon U.S. Corps of Engineers

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M-3905

the Coast Range and 140 inches in the Cascade Mountains (fig. 2). About 60 percent of the annual precipitation occurs from November through February while only about 10 percent occurs from June through September. Below 2,000 feet elevation, most of the precipitation occurs as rain at low intensities. Intensity of precipitation increases with elevation. Snow increases from about 2 percent of the annual precipitation 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. This is particularly true of the Sandy Subbasin which receives considerable summer flow from glaciers on Mount Hood (photo 1). Summer precipitation in the basin is limited to occasional light rains and thunderstorms.

Photo 1.--Snow and year around glaciers on Mount Hood act as storage for winter precipitation, adding to the summer water supply in the Lower Willamette River Basin, Oreg. FS photo. NO. 498693

The prevailing winds are from the west and northwest in the summer and from the south and southwest in the winter. Wind velocities are usually moderate, but strong winds can 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, hot weather in summer.

Seasonal temperature variations are small in the Coast Range and Willamette trough. 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 trough is from March to November, a period of 180 to 250 days. The frost-free season decreases to less than 30 days at the higher elevations in the Cascades.

Topography

The topography and structure of the Lower Willamette River Basin is generally a broad, northerly sloping syncline or trough, the axis of which roughly parallels the Willamette River to the Columbia River. The basin has three topographic-structural provinces which are from west to east, respectively, the Coast Range uplift, the Willamette trough, and the western and high Cascades. The generalized geologic map (fig. 3) illustrates the geologic structure of the basin.

Coast Range Uplift. The Coast Range uplift province includes approximately one-sixth of the basin. It is a broad uplift area caused by anticlinal folding of the underlying formations. Considerable faulting and related volcanic activity and subsequent erosion has formed the rugged foothills and peaks of the Coast Range. The topography is generally one of irregular ridges and short steep slopes. The areas of sedimentary rock are usually maturely dissected and have numerous slumps and slides, and the areas of basic igneous rock are less dissected because of their greater resistance to weathering and erosion and contain drainages that are rugged, steep, and convex. The drainage system in the basin has reached a mature state except for the smaller, more youthful streams in the higher elevations.

The summit elevations are generally 1,000 to 2,600 feet except for a few peaks with elevations up to 3,000 feet.

Willamette Trough. The Willamette syncline, or trough province, includes the central one-third of the basin. This area is divided into three general sections -- the large, smooth, relatively level Tualatin River Valley, the relatively level Portland area, and the gently rolling terraces and foothills of the Clackamas River drainage. Elevations of this section of the province vary from 10 feet on Sauvie Island to 850 feet on the hills near Estacada. The relatively smooth topography of the Willamette trough is broken by low, rolling hills or buttes that reach a maximum elevation of 1,600 feet. These include the Portland Hills anticline in the north, the Chehalem Mountains anticline in the southwest, and various smaller mountains or buttes including Cooper Mountain, Bull Mountain, Petes Mountain, Mt. Tabor, Mt. Scott, Rocky Butte, and Powell Butte.

Western and High Cascades. The western and high Cascades province comprises the eastern half of the basin. It begins at the east edge of the Willamette trough and extends to the summit of the Cascades. The rugged topography of the western Cascades is characterized by steep slopes, sharp ridgetops, and deep canyons. Elevations range from about 200 feet near the Columbia River to 4,800 feet on the highest peak. The high Cascades has rugged, steep topography north of Mount Hood and less rugged, rolling topography south of Mount Hood. The elevation of the summit of the Cascades varies from 2,500 feet to 11,245 feet on Mount Hood. The drainages include

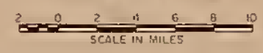
FIGURE 3

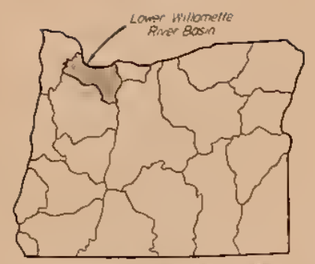
GENERALIZED GEOLOGIC MAP

LOWER WILLAMETTE RIVER BASIN

OREGON

SEPTEMBER 1963





RIVER BASIN LOCATION

SUBBASINS

8 TUALATIN
9 CLACKAMAS
10 COLUMBIA
11 SANDY

SOIL CONSERVATION DISTRICTS

SAUVIE ISLAND
SCAPPOOSE
SANTIAM
EAST MULTNOMAH
YAMHILL COUNTY
WASHINGTON COUNTY
NORTH CLACKAMAS
SOUTH CLACKAMAS

COAST RANGE

HIGH CASCADES

WESTERN CASCADES

WILLAMETTE TROUGH

NORTH COAST BASIN

HOOD BASIN

DESCHUTES BASIN

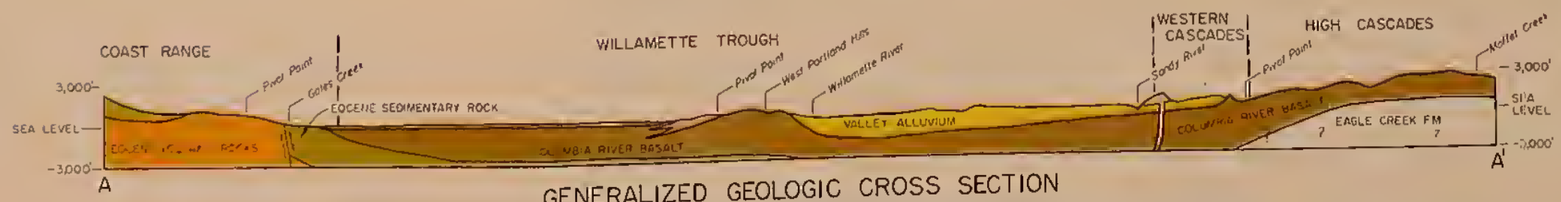
WARM SPRINGS INDIAN RESERVATION

MT. HOOD NATIONAL FOREST

COUNTY LOCATION

LEGEND

- Valley Alluvium
- Plio–Pleistocene Lavas
- Miocene Tuffs and Lavas
- Columbia River Basalt
- Eocene Sedimentary Rock
- Eocene Volcanic Rock
- Anticline Axis
- Syncline Axis
- Fault Traces
- River Basin Boundary
- Subbasin Boundary
- National Forest Boundary
- Soil Conservation District Boundary



GENERALIZED GEOLOGIC CROSS SECTION

U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE M-3905

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the Clackamas and Sandy River and their tributaries, all of which are deeply incised. In the high Cascades near Mount Hood, drainage formation is influenced by glacial action and display the typical U-shaped canyons with hanging valley tributaries.

Mount Hood and the Columbia River Gorge are the outstanding topographic features of this province.

Geology

A consideration of the rock types and their structure in the Lower Willamette River Basin results in the recognition of three geologic provinces. They are from west to east, respectively, the Coast Range uplift, the Willamette trough, and the western and high Cascades (fig. 3).

Coast Range Uplift. The rocks in this province are relatively young and are only slightly altered either in structure or in mineral association. Igneous activity producing dikes and sills is not common.

The Tillamook volcanics formation of early Eocene age is a series of submarine lava flows, breccias, and tuffs of unknown thickness. It is exposed along the fault face on the south side of Gales Creek Valley. The Yamhill formation, a middle Eocene sedimentary unit of micaceous siltstone and sandstone, rests on the Tillamook volcanics and is exposed in the upper Tualatin Valley near Cherry Grove. Along the western portion of this province the Cowlitz, Nestucca, Keasey, Pittsburg, and shale of late Eocene to late Oligocene age are found intercalated with the volcanic flows, breccias, and tuffs of the late Eocene Goble volcanics.

The Coast Range area was uplifted during the early Miocene epoch and after being eroded to a surface of low relief was lowered to near sea level in middle Miocene. The middle Miocene Columbia River basalt was poured out on this planed surface. The basalt series is made up of flows of dark-gray to black, dense, very fine grained basalt in thickness up to 1,000 feet with well developed columnar jointing and persists as the primary rock unit in the northern part of the province. Following this period of extrusion, the area was again warped upward to approximately its present altitude accompanied by some minor folding such as the Portland Hills anticline. Following weathering and erosion of the Columbia River basalt, a thick, structureless, light brown silt, known as Portland Hills silt and believed to be loess of probably middle Pleistocene age, was deposited on the Portland Hills in depths of 25 to 100 feet.

Ground water is not plentiful in this province. Tillamook volcanics are generally of low permeability and yield small amounts of water. The sedimentary rocks are also low yielding, producing only a small amount of poor quality water. The Columbia River basalt is the chief water-bearing rock containing a moderate quantity of good quality water in the scoriaceous upper part of flows and in the crevices and joints.

Willamette Trough. Downfolding of the rock formations created the Willamette syncline, a structural depression, with hills of moderate relief separating broad flats filled with alluvial sediments from the surrounding hills. The Columbia River and the Willamette River below the falls at Oregon

City were influenced by the vacillating sea level and are in a mature state with drowned valleys, broad floodplains, sloughs, lakes, and islands. The upper Willamette River and Tualatin River have broad floodplains and meander belts with sloughs and oxbow lakes. The Clackamas River and Sandy River are youthful streams with deeply incised valleys.

The rock formations beneath the alluvial sediments are presumed to be the same as the Coast Range and the Cascades. The Eocene sedimentary and volcanic formations underlie the Columbia River basalt which crops out in the area west of the Willamette River; namely, the Chehalem Mountains, Portland Hills, Petes Mountain, Cooper Mountain, Bull Mountain, and, most prominently, the falls at Oregon City. Resting on the Columbia River basalt in depths up to 1,500 feet is the Troutdale formation of middle Pliocene age. This formation consists of beds of micaceous and quartzose sandstone and siltstone and tuffaceous siltstone, sandstone, and conglomerate. These beds can be traced along the Columbia from St. Helens to Bonneville and are found as outcrops on Rocky Butte; Westover Terrace in Portland Hills; and in places near Oswego, Jennings Lodge, and Clackamas. Sediments equivalent to the Troutdale composed of sand, silt, and clay of mafic mineralogy from the mountains of the Willamette Basin but lacking the typical quartzite pebbles of the Troutdale are found south of the basaltic barrier at Oregon City. The Boring lavas of light gray to dark gray, fine grained basalt and andesite were extruded over the Troutdale in flows, lava domes, cones, and intracanyon flows. These late Pliocene flows remain as buttes near Gresham and Boring and cap many hills in the vicinity of Oregon City. They also exist as erosional remnants along the slope of the Portland Hills near Beaverton and Metzger. The Portland Hills silt, presumed to be aeolian, covers the Portland Hills and hills west of Gresham and Boring in Clackamas County.

During the late Pliocene and much of the Pleistocene time there were at least three different actions which affected the basin's geology. These were uplift, glaciation, and deglaciation. Uplift with associated erosion caused incision of the streams and alluviation of the valleys. Glaciation caused lowered sea level and stream incision as ice accumulated on land. Deglaciation resulted in drowned streams, stream cut terraces, and alluviation.

Two alluvial formations from Pleistocene time and one from more recent times are found overlying the Troutdale formation. Semi-consolidated, poorly sorted, deeply weathered gravels and sands equivalent to Lacomb and Leffler gravels are found capping the higher terraces along the Clackamas and Sandy Rivers and a small area near North Plains and Bowers Jct. in Washington County. A homogeneous, light brown, faintly stratified silt with a small area of interbedded Linn gravels is known as the Willamette silts. Equivalent to the Willamette silts in the Portland basin is a stratified and cross bedded sand and gravel with scattered boulders of igneous and metamorphic rocks known as Portland sands and gravels. A deposit of unconsolidated sand, gravel, silt, clay, and pyroclastic debris is found on the floodplain.

Moderate amounts of ground water are found in this province. The Columbia River basalt is the chief water bearing unit and produces good quality water from the upper, scoriaceous part of the flows. The water bearing capacity of the Troutdale formation is variable. In the area near Portland,

water is found in the upper few hundred feet of gravel and sand; whereas, in the formation equivalent to the Troutdale in the Tualatin Valley, only small quantities exist because of less permeable, finer textured sediments. Boring lavas yields small amounts of water from fractures, joints, and porous flows. Some water is found in the gravelly phase of the Pleistocene sediments, and the recent alluvium yields water from the sand and gravel beds below the water table.

Western and High Cascades. At least 7,500 feet of a slightly to moderately deformed monotonous sequence of lava flows and pyroclastics (solid material ejected explosively from volcanic vents) and a small amount of marine sedimentary rocks are found in this province. Two physiographic provinces, the western Cascades and the high Cascades on the east, are described.

The late Eocene Goble volcanics series is the oldest described formation. Resting on the Goble volcanics is the early Miocene Eagle Creek formation consisting of mud flows of volcanic debris and containing fossil wood and leaves. In middle Miocene time the land surface was eroded to low relief followed by the pouring out of the Columbia River basalt in thicknesses of 200 to 2,000 feet. These flows are exposed in the Columbia River Gorge and other valleys. The Rhododendron formation of basaltic breccia, tuffs, and flows was deposited in late Miocene time and is exposed along upper Clackamas drainages. Closely following deposition of the Rhododendron was the gentle arching of the Cascade area which together with Troutdale sediments and the Boring or Cascan extrusion form much of the present topography.

A fault along a north-south line between the western and high Cascades dropped the high Cascades area during the late Pliocene or early Pleistocene. Active extrusion of the Plio-Pleistocene Cascan lavas built the high Cascades to its present towering heights. In some places these flows have poured out over the western Cascades or down the valleys as intra-canyon flows. Mount Hood is a cinder cone of flows, ash, and breccias cut by dikes and intrusions. Glaciers of the Wisconsin stage eroded the slopes of Mount Hood and left unsorted bouldery gravel morains and stratified gravel, sand, silt, and clay deposits.

Ground water in small quantities and of poor quality is found in the older volcanic formations. Columbia River basalt and other flows of middle Miocene to early Pliocene and the Troutdale formation are the most important sources of water. The Plio-Pleistocene Cascan lavas of the high Cascades are not important sources of water but serve as helpful storage for maintaining streamflow in the summer months.

Soils

Seven general soil areas in the Lower Willamette River Basin are delineated on the general soil map (fig. 4) and described in the narrative. The factors used in forming the areas are physiography, kind and shape of the landform; geology, source and kind of parent or underlying material; and characteristics of the soils. Each of the soil areas contains one or more soil groups which have similar parent material and may be related in other ways.

Soils Derived from Recent Alluvium. As streams flow through the valleys, they have developed floodplains of recent alluvium by depositing sediment. This sediment of gravel, sand, silt, clay, and pyroclastic debris gives rise to soils with limited development and characteristics conforming closely to the parent material. Areas of these soils are subject to flooding with the related erosion, drainage, and cropping problems. The main use is cropland. Almost all of the soils respond well to irrigation. Water is generally available from wells or streams. Three general areas of recent alluvial soils are found in the basin.

The recent alluvial soils of the Willamette River and other streams is the Camas-Chehalis-Wapato group. Soil texture and internal drainage are used as criteria for separating and describing the soil series. Camas is an Alluvial soil with a moderately shallow, excessively drained, coarse textured profile. Newberg is an Alluvial soil with a very deep, somewhat excessively drained, moderately coarse textured profile. Cloquato is an Alluvial soil with a very deep, well drained, medium textured profile. Chehalis is an Alluvial soil with a very deep, well drained, moderately fine textured profile. Maytown is an Alluvial soil with a very deep, moderately well drained, moderately fine textured profile. Wapato is a Low Humic Gley soil with a very deep, imperfectly drained, moderately fine textured profile. Reed is a Low Humic Gley soil with a very deep, poorly drained, very fine textured profile. Cove and Tangent are Humic Gley soils with very deep, poorly drained, very fine textured profiles.

Along the Columbia River and the Lower Willamette River recent alluvial soils are the Sauvie group. Sauvie is a Low Humic Gley soil with a very deep, poorly to imperfectly drained, medium to moderately fine textured soil. Mukilteo peat is a poorly drained, shallow to very deep, organic soil. There are also a Regosol that has an excessively drained, very deep, moderately coarse textured profile over sand and an Alluvial soil with a very deep, well to somewhat excessively drained, moderately coarse to medium textured profile over sand.

A third group of alluvial soils is distributed along the upper Clackamas River and the Sandy River and has not been completely described and correlated. The parent material is alluvium from residual soils and upland terraces of glacial material.

Soils Derived from Silty Material on Terraces. Adjacent to the recent alluvial soils is a higher terrace composed of sediments of two different formations. Most of the parent material is Willamette silts in the valley south and west of Oregon City and Portland sands and gravels in the Portland area. These soils are mainly used for cropland, and almost all respond well to irrigation. The soils of this area are level to gently sloping, moderately coarse to fine textured, somewhat excessively to poorly drained, and slightly to strongly acid.

The drainage catena composed of the Hillsboro, Willamette, Woodburn, Amity, and Dayton soils has developed on the Willamette silts. Hillsboro is a Prairie like soil with a very deep, well drained, medium textured profile. Willamette is a Prairie like soil with a very deep, well drained, moderately fine textured profile. Woodburn is a Gray Brown Podzolic soil with a very deep, moderately well drained, moderately fine textured profile

FIGURE 4

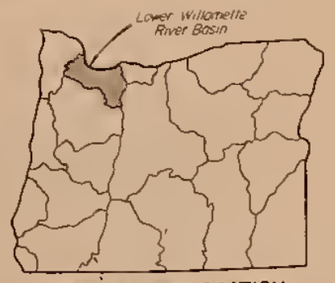
GENERAL SOIL MAP

LOWER WILLAMETTE RIVER BASIN

OREGON

SEPTEMBER 1963

SCALE IN MILES 2 0 2 4 6 8 10



RIVER BASIN LOCATION

SUBBASINS

8 TUALATIN

9 CLACKAMAS

10 COLUMBIA

11 SANDY

COUNTY LOCATION

LEGEND

- Soils Derived From Recent Alluvium
- Soils Derived From Silty Materials on Terraces
- Soils Derived From Silty Materials on Uplands
- Soils Derived From Loess on Terraces
- Soils Derived From Loess on Uplands
- Soils Derived From Igneous Materials
- Soils Derived From Sedimentary Rock
- River Basin Boundary
- Subbasin Boundary
- National Forest Boundary

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with a fragipan. Amity is a Gray Brown Podzolic-Low Humic Gley integrade soil with a very deep, imperfectly drained, moderately fine textured profile. Dayton is a Planosol soil with a poorly drained, deep, fine textured profile with a claypan at 12 to 20 inches from the surface. There are small areas of gravelly soils including the well drained Sifton and Salem, the imperfectly drained Clackamas, and the poorly drained Courtney.

Moderately deep soils with gravel throughout the profile and deep to very deep soils with partly consolidated sand and gravel substratum occur on the Portland sands and gravels. Multnomah is a moderately shallow to deep, somewhat excessively drained soil and is associated with moderately shallow to moderately deep, imperfectly drained Clackamas, and very deep, well drained Hillsboro and Willamette.

Soils Derived from Silty Materials on Uplands. The silty soil area is located east of the Willamette River. The parent material is a mixture of alluvium, loess, and residuum from igneous and sedimentary rock and weathered gravel. These soils are used mostly for cropland, and almost all of them respond well to irrigation.

A drainage catena of soils containing the Cazadero, Cottrell, Dubay, and Carver are associated with the Bornstedt and Powell soils. Cazadero is a deep to very deep, well drained, moderately fine textured Reddish Brown Lateritic soil. Cottrell is a very deep, moderately well drained, fine textured Reddish Brown Lateritic soil. Dubay is a deep to very deep, imperfectly drained, fine textured Low Humic Gley soil. Carver is a moderately deep to deep, poorly drained, fine textured Low Humic Gley soil. Bornstedt is a moderately deep, moderately well drained, moderately fine textured Reddish Brown Lateritic soil with a fragipan at 20 to 48 inches below the surface. Powell is an imperfectly to poorly drained, moderately shallow to deep, fine textured Low Humic Gley-Sols Lessive integrade soil. Other deep, well drained, medium textured Reddish Brown Lateritic soils occur on the higher areas.

Soils Derived from Loess on Terraces. The loess soil areas occur in the same physiographic position as the terraces formed by the Willamette silts and Portland sands and gravels. In some locations they are adjacent. The method of deposition of this loessial parent material is either by aeolian action or a combination of aeolian and alluvial action as some has been redistributed by water. These soils are used mostly for cropland, and almost all respond well to irrigation.

A drainage catena is recognized including the following soils: Cornelius, Quatama, Helvetia, Aloha, and Huber. Cornelius is a very deep, well drained, moderately fine textured Gray Brown Podzolic like soil. Quatama is a very deep, moderately well drained, medium textured Gray Brown Podzolic like soil which may have a weak fragipan at 48 inches or deeper. Aloha is a very deep, imperfectly drained, medium textured Gray Brown Podzolic like soil with a weak fragipan at 30 to 40 inches below the surface. Huber is a moderately deep, poorly drained, fine textured Low Humic Gley soil. Helvetia is a very deep, moderately well drained, fine textured Reddish Brown Lateritic soil occurring on slightly higher elevations.

Soils Derived from Loess on Uplands. A deposit of light brown, massive, sandy and silty loess in depths as great as 100 feet mantles the Portland

Hills, the Chehalem Mountains, and hills between Gresham and Oregon City. This homogeneous, structureless, silt is composed predominately of quartz and other minerals that indicate that it is not the product of residual weathering of basalt. It is believed that the surface of the loess conforms rather closely to that of pre-existing topography of the underlying rock. The origin of the loess was the glacial outwash plains adjacent to the Columbia River. Forest is the predominate land use on these soils, but small areas are used for cropland and range. Almost all of them respond well to irrigation.

The soils are the Laurelwood, Kinton, Cascade, and Delena series. Laurelwood is a very deep, well drained, medium textured Reddish Brown Lateritic soil. Kinton is a very deep, moderately well drained, moderately fine textured Reddish Brown Lateritic soil with a weak fragipan at 24 to 36 inches. Cascade is an imperfectly drained, fine textured Sols Lessive soil with a moderate fragipan at 24 to 48 inches. Delena is a very deep, poorly drained, moderately fine textured Low Humic Gley soil in depressional areas with a moderate fragipan at less than 48 inches.

Soils Derived from Igneous Materials. Soils developed from igneous materials occur on most of the Cascade Mountains and the higher elevations of the Coast Range. The parent material is weathered basalt, andesite, gabbro, rhyolite, and consolidated pyroclastic materials. Small areas of young lava flows in the high Cascades have weathered very little and have little to no soil development. The soils in this group are used mainly for forest and recreation with small areas used for cropland and range.

Estacada is a deep, well drained, moderately fine textured Reddish Brown Lateritic soil in the lower areas of the Cascades. Nekia is a moderately deep to deep, well drained, fine textured Reddish Brown Lateritic soil in the lower area. McCully is a very deep, well drained, fine textured Sol Brun Acide soil in the lower foothill area of the Cascades. Olympic is a moderately deep to deep, well drained, medium to moderately fine textured Reddish Brown Lateritic soil in the lower foothill area. Viola is a moderately shallow to moderately deep, poorly drained, fine textured Planosol soil in the Cascades. Kinney is a moderately deep to very deep, well drained, moderately fine textured Sol Brun Acide soil in the high Cascades. The Sandy-Bull Run soil survey by the Forest Service indicates that Brown Podzolics, Podzolics, Sol Brun Acides, and Regosols also occur in the high Cascades.

Soils Derived from Sedimentary Rocks. This group of soils is found in the Coast Range, and the parent material is weathered marine micaceous and tuffaceous sandstone, siltstone, and shale.

The Willakenzie, Peavine, and Melbourne series are associated with Hazelair, Dupee, and Panther soils. Willakenzie and Peavine are moderately deep to deep, well drained, moderately fine textured Reddish Brown Lateritic soils. Melbourne is a moderately deep to deep, well drained, moderately fine textured Reddish Brown Lateritic soil. Hazelair is a moderately deep to deep, imperfectly drained, fine textured Prairie like Humic Gley intergrade soil. Dupee is a moderately deep to very deep, imperfectly drained, moderately fine, fine textured Humic Gley soil. Panther is a moderately deep, poorly drained, fine textured Humic Gley soil.

The Carlton, Chehalem, and Crossett series on adjoining fans and footslopes are recipient from the above-described soils. Carlton is a moderately well drained, very deep, fine textured Prairie like soil. Chehalem is a very deep, imperfectly drained, fine textured Prairie like soil. Crossett is a moderately shallow to moderately deep, poorly drained, very fine textured Humic Gley soil.

Forest is the major use of these soils, but smaller areas are devoted to cropland and range.

Land Capability

An interpretive grouping of soils into "Land Capability Classification" has been developed by the Soil Conservation Service. Soil characteristics such as depth, texture, wetness, slope, erosion hazard, overflow hazard, permeability, structure, reaction, water-holding capacity, inherent fertility, and climatic conditions as they influence safe use and management 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. 5). 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.

Generally speaking, the classification can be broken into two divisions: (1) land in capability classes I through IV is 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 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 and soil surveys within the Lower Willamette River Basin and are summarized in table 1.

SETTLEMENT AND HISTORY

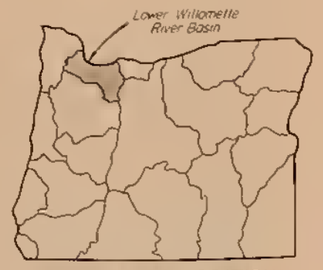
Although the basin was explored prior to 1800, the most significant exploration was the Lewis and Clark expedition of 1805. Trappers and employees of British and American fur companies traveled through the area as early as 1812. The first settlers in the Lower Willamette River Basin were retired Hudson Bay Company employees who settled in the east Portland area of Multnomah County. Settlers began arriving about 1835 and increased rapidly after 1840. The Donation Land Claim 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 were production of small grains and beef cattle. Rapid increases in production of these commodities followed de-

Table 1.--Estimated acreage of land by capability class and subclass, Lower Willamette River Basin, Oreg., 1963

Capability class	Subbasin				
	8 Tualatin	9 Clackamas	10 Columbia	11 Sandy	Total
	Acres	Acres	Acres	Acres	Acres
I	4,000	...	5,600	600	10,200
IIe	12,500	38,000	21,600	5,200	77,300
IIw	50,200	9,400	24,700	1,600	85,900
IIs	48,400	6,900	21,500	1,500	78,300
Total II	111,100	54,300	67,800	8,300	241,500
IIIe	61,700	37,600	31,100	11,000	141,400
IIIw	26,800	7,600	32,800	13,100	80,300
IIIs	...	5,600	3,300	2,100	11,000
Total III	88,500	50,800	67,200	26,200	232,700
IVe	59,600	32,700	11,400	7,100	110,800
IVw	3,600	1,700	1,300	...	6,600
IVs	100	2,800	19,100	7,100	29,100
Total IV	63,300	37,200	31,800	14,200	146,500
Total I-IV	266,900	142,300	172,400	49,300	630,900
Vw	1,800	...	...	...	1,800
VIe	90,200	156,700	42,100	94,100	383,100
VIs	...	600	...	1,600	2,200
Total VI	90,200	157,300	42,100	95,700	385,300
VIIe	88,700	347,400	21,200	212,000	669,300
Total V-VII	180,700	504,700	63,300	307,700	1,056,400
VIII	400	6,300	11,300	14,400	32,400
Total land area	448,000	653,300	247,000	371,400	1,719,700
Water area	...	...	27,100	2,000	29,100
Total in basin	448,000	653,300	274,100	373,400	1,748,800

Source: Compiled by USDA, Soil Conservation Service.



RIVER BASIN LOCATION

SUBBASINS

8 TUALATIN
9 CLACKAMAS
10 COLUMBIA
11 SANDY

FIGURE 5

GENERALIZED LAND CAPABILITY CLASSES

LOWER WILLAMETTE RIVER BASIN

OREGON

SEPTEMBER 1963

SCALE IN MILES

COUNTY LOCATION

LEGEND

River Basin Boundary

Subbasin Boundary

National Forest Boundary

LEGEND

LAND SUITED FOR CULTIVATION AND OTHER USES

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 or 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 — Soil 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.

LAND LIMITED IN USE (RESERVED) NOT SUITED FOR CULTIVATION

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

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velopment 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 important changes in the basin's economy between 1870 and 1940. Agriculture became more diversified as wheat and flax production decreased and such crops as hops, mint, and vegetables were introduced. Although the population continued to center in the main valley, there were gradual increases in the foothills of the Cascades and Coast Range based on logging, tourism, 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, manufacturing, wholesale and retail trades, and service industries have expanded rapidly while agriculture and lumbering have become relatively less important.

POWER

The Lower Willamette River Basin is a power deficient area and is expected to continue to be. Its water power is of greatest value in its ability to meet peak loads.

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 and early spring. In order to provide maximum efficiency, power reservoirs in the Lower Willamette River Basin should be regulated to conserve as much of the stored water as possible until the Columbia River system is nearing depletion, about the first of September.

The Clackamas River is the major source of water power within the basin.

TRANSPORTATION

The Lower Willamette River Basin is served by an excellent road and highway system. The major north-south routes are Interstate 5, U. S. 99W, U. S. 99E, Oregon 47, Oregon 211, and Oregon 213. The major east-west routes are Interstate 80N, U. S. 30, U. S. 26, Oregon 8, and Oregon 212. There is an extensive network of secondary roads. A system of access roads in the

forested areas has been developed and is being added to annually to meet man's needs for use of this land. Regularly scheduled bus and motor freight service is available to the incorporated cities and towns of the basin along the major highways and roads.

Five major railroads provide both passenger and freight service in the basin. The Southern Pacific and the Spokane Portland and Seattle Railways extend south from Portland and with branch lines serve many of the principal cities and towns in the basin. The Union Pacific enters the basin from the east and terminates at Portland. The Great Northern and Northern Pacific enter from the north at Portland and terminate at that city. The Portland Traction Co. operates on electric train from Portland to Gresham, Oregon City, and Boring.

There are five airports in the basin that are classified for public use by the Oregon State Board of Aeronautics. Trans-continental air lines provide direct service from Portland to points outside the basin, and regular air line service is available to other cities in the basin.

Shallow-draft vessels navigate the Columbia and the Willamette Rivers moving freight in barges and towing log rafts. Ocean-going vessels navigate the Columbia and Willamette Rivers to Portland. In 1960, they carried 5,796,000 short tons import and 3,080,000 short tons export. Approximately two-thirds of the foreign export was agricultural produce. In 1956, 1,600 ships called, making Portland the nation's eleventh ranking port in record of ship's arrivals and departures.

LANDOWNERSHIP

Landownership has been classified as federal, state, county and municipal, and private (table 2). Figure 6 shows the general location of the various ownerships.

About 56 percent of the basin is privately owned. Tualatin and Columbia Subbasins are 91 percent privately owned compared to 33 percent of Clackamas Subbasin and 28 percent of Sandy Subbasin.

Almost 41 percent of the basin is in federal ownership, approximately 95 percent of which is in the Mount Hood National Forest. The remainder is Oregon and California Revested Lands and Public Domain administered by the Bureau of Land Management.

The State of Oregon owns 2 percent of the basin. Of this, sixty percent is managed by the Board of Forestry in the Tualatin Subbasin. Thirty-three percent is managed by the Game Commission as game management areas on Sauvie and Government Islands. Most of the remainder is state parks. No acreages for state highway rights-of-way are included in these figures.

Slightly less than one percent is owned by counties and municipalities. The municipal ownership is mainly watershed areas and Forest Park in Portland. The county ownerships represent mainly cutover land that has been foreclosed for non-payment of taxes.

FIGURE 6

LAND STATUS

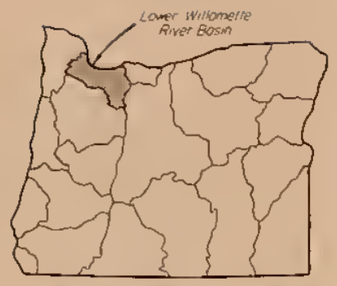
LOWER WILLAMETTE RIVER BASIN

OREGON

SEPTEMBER 1963

SCALE IN MILES 2 0 2 4 6 8 10

RIVER BASIN LOCATION



SUBBASINS

8 TUALATIN

9 CLACKAMAS

10 COLUMBIA

11 SANDY

COUNTY LOCATION

LEGEND

- U S Forest Service
- Bureau of Land Management
- County and Municipal
- State of Oregon
- Large Private
- Small Private
- River Basin Boundary
- Subbasin Boundary
- National Forest Boundary

LAND USE

A generalized pattern of land use is shown on figure 7, and a tabulation of land use by ownership class is made in table 2.

Slightly over 68 percent of the basin is forest with the major portion in the Coast and Cascade Mountain Ranges. The Clackamas Subbasin contains 46 percent of the basin's forests.

Cropland, which is found mainly in the valley areas, accounts for almost 19 percent of the basin's land use. Thirty-four percent of the Tualatin Subbasin is devoted to crops as compared to 5 percent of the more rugged Sandy Subbasin.

Thirteen percent of the basin is used for other purposes including cities, towns, and roads. Also included are non-vegetated areas such as lava flows and areas above timberline in the Cascade Mountains.

POPULATION

The Lower Willamette River Basin is the most populous area in the State of Oregon. In 1960, the population was about 726,000, or 41 percent of the state's population. The population density is 266 persons per square mile as compared to 18 persons per square mile for the state.

More than half of the population, or 372,700, live in the metropolitan city of Portland. An additional 248,900 live in urban areas, including 11 cities and towns with more than 2,500 inhabitants. About 3 percent of the people live on farms, and the remaining 12 percent make up the rural nonfarm population (table 3).

Table 3.--Population, Lower Willamette River Basin, Oreg., 1960

Place of residence	Number of inhabitants
Urban areas	621,600
Rural areas:	
Farm	19,400
Nonfarm	85,000
Total	726,000

Population has continually increased during each ten year census interval since 1870. Figure 8 shows the population growth for Clackamas, Multnomah, and Washington Counties as well as the City of Portland. The rate of growth was especially high during the war years of the 1940's. Since 1950, population in the basin increased by 17.5 percent compared to 16.3 percent for the state.

FIGURE 7

GENERALIZED LAND USE

LOWER WILLAMETTE RIVER BASIN

OREGON

SEPTEMBER 1963

SCALE IN MILES 2 0 2 4 6 8 10

RIVER BASIN LOCATION

SUBBASINS

8 TUALATIN

9 CLACKAMAS

10 COLUMBIA

11 SANDY

COUNTY LOCATION

LEGEND

- Forest
- Urban
- More Than 85% Cultivated
- Upper Slope Forest and Alpine Zone
- Mixed Use
- River Basin Boundary
- Subbasin Boundary
- National Forest Boundary

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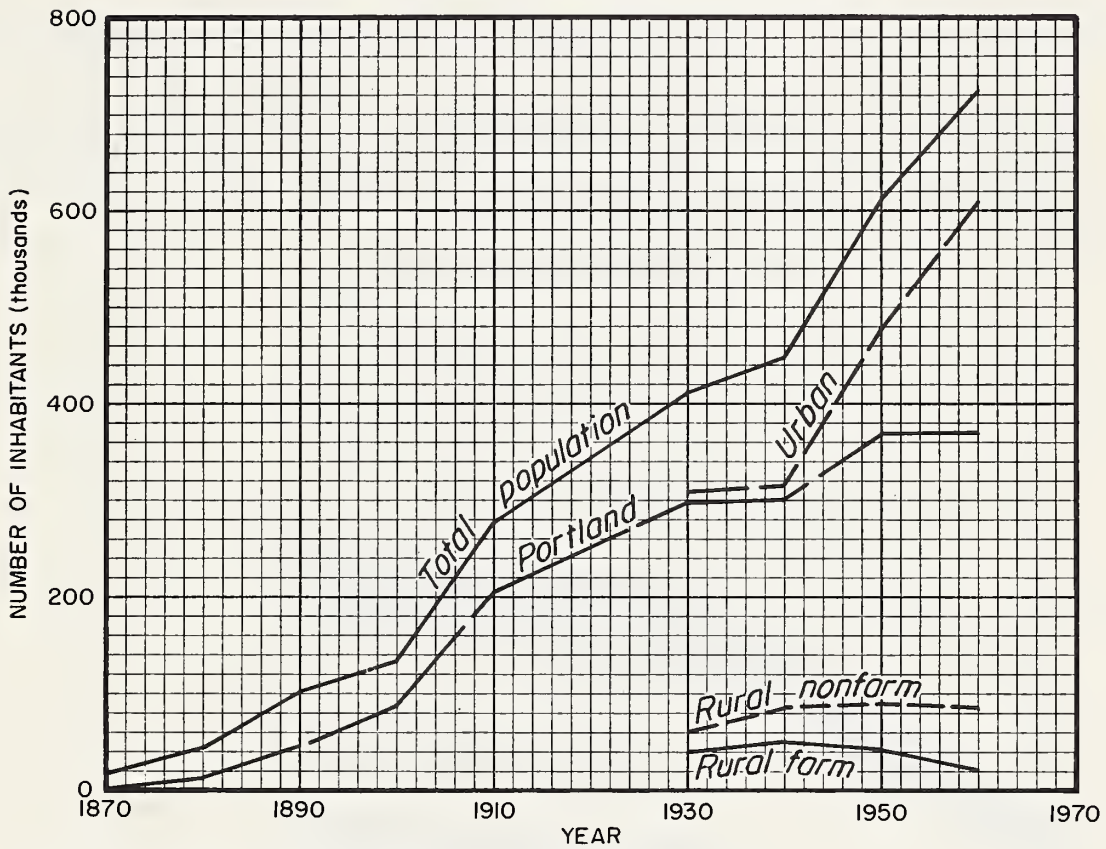
Population of three principal counties[1/] in the Lower Willamette River Basin, Oregon, 1870 - 1960.



1/ CLACKAMAS, MULTNOMAH AND WASHINGTON COUNTIES.

Source: U. S. Census of Population

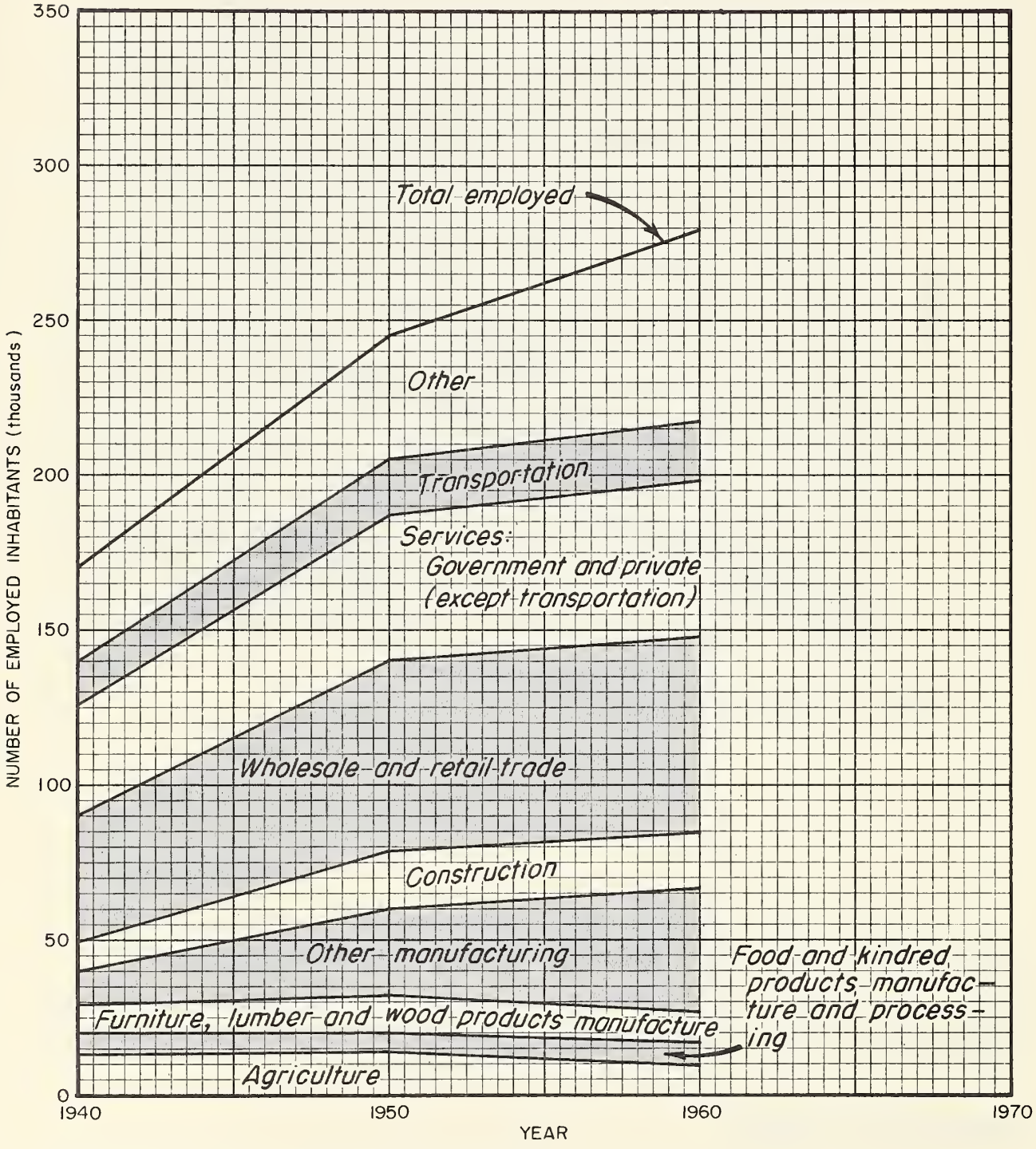
Figure 8

Population in Portland increased until 1950 and then leveled off at about 373,000. As in most metropolitan areas, the greatest growth during the past 20 years has occurred in the fringe areas of the City of Portland. Neither farm, forest, nor stony cliff has restrained the outward pouring of humanity in its quest for more growing room. The results are a fast growing urban population and a declining farm population.

EMPLOYMENT AND INDUSTRY

The 1960 Census of Population shows that about 277,000 people were employed in Clackamas, Multnomah, and Washington Counties. This is 38 percent of the population of the three counties. Figure 9 shows employment in these counties from 1940 to 1960 by employment group. In 1960, wholesale and re-

Employment in three principal counties 1/ in the Lower Willamette River Basin, Oregon, 1940-1960.



1/ CLACKAMAS, MULTNOMAH AND WASHINGTON COUNTIES.

Source: U. S. Census of Population

Figure 9

tail trade was the largest employment group with 23 percent of the working force. Government and private services were second with 18 percent followed by other manufacturing, 14 percent; transportation, 7 percent; construction, 6 percent; furniture, lumber, and wood products manufacture, 4 percent; agriculture, 3 percent; and food and kindred products, 3 percent. The remaining 22 percent of those employed work in other occupations.

Since 1940, employment has increased in every employment group except agriculture and manufacturing of wood products. Employment in "other manufacturing" has shown the largest increase, more than trebling since 1940.

FOREST LAND MANAGEMENT IN THE BASIN

CHARACTERISTICS OF FORESTED AREAS

Forest Stands

The forests of the Lower Willamette River Basin may be divided into the following four zones on the basis of ecology, climate, and landownership: the valley zone, the principal forest zone, the upper slope forest zone, and the subalpine forest zone.

The valley zone generally lies below 1,000 feet elevation and has the driest and warmest climate. 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 and is generally in blocks of less than 500 acres owned by farmers and ranchers and intermingled with agricultural land. There are both hardwood and softwood stands in this zone, with the hardwood stands occurring on the bottom lands and on dry sites. Cottonwoods, alder, bigleaf maple, and willows are the most common species on bottom lands. Oregon white oak is found on the drier sites. Coniferous stands occur on a variety of sites with Douglas-fir as the most common species mixed with grand fir, western hemlock, and western red cedar.

The principal forest zone begins between 500 and 1,000 feet elevation and extends up to 3,000 to 4,000 feet. The climate of this major timber producing zone is characterized by annual precipitation ranging from 60 to 140 inches, moderate winter snowfall with virtually no snowpack development, and somewhat cooler temperatures than found in the valley zone. Approximately 90 percent of the land is forested. Coniferous forests of Douglas-fir predominate with lesser amounts of western hemlock, western red cedar, and true firs. Stands of red alder occur in the lower elevations of the Coast Range where fire or logging removed the original stand. Most of the forest land is owned by large timber companies or the public.

The upper slope forest begins at about 3,000 to 4,000 feet and extends upward to 5,000 to 6,000 feet, covering a large area in the Cascades. The climate of this zone is characterized by annual precipitation ranging from 90 to 140 inches, heavy winter snowfall with a significant snowpack, and cool summer temperatures. About 80 percent is forested; the remainder consists of areas of rock, outcrops, shallow stony soils, meadows, and lakes. True fir-mountain hemlock stands are predominant. Most of the land is in the Mount Hood National Forest.

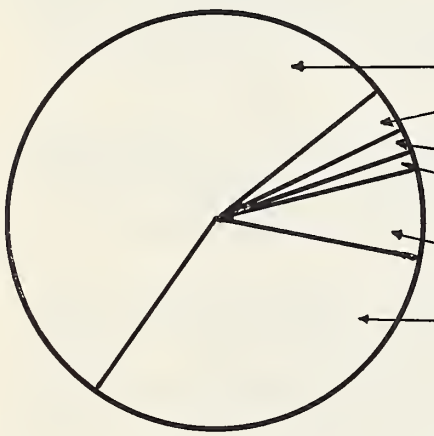
The subalpine forest zone begins at about 5,500 to 6,000 feet elevation in the Cascades and extends to the upper limit of tree growth. The climate

is characterized by heavy winter snowfall and an average frost-free growing season of approximately 30 days. The principal tree species--subalpine fir, mountain hemlock, white bark pine, and Alaska yellow-cedar--occur in scattered stands intermingled with meadows and barren areas. Only a few peaks along the crest of the Cascades are above timberline. Most of the land in this zone is in the Mount Hood National Forest.

Forest Landownership

Sixty-two percent of the forest land in the basin is publicly owned (fig. 10). Almost 90 percent of this is in the Mount Hood National Forest, administered by the Forest Service of the Department of Agriculture. Five percent is public domain and Oregon and California Railroad revested lands administered by the Bureau of Land Management of the Department of the Interior. These BLM administered lands are scattered throughout the forested portion of the basin. Three percent is state forest land, mainly at the eastern edge of the Tillamook burn in Washington County. Portland and Forest Grove own significant amounts of forest land in their respective municipal watersheds. Portland also owns the 6,000 acre Forest Park which is partially within the city limits.

Forest landownership, Lower Willamette River Basin, Oreg., 1963



Ownership class	Acres	Percent
Public:		
National forest	663,780	56
Public domain and O&C lands	36,850	3
State	24,200	2
Municipal	16,000	1
Private:		
Large private (over 5,000 acres)	85,000	7
Other private (less than 5,000 acres)	371,420	31
Total	? 1,197,250	100

See p. ii

Figure 10

About 38 percent of the forest land is privately owned. The majority of this, 81 percent, is in small ownerships while the remaining 19 percent is held by 10 owners.

Forest Land Use

The major uses of forest land in the Lower Willamette River Basin are production of commercial timber, water, and outdoor recreation. Other uses

including wildlife habitat, production of forage for livestock, and 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. Most federal and state forest land is managed to accommodate a balance of several uses, but some is used primarily for outdoor recreation with uses such as livestock grazing and timber harvesting modified or excluded.

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 influence 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 nation. By law, the majority of the Bureau of Land Management lands are devoted to permanent forest production in conformity with the principle 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 an increase in the multipurpose use of forest land, particularly timber management and outdoor recreation on private land. 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 Lower 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. Land class and cover type classification for the Lower Willamette River Basin is shown in tables 4 and 5. This classification is based primarily on the Forest Service system of four 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 harvest-

Table 4.--National forest land, Lower Willamette River Basin, Oreg., 1962

Land class and cover type	Subbasin 9 Clackamas	Subbasin 11 Sandy	Total
	Acres	Acres	Acres
Sawtimber stands:			
Old-growth Douglas-fir	128,700	41,700	170,400
Other Douglas-fir	40,500	20,500	61,000
Western hemlock	65,800	35,800	101,600
Western red cedar	11,700	11,700	23,400
True fir-mountain hemlock	45,900	23,100	69,000
Other conifers	1,200	...	1,200
Hardwoods	1,800	3,100	4,900
Poletimber stands:			
Douglas-fir	23,900	39,700	63,600
Western hemlock	11,400	5,200	16,600
True fir-mountain hemlock	26,400	10,500	36,900
Other conifers	17,500	4,200	21,700
Hardwoods	1,200	3,700	4,900
Seedling-sapling stands:			
Douglas-fir	12,700	8,100	20,800
Western hemlock	1,800	4,600	6,300
True fir-mountain hemlock	11,200	8,300	19,500
Other conifers	2,600	1,000	3,600
Hardwoods	600	2,800	3,400
Not stocked	8,500	3,100	11,600
Subtotal	413,400	227,000	640,400
Noncommercial and nonforest	10,200	21,000	31,200
Reserved forest land	...	5,100	5,100
Total	423,600	253,100	676,700

Source: Estimated from inventory statistics, Mount Hood National Forest.

ing is modified to protect or enhance recreational or watershed values is called "modified-commercial" forest land. Commercial forest land is further subdivided by cover types.

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.

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 5.--Land class, cover type, and timber volumes, Lower Willamette River Basin, Oreg., 1962

Land class and cover type	Subbasin 8 Tualatin		9 Clackamas		10 Columbia		11 Sandy		Total	
	Acres	MMBF	Acres	MMBF	Acres	MMBF	Acres	MMBF	Acres	MMBF
Conifers:										
90 years and older:										
Bureau of Land Management	1,600	40.0	3,800	83.0	1,000	23.6	3,100	68.8	9,500	215.4
State 1/	700	15.7	...	...	...	...	...	...	700	15.7
Large private	1,100)	332.1	1,800)	1,257.5	700)	31.2	2,000)	634.9	5,600)	2,255.7
Other	5,000)		17,500)		...)		6,900)		29,400)	
80 years and younger:										
Bureau of Land Management	7,900	81.0	5,600	48.0	4,700	48.1	4,700	39.4	22,900	216.5
State 1/	20,100	34.3	...	...	...	...	...	...	20,100	34.3
Large private	28,000)	1,165.9	12,400)	949.1	11,300)	453.1	4,000)	428.9	55,700)	2,997.0
Other	123,400)		56,000)		36,000)		14,000)		229,400)	
Hardwoods:										
Bureau of Land Management	650	...	1,000	...	350	...	800	...	2,800	...
State 1/	100	...	...	...	...	...	...	...	100	...
Large private	4,900	...	3,600	...	3,300	...	8,000	...	19,800	...
Other	22,860	...	15,800	...	11,000	...	27,160	...	76,820	...
Nonstocked and non-forest:										
Bureau of Land Management	650	...	1,000	...	350	...	800	...	2,800	...
State 1/	7,300	...	...	...	...	...	...	...	7,300	...
Large private	...	...	1,200	...	2,700	...	...	...	3,900	...
Other	...	...	13,330	...	8,400	...	...	...	21,730	...
Total:										
Bureau of Land Management	10,800	121.0	11,400	131.0	6,400	71.7	9,400	108.2	38,000	431.9
State 1/	28,200	50.0	...	...	...	...	...	...	28,200	50.0
Large private	34,000)	1,498.0	19,000)	2,206.6	18,000)	484.3	14,000)	1,063.8	85,000)	5,252.7
Other	151,260)		102,630)		55,400)		48,060)		357,350)	

1/ Includes City of Forest Grove forest land.

Source: Bureau of Land Management, State Forester Inventories, Forest Survey, N. W., Oregon, and estimates by USDA Survey Party.

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.

Protection of Forest Resources

Protection from Fire. Fire protection for forest resources in the Lower Willamette River Basin is shared by the Federal Government, the State of Oregon, and several rural fire protection districts. Generally, the Forest Service protects land within the national forests; the State of Oregon protects land outside the national forest but within the principal forest zone; and the rural districts protect land within the valley. There are isolated areas in the valley which lack organized fire protection at present, but rural districts are expanding and gradually eliminating these unprotected pockets.

The major causes of fires on the Mount Hood National Forest are lightning, smokers, campfires, and logging operations. Lightning fires are most common along the crest of the Cascades, particularly at the headwaters of the Clackamas River. Fires caused by forest users are most common in heavily used recreation areas and along major highways. Wild fires resulting from debris burning are most common during the fall slash burning period.

Photo 2.--Regular recording of weather observations from weather stations located throughout the basin makes more accurate weather forecasts possible. Mt. Hood N. F. photo. NO. 1

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, if the meterologists could

accurately predict the east wind periods, escaped slash fires could be held to a minimum. As it is, slash fires are occasionally fanned to life by the dry, east winds a month after burning operations have been completed.

Protection forces are adequate to control average fires. However, they sometimes are not adequate to control fire resulting from severe lightning storms or extreme burning conditions.

Protection from Insect, Disease, and Animal Damage. Protection of the forests of the Lower Willamette River Basin from insect, disease, and animal damage is primarily a responsibility of the individual landowners and managers. However, many owners join together in combatting forest pest problems. Their cooperative efforts are coordinated by the Northwest Pest Action Council, an organization of public and private officials. The 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 woolly aphid, the spruce budworm, and the Douglas-fir bark beetle, all of which have reached epidemic numbers at times in the past. Insect pest populations are presently of an endemic nature, killing an occasional weakened tree. Total losses from insects are, however, quite large. Control of forest insects lies primarily in keeping forest stands in a vigorous condition, promptly disposing of windthrown or fire killed timber that provide a breeding place for insects, and promptly controlling epidemic outbreaks of insect populations.

Chemicals are used to control insect outbreaks only when consultation with interested agencies indicates that other resources will not be damaged.

As a result of the October 12, 1962, windstorm, there are many areas where extensive blowdown occurred. Every effort is being made to remove this material from the forests by the spring of 1964. This urgency is needed because of the Douglas-fir bark beetle. This beetle attacks weakened and recently dead trees where it lays its eggs between the wood and the bark during the late spring. The eggs hatch and the larvae travel through the cambium layer which lies between the wood and the bark. The following spring they emerge as adults and start looking for a place to lay their eggs. Lacking enough recently dead or weakened trees, they will attack healthy ones. When their numbers are large, they can kill healthy timber. Natural enemies and a healthy, vigorous forest are the best ways to keep these insects at safe levels.

There are several important diseases of forest trees in the basin. The Douglas-fir root rot (Poria weirii) causes windthrow losses to mature stands and kills young trees. White pine blister rust attacks and kills 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 1,149,000 acres of commercial forest land with an estimated 25.5 billion board feet of softwood timber in the Lower Willamette River Basin (tables 5 and 6). 1/

Table 6.--National forest timber volume 1/, Lower Willamette River Basin, Oreg., 1962

Species	Subbasin 9 Clackamas	Subbasin 11 Sandy	Total
	MM bd. ft.	MM bd. ft.	MM bd. ft.
Douglas-fir	8,925	3,069	11,994
Western hemlock	2,834	1,545	2,379
True fir-mountain hemlock	2,040	860	2,900
Western red cedar	442	425	867
Other conifers	41	10	51
Hardwoods	22	35	57
Total	14,304	5,944	20,248

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

Source: Estimated from inventory statistics, Mount Hood National Forest.

The most productive timber areas in the basin are in the Coast Range and from 1,500 to 3,000 feet elevation in the Cascades. In these areas of heavy precipitation and moderate temperatures the site index 2/ for Douglas-fir averages from 130 to 160. Site quality decreases with increasing elevation and steepening terrain in the Cascades. For instance, commercial forest land in the Clackamas and Sandy Subbasins has an average site index of 101 in the national forest. Above 4,000 feet in the Cascades the site index rarely exceeds 90.

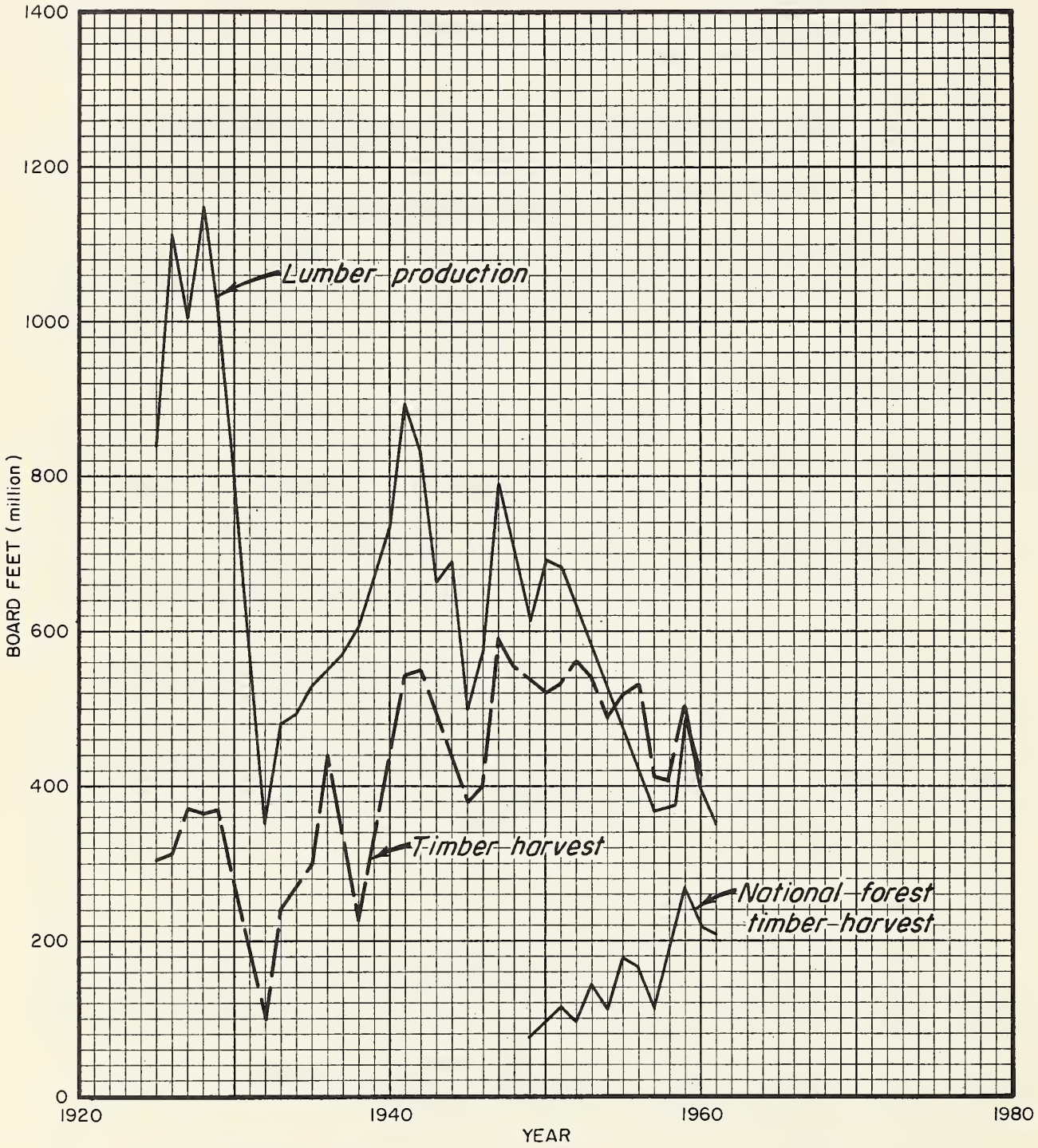
Logging and Wood-Using Industries

Logging and sawmilling began at the time of settlement, and timber harvest increased to almost 600 million board feet annually by the late 1940's. Lumber production exceeded timber harvest in the Lower Willamette River Basin until 1955; since then timber harvest has led slightly (fig. 11). Almost all of the large cargo mills have closed, and lumber is now mainly produced by smaller, more efficient mills. The number of plywood plants has increased

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

2/ Site index is an expression of forest site quality based on the height of the dominant timber of an arbitrary age. Age 100 has been chosen for Douglas-fir.

Timber harvest and lumber production from Clackamas, Multnomah and Washington Counties, Lower Willamette River Basin, Oregon, 1925-1961.



Source: U. S. Forest Service and West Coast Lumbermens' Association.

Figure 11

greatly since 1950. The majority of the lumber and plywood produced in the basin is from local timber. Some timber is exported to other areas for manufacture.

There was little demand for public timber prior to 1950 because of the abundance of accessible, high quality private timber. As the private timber became less plentiful, demand for public timber has steadily increased. In 1950, the national forest accounted for only 19 percent of the harvest while in 1962 it accounted for 52 percent.

Tables 7 and 8 show the number and the installed capacity of wood-using industries in the Lower Willamette River Basin in 1962. These industries require large quantities of raw material. It is estimated that sawmills, veneer, and plywood plants require an annual supply of 800 million board feet to operate at full capacity. The pulp and paper industry used 124 million board feet of logs in 1960 in addition to large quantities of chips from sawmills and plywood plants.

Table 7.--Wood-using industrial establishments, Lower Willamette River Basin, Oreg., 1963

Product	Subbasin				
	8 Tualatin	9 Clackamas	10 Columbia	11 Sandy	Total
	Number	Number	Number	Number	Number
Primary products:					
Lumber	9	10	11	5	35
Plywood, veneer	3	1	8	1	13
Shingles	...	...	3	...	3
Pulp and paper	...	2	3	...	5
Hardboard, particle board, etc.	1	...	1	...	2
Remanufactured products	2	...	8	...	10
Specialty products	...	...	4	...	4

Source: Crow's Buyer's and Seller's Guide of the Western Lumber and Plywood Industries, C. C. Crow Publications, Inc., Portland, Oregon, 1963. Lockwood's Directory of the Paper and Allied Trades, Lockwood Trade Journal Co., Inc., New York, 1963.

Sawmills and plywood plants produce large quantities of wood residue that can be used to manufacture wood fiber products. Better use of this residue could be an important contribution to the economy of the area, but it 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 fiber products.
2. Markets for wood fiber 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 industrial wastes.
5. Availability of sufficient quantities of good quality water.

Table 8.--Installed production capacity of certain wood-using industries, Lower Willamette River Basin, Oreg., 1963

Product	Subbasin				
	8 Tualatin	9 Clackamas	10 Columbia	11 Sandy	Total
Lumber, M bd. ft./8 hrs.	581	420	950	130	2,081
Plywood, veneer, million sq. ft./ mo. 1/	8	1.5	42.7	4	56.2
Hardboard, particle board, million sq. ft./mo. 1/	100 2/	...	160	...	160
Pulp and paper, tons/24 hrs.	...	620	118	...	738

1/ Three-eighth inch basis.
2/ Tons pulp/24 hours used for hardboard.

Source: Crow's Buyer's and Seller's Guide of the Western Lumber and Plywood Industries, C. C. Crow Publications, Inc., Portland, Oregon, 1963. Lockwood's Directory of the Paper and Allied Trades, Lockwood Trade Journal Co., Inc., New York, 1963.

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 Lower 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 common in areas of moderate terrain or in stands where the volume harvested per acre is not large (photo 3). Logs are generally hauled to mills by truck though rail and water transportation are also used (photo 4).

The large volume of cull logs and slash resulting from logging operations is usually disposed of by broadcast burning or spot burning of heavy accumulations in early fall during periods of low fire danger. Broadcast slash burning, if properly employed, reduces the fire hazard and may encourage natural regeneration if the 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, soils, and watershed management. Unburned old-growth slash is a serious fire hazard for which the landowner is responsible under state law.

Photo 3.--Cable yarding system operating on steep ground in the Clackamas Subbasin. Mt. Hood N. F. photo. NO. 2

Photo 4.--First loads of old growth Douglas-fir removed from Fish Creek drainage, Clackamas Subbasin, 1943. FS photo.
NO. 428339

Thus, it appears that slash burning may continue to be a widespread practice so long as old-growth timber is being harvested or until more complete utilization reduces 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 if cutting areas are small and are near a seed source (photo 5). Planting of nursery-raised seedlings and direct seeding are common methods of supplementing natural regeneration. Deficient summer moisture conditions, high temperatures, competition from other vegetation, grazing of domestic and wild animals, and destruction of seed by small rodents are common regeneration problems in the basin.

Photo 5.--Douglas-fir regeneration is usually adequate in cutting areas with a nearby seed source, Sandy Subbasin. Mt. Hood N. F. photo. NO. 3

Young timber stands need intensive cultural treatment to improve the quality and quantity of wood growth. An effective measure is thinning young stands to remove dead, dying, damaged, overcrowded, and diseased trees giving desirable trees more growing space. Public and private owners have been doing limited amounts of thinning 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. Young 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 private ownerships that employ professionally trained foresters are usually the best managed lands. Generally, private commercial forest land of less than 5,000 acres is not managed as well from the standpoint of timber production as larger tracts.

Sustained Yield Potential

Old-growth timber is still the dominant raw material for wood-using industries of the Lower Willamette River Basin, but young-growth is increasing in importance. The remaining commercial old-growth timber will probably be completely harvested in about 50 years. Therefore, the potential sustained growth of the basin's forests is of great importance in determining how much raw material will be available annually.

The long term sustained annual yield of the basin's forests 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.
9. Taxation policies.

Considering the previous points, and applying many assumptions, potential allowable annual cut estimates have been made for state and private lands (table 9).

The figures for the private lands assume that from 25 to 50 percent of the area is suitable for intensive management, that 80 percent of existing hardwood stands will be converted to Douglas-fir, and that stocking varies from 50 to 70 percent of normal.

The calculations for the state land are based on existing timber stands reaching maturity and being harvested on a 90 year rotation. This is an anticipated figure because over 50 percent of the state forest land in this basin is presently 10 years old.

The present allowable annual cut for federal and some state managed land is also shown in table 9.

The potential annual allowable cut for the basin is estimated to be 448.8 million board feet.

Table 9.--Allowable annual cut for federal and state managed land, Lower Willamette River Basin, Oreg., 1963

Ownership class	Allowable annual cut				
	Subbasin				
	8 Tualatin	9 Clackamas	10 Columbia	11 Sandy	Total
	Millions of board feet				
National forest	...	176.1	...	64.0	240.1
Bureau of Land Management	5.2	6.1	3.3	5.1	19.7
City of Forest Grove	0.5	...	...	...	0.5
State 1/	8.5	...	...	...	8.5
Private 1/	75.0	40.0	35.0	30.0	180.0
Total	89.2	222.2	38.3	99.1	448.8

1/ Potential allowable annual cut estimated by USDA Survey Party.

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

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 pioneer heritage. Recently increased urbanization has caused more people to seek the out-of-doors to "get away from it all" through sightseeing, winter sports, picnicking, 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 recreation. All of these factors have brought about an increase in the recreation use of forest land.

The basin's forested areas have many attractions that make them desirable for recreation. Mount Hood is the major attraction and receives year around attention from sightseers, hikers, and skiers (photo 6). Another attraction for the sightseer, picnicker, fisherman, and others is the Columbia Gorge. Even through Mount Hood and the Columbia Gorge are major attractions, the other forested areas also get their share of recreation visits.

The Willamette and Columbia Rivers are used for a variety of recreational activities such as boating, swimming, fishing, and water skiing, but pollution has tended to limit the attractiveness of the main stem of the Willamette. Timothy Lake, developed as a regulating reservoir for Portland General Electric Company's downstream hydroelectric projects, has become a heavily used recreation area. Recreation use of the Clackamas River, long a favorite of trout fishermen, has continued to increase. Lakes and streams in the headwaters of the Clackamas River are visited by many fishermen, sightseers, and campers.

Photo 6.--Springtime visitors to Mount Hood enjoy skiing, hiking, and sightseeing. Mt. Hood N. F. photo. NO. 4

Recreation Zoning

Because of the increasing importance of recreation, it is necessary to manage the natural attractiveness of forest land for recreation use. On public forest land landscape management zones have been established around potential and developed recreational sites and lakes, streams, roads, and trails used for recreation travel. These landscape zones vary in size according to topography; the aim is to create a pleasing view of the forest. Commercial activities are modified in these areas to preserve a suitable environment for recreation. Timber management is carried on with the objective of producing a healthy forest cover that is also aesthetically pleasing.

It is also important to preserve some areas in a near-natural condition for recreation or for scientific study and observation. The 14,170 acre Mount Hood Wild Area is one of the tracts classified by the Forest Service primarily for wilderness recreation. It contains spectacular alpine scenery including Mount Hood, the highest peak in Oregon (photo 7). About 5,100 acres of the wild area are in the Lower Willamette River Basin. This portion alone received an estimated 800 visits during 1960, mostly in the form of hikes on the Timberline Trail which encircles the mountain.

Recreation receives special consideration in the management of other national forest areas also. In addition to the 5,100 acres in the Mount

Photo 7.--A seldom seen view of Mount Hood from the Zigzag Glacier prong of the Sandy River. FS photo. NO. 248893

Hood Wild Area and the stream, lake, road and trail zones, there are 25,000 acres in the Columbia Gorge Recreation Area, and 83,700 acres in the Mount Hood Recreation Area.

Trends in Use

Comprehensive recreation use data for the entire basin is not available, but data from the Mount Hood National Forest indicates that more and more people are making one day trips for sightseeing or picnicking (fig. 12). The general trend is toward one day round trips with only a moderate numerical increase in the number of overnight visitors. The Mount Hood data presented in table 10 shows a 140 percent increase in recreation use since 1957, but during this period picnicking increased 193 percent.

Primary purpose of national forest recreation visits as a percentage of total recreation visits, Lower Willamette River Basin, Oregon, 1957 - 1962.

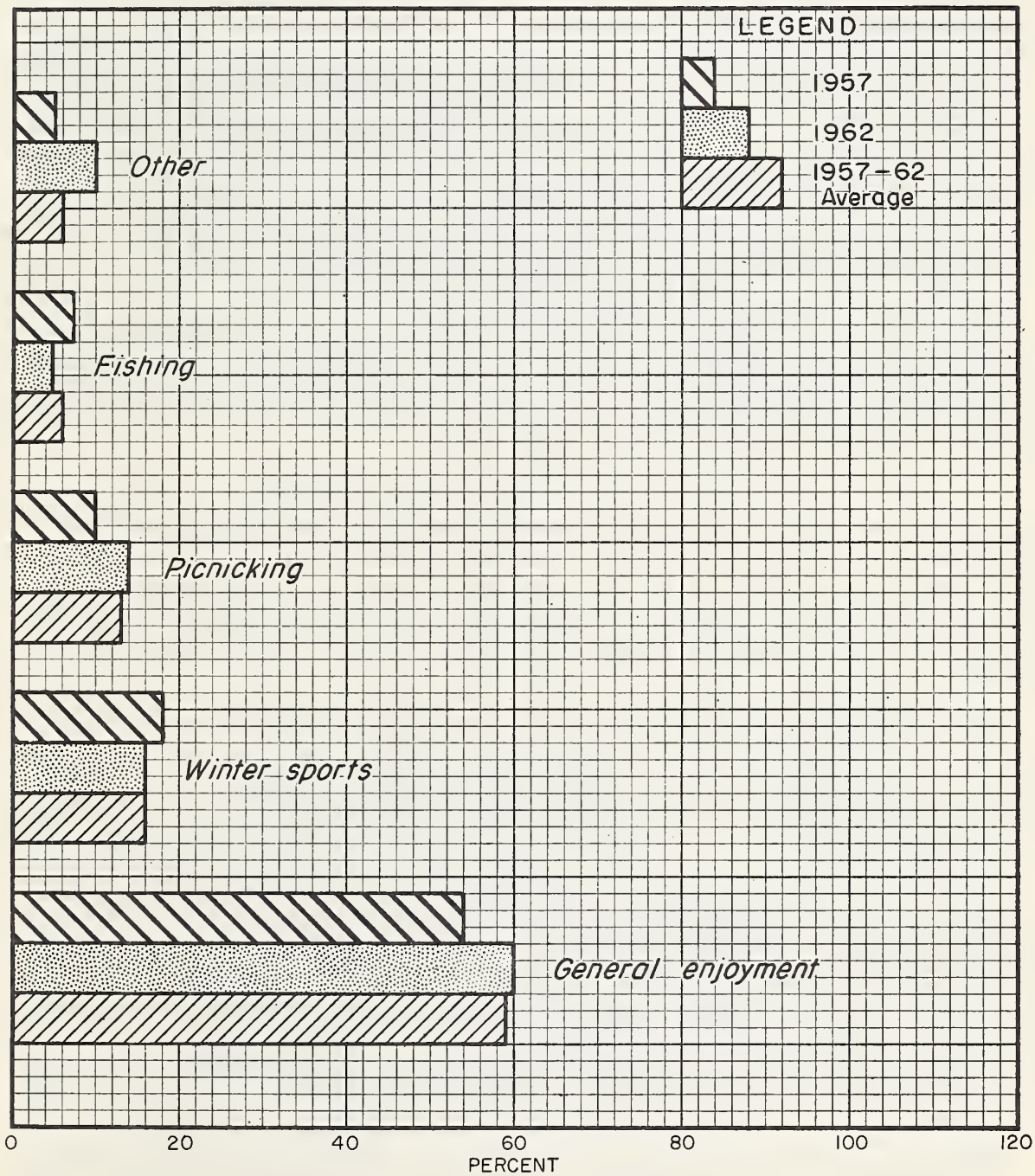


Figure 12

Table 10.--Recreational visits to state parks and national forests, Lower Willamette River Basin, Oreg., 1957-1967

Agency	Number of visits					
	1957	1958	1959	1960	1961	1962
	Millions of visits					
National forests:						
Clackamas Subbasin	.17	.23	.25	.26	.29	.31
Sandy Subbasin	1.62	1.85	1.82	1.88	1.94	2.15
National forest total	1.79	2.08	2.07	2.14	2.23	2.46
State parks (1958-61):						
Sandy Subbasin	...	1.10	1.15	.99	1.05	...

Source: Forest Service and Oregon State Highway Department.

Areas within a one day round trip distance of population centers will become increasingly popular. There are several county, city, and private recreation areas that have experienced heavy increases in use in the past five years. It appears that this trend will continue, and the recreation on private land will probably expand considerably.

Because of its ease of access and proximity to the Portland metropolitan area, the Mount Hood National Forest has long been a favorite with sightseers and campers. This has been particularly true of the Government Camp-Summit area (photos 8 and 9). Recreation use of the Clackamas River area has almost doubled in the last six years as a result of improved roads, development of Timothy Lake, and improvement of other recreational facilities.

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

National forest recreational use is expected to increase about 500 percent during the next 40 years. Use of the state parks and other land is expected to almost double in the next 15 years. Visitors come from all parts of the state, nation, and foreign countries to take advantage of the facilities in the basin. Recreation is a growing 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 other areas of Oregon become more heavily populated, forested areas that are available for recreation will become increasingly important.

The Bureau of Land Management's recreation program also is geared to provide all types of outdoor recreation for the public. BLM cooperates with counties, municipalities, and appropriate groups in making suitable recreation land available and in obtaining cooperative access through private lands to public recreation areas.

Photo 8.--Government Camp has long been the destination of sightseers and picnickers, Rafferty's Hotel, July 1923. FS photo. NO. 189661

Photo 9.--Huckleberry pickers checking in at Summit Guard Station. FS photo. NO. 172114

The BLM has developed one recreation site with camping and picnic facilities and is developing four additional areas. Some of these recreation areas are designed for overnight camping; other areas are designed for picnicking.

There are 14 state parks totaling 2,375 acres. All of the state parks, except Willamette Stone, have picnic facilities, and two have overnight camping.

There are 13 county parks with 1,828 picnic units and 38 camp units. Several of these parks have boat ramps.

Portland General Electric Company maintains six parks with 124 picnic units and 148 camp units. These parks are generally adjacent to their hydroelectric project reservoirs.

All public ownerships are planning to provide increased facilities as needed to meet future demand. For example, it is estimated that the Forest Service has five times as many sites available for campground development as are presently in use. The State of Oregon has proposed additional recreational development on three existing sites and three potential areas in the basin. The counties are actively planning additions to their facilities.

Public Recreational Facilities

The developed recreational facilities of the Lower Willamette River Basin consist of national forest and Bureau of Land Management recreational areas, state, county, and privately owned.

The national forest facilities include 56 forest camps with a total of 774 family units. 1/ The camps range in size from 1 to 59 family units. The facilities available range from primitive to piped water, shelters, bathtubs, and flush toilets although all these refinements may not necessarily be found in one forest camp.

The Forest Service allows occupancy of certain tracts of land by individuals or groups for recreational purposes under authority of annual or term special use permits. There are 10 summer home areas in the basin with approximately 600 homesites which are used by private individuals. Nine organizations have ski lodges on the slopes of Mount Hood in addition to Timberline Lodge, which is federally owned but operated by concessionaire under special use permit. There are three public service sites which provide facilities for skiers or vacationists. Multnomah Falls Lodge in Columbia Gorge is also federally owned and operated by a consessionaire on a special use permit. Hoodview and Gone Creek Forest Camps, which are on national forest land, were constructed and are maintained by Portland General Electric Company on a special use permit.

1/ A family unit conists of a table, fireplace, campsite, and parking space.

Photo 10.--Timberline Lodge has been a popular mountain recreation center since its completion in 1937. Mt. Hood N. F. photo. NO. 5

WILDLIFE

The wildlife and sports fishery resources of the state are managed by the Oregon State Game Commission. The commercial fishery is managed by the Fish Commission of Oregon. Habitat conditions, which have a marked influence upon size of wildlife and fish populations, are controlled by landowners.

Big Game

The most numerous big game animal in the basin is the Columbian black-tailed deer. The deer population has been increasing because logging has created a more favorable habitat in many areas. Hunting pressure is variable depending upon accessibility. It is estimated that the 1961 deer harvest in the basin was approximately 3,300 animals; 60 percent of these were bucks.

There is a small elk herd near the headwaters of the Clackamas River, and some are found in the Coast Range, but the harvest in this basin is insignificant.

A relatively stable black bear population is found throughout the basin; they are now classified as a game animal in the national forests along the Cascades.

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. If access to both public and private land were improved, hunting pressure would be more uniform.

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, caneberries, and idle farmland. Game farm raised pheasants are liberated by the Game Commission to supplement natural breeding stock. The population of most game bird species has been fairly stable in recent years despite strong hunting pressure.

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 although they have cyclic fluctuations.

Silver gray squirrels are common near the walnut and filbert orchards of Washington County and are responsible for considerable damage so there is no closed season or bag limit on them. Other species of squirrel are common in forested areas. Cottontail and snowshoe rabbits are fairly common in most of the basin.

Migratory Waterfowl

Migratory waterfowl are abundant during the migration period. During the 1961-62 season as many as 263,000 birds were on Sauvie Island at one time.

The State Game Commission has purchased 13,000 acres on Sauvie, Government, Lemon, and McGuire Islands to preserve and develop wintering grounds for waterfowl. Public hunting is permitted on approximately half of this area. During 1961, 8,500 hunters took 12,500 game birds from the Sauvie Island public hunting area.

Furbearers

Many species of furbearers such as beaver, racoon, gray fox, red fox, marten, mink, muskrat, otter, skunk, and weasel are found in the basin. 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 sometimes cause considerable damage.

Predators

There are some predators; coyote and bobcat are the most common.

Anadromous Fish

All of the major streams and many of the minor streams in the basin maintain runs of anadromous fish. The Oregon Fish Commission indicates that until recently a majority of the coho, or silver, salmon passing above the falls at Oregon City originated in the Tualatin system. This situation may now be undergoing some change as a result of apparently successful efforts in the past few years to establish coho salmon in the Yamhill and Molalla Rivers. Estimates of the Willamette River spring chinook run indicate that approximately five percent of the run migrates up the Clackamas River. Comparative figures for the Sandy River are not available although over 100 fall chinook returned to Cedar Creek hatchery in 1962.

It is known that low summer flows accompanied by high water temperatures and stream turbidity are detrimental to migration and spawning. The Fish and Wildlife Service states that water for their hatchery should be free of sediment and range from 45° to 60° F. in temperature.

Photo 11.--Eagle Creek National Fish Hatchery produces over five million salmon and steelhead fingerlings per year, Clackamas Subbasin, 1961. F and WS photo.

The Eagle Creek National Fish Hatchery which has been in operation since the late 1950's collected over 12 million eggs and produced over 100,000 pounds of fingerling salmon and steelhead last year (photo 11). The majority of these five million fingerlings were released in Eagle Creek where there are only two natural and no artificial barriers to hinder their migration.

Comparative production figures are not available at present for the Oregon Fish Commission Hatchery on Cedar Creek, but about 5,400 adult fish returned in 1962.

Native Fish

The streams, lakes, and reservoirs in the 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 bass, small-mouth bass, white crappie, black crappie, bullhead catfish, and bluegill. Streams and lakes in the mountains with cool water temperatures contain several species of trout.

Many of the lakes and streams are heavily fished so the Game Commission supplements natural stocking with hatchery-raised fish.

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 increase of trash fish and made some streams totally unsuitable for trout fishing during low summer flows.

RANGE

There is an estimated 52,850 acres of forest land that is used for livestock grazing in the Lower Willamette River Basin. This is predominately privately owned land in or near the Willamette Valley and is intermixed with range or cropland. It consists of land that varies from relatively open, 10 percent stocked, to completely stocked stands. This land varies from gentle to steep slopes except in areas with intermixed cropland where the gentler slopes were cleared for cropland leaving the steeper slopes in forest. The forage is generally of low quality, being mostly brush including poison oak and inferior species of grass. A small amount has been cleared and seeded to improved forage plants. All kinds of livestock are grazed on this land, but probably sheep and goats are best adapted because of their ability to browse.

There are 450 animal unit months of permitted grazing on national forest land, mainly in the upper slope forest zone where there are small meadows and open timber stands. At one time, sheep grazed large portions of the upper slope and subalpine zones, severely depleting 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 watershed and recreational values of the mountain areas and less emphasis on value for grazing.

WATER

Water Yield

It is estimated that 80 percent of the annual water yield from the Lower Willamette River Basin comes from forest land. Forest land is, therefore, vitally important in controlling quality, quantity, and timing of water yield. At low elevations, forest cover helps maintain soil conditions that facilitate 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 rather than 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.

Domestic Water

Most domestic water used in the basin comes from basin watersheds. These watersheds range in size from small individual streams to drainages the size of the Clackamas River. It is imperative that the source of domestic water be managed so as to provide uniform flows of high quality water.

At least four of the urban areas of the basin obtain their domestic water supplies from identifiable watersheds. St. Helens and Forest Grove own major portions of their respective watersheds. Oregon City, West Linn, and Portland obtain their water from watersheds on the Mount Hood National Forest. These cities have formal agreements with the Forest Service covering the management of their water source.

Bull Run Watershed. The Bull Run Forest Reserve, now included in the Mount Hood National Forest, was established in 1892. Laws and regulations concerning its use for other than water production were enacted in subsequent years. Because of its geology and location, this watershed enables Portland to have one of the best water sources available to any city of comparable size.

This area which provides Portland and surrounding areas with an average of 70,000,000 gallons of water per day 1/ is an example of a well managed watershed. Here water and timber are being produced and harvested at the same time. In order to maintain water yields suitable for domestic consumption with minimum treatment, the following road building and timber harvesting practices are followed:

1. All roads are located away from live or intermittent streams with particular attention to road design (photo 12). Some important factors of road design are:

1/ 69th Annual Report, Bureau of Water Works, Dept. of Pub. Util., Portland, Oregon, 1962.

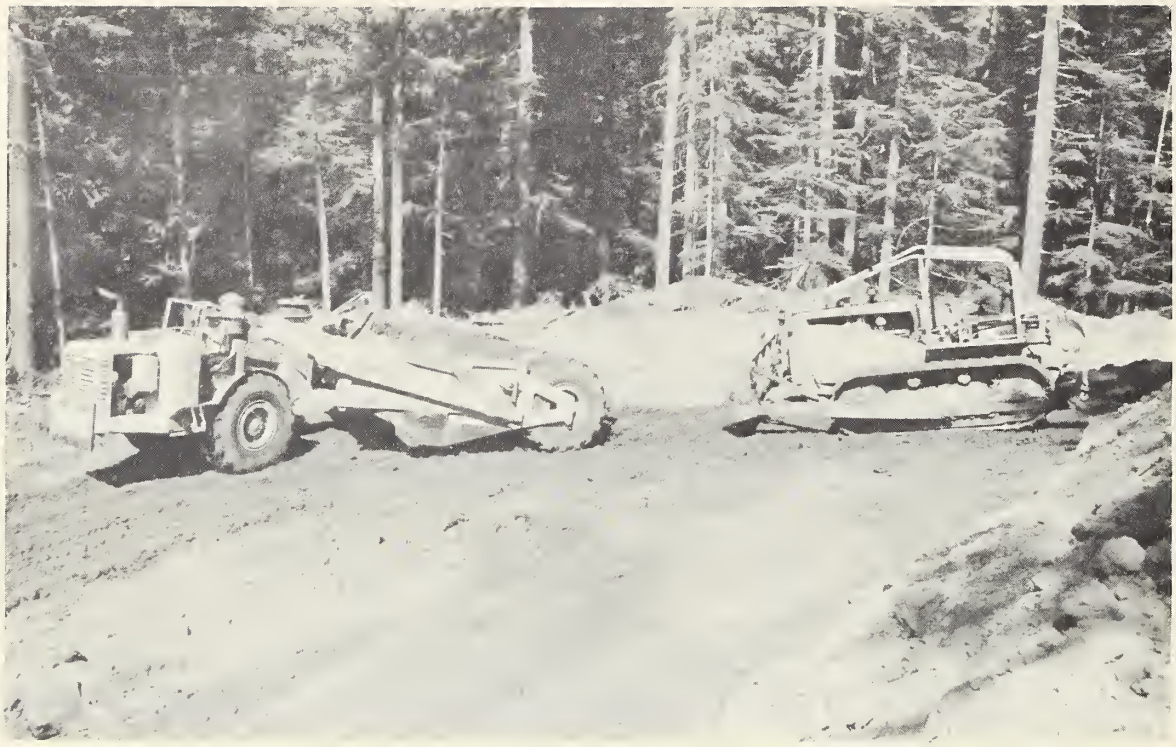


Photo 12.--Forest access roads are located and designed away from streams where possible. FS photo. NO. 485544

a. Balancing cuts and fills within practical limits.
b. Keeping cuts and fills as small as possible and providing prompt protection for exposed slopes by structural devices or revegetation.
c. Compromising grade and alignment if necessary to favor locations which minimize soil disturbance.
d. Planning adequate cross drainage to prevent ditch scour.
e. Ensuring that ditch water is not diverted directly into natural stream channels.

2. Natural stream channels are protected during logging by:

a. Installing temporary metal or log culverts when stream crossings are necessary.
b. Keeping streams free of logging debris.

3. Water quality is maintained by:

a. Constructing water bars or drainage dips to divert water from skid trails and fire lines.
b. Maintaining stream side strips of green timber.
c. Revegetating logging-disturbed areas where exposed soils are susceptible to erosion.
d. Providing sanitary facilities for users of the watershed.

4. Soil erosion and disturbance are held to a minimum by:

   a. Cutting in patches of less than 25 acres.
   b. Using high-lead logging systems.
   c. Maintaining stream side strips of green timber.
   d. Disposing of slash promptly by light burning.
   e. Planting cutover areas immediately after slash disposal.

South Fork Watershed. The South Fork watershed provides municipal water to Oregon City and West Linn. It is another example of how watershed values can be maintained while also providing other forest benefits (photo 13). This watershed provides timber, recreational opportunities, and wildlife habitat.

Photo 13.--South Fork Clackamas River near the Oregon City-West Linn water supply intake structure. FS photo. NO. 485520

Measures similar to those prescribed for the Bull Run are also used here to protect the water quality and to prevent damage to the watershed values.

Uncontrolled activities connected with any of these uses could impair watershed values of forest land. However, by limiting the intensity of use and by following specific watershed management 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.

Water Requirements on Forest Land

There are many kinds of water requirements, both consumptive and nonconsumptive, on forest land but few quantitative estimates have been made of these requirements. Estimates of certain consumptive water requirements on national forest land in the basin are presented in table 11 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.

Table 11.--Estimated national forest consumptive water use 1/, Lower Willamette River Basin, Oreg.

Use	Subbasin		
	9 Clackamas	11 Sandy	Total
	Millions of gallons		
Domestic at administration sites 2/	1.8	1.7	3.5
Domestic at recreation sites	4.7	34.2	38.9
Livestock	0.1	...	0.1
Total	6.6	35.9	42.5

1/ Includes only water used and should not be confused with amount stored to provide for this consumption.
2/ Does not include water obtained from municipal sources.

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

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 recreation areas and at recreation facilities such as summer home areas, organization 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.

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. 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 aesthetically 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 remain at the present level. Deer are already near capacity populations, and it is doubtful that any substantial increases can be expected.

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 if fish and the aquatic plants and animals they use for feed are to thrive. An important part of maintaining water quality is the maintenance of adequate streamflows and lake levels (photos 14 and 15). When water quantities are low, especially during summer months, the water temperature is likely to rise, oxygen decreases, 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:

Photo 14.--Trillium Lake was a meandering stream through a pothole and a wet meadow before a cooperative improvement program. FS photo. NO. 442090

Photo 15.--Trillium Lake is now a popular public fishing area developed cooperatively by the Oregon State Game Commission and the U. S. Forest Service. FS photo. NO. 500818

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 abatement 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 young-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. Operations 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 Lower Willamette River Basin is highly diversified. The temperate climatic conditions and fertile valley soils are conducive to the production of a multitude of agricultural products. Within the basin is Portland, the population center of Oregon, offering ready markets for many of the farm products.

The Tualatin is the major agricultural subbasin. It contains nearly half of the farms in the basin, over half of the cropland, and 45 percent of the irrigated land. The Columbia Subbasin, with 18 percent of the cropland and 39 percent of the irrigated land, is next in importance followed by the Clackamas and Sandy Subbasins.

Agriculture in all of the subbasins is affected by the pressures of the growing urban population, which has resulted in a shifting of agricultural land to other uses, higher taxes and inflated values on much of the remaining agricultural land, and more part-time farms. The expansion of the urban communities will undoubtedly continue to cause rapid changes in the agricultural sector of the economy.

Agricultural Data

Data on land use, economics, 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 a hydrologic basis was desired to facilitate future planning and comparison of potential projects. The USDA River Basin Survey Party made a reconnaissance survey of 22 small watershed areas in the Lower 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. 21), and information for each watershed is shown in tables 12A through 12E.

This information was estimated by local personnel of the Soil Conservation Service and the Forest 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 were used throughout much of this report.

Agricultural Land Use

The land base for agriculture consists of 55,300 acres of rangeland, 52,850 acres of grazed forest land, and 268,000 acres of cropland (table 13).

Table 12A.--Reconnaissance data on tributary areas studied, Tualatin, Subbasin 8, Lower Willamette River Basin, Oreg., 1963

Item	Unit	East Fork Dairy Creek A	McKay Creek B	West Fork Dairy Creek C	Gales Creek D	Tualatin River E	Fanno Creek F	Baker Creek G	Chicken Creek H	Total
Number of farms	Number	370	475	270	225	1,345	130	190	120	3,125
LAND USE:										
Forest land grazed	Acres	1,800	3,500	1,500	1,200	9,300	1,250	2,000	1,500	22,050
Forest land not grazed	do.	25,740	20,490	32,190	36,920	77,110	2,820	5,620	1,320	202,210
Cropland	do.	20,900	27,600	13,500	7,600	65,740	4,240	5,900	6,100	151,580
Rangeland	do.	1,000	3,150	1,500	500	9,990	400	400	500	17,440
Other	do.	2,500	7,200	1,500	1,000	26,910	14,090	900	620	54,720
Total watershed area	do.	51,940	61,940	50,190	47,220	189,050	22,800	14,820	10,040	448,000
Cropland use:										
Dryland	Acres	17,750	27,100	12,300	6,100	57,340	3,990	5,500	5,650	135,730
Irrigated	do.	3,150	500	1,200	1,500	8,400	250	400	450	15,850
Total	do.	20,900	27,600	13,500	7,600	65,740	4,240	5,900	6,100	151,580
Potential cropland	Acres	3,000	3,000	3,000	1,500	8,100	500	1,000	1,000	21,100
IRRIGATION:										
Water source:										
Pumped from streams	Acres	2,700	500	1,050	1,475	6,950	200	250	375	13,500
Pumped from wells	do.	200	...	...	...	650	50	100	...	1,000
Other	do.	250	...	150	25	800	...	50	75	1,350
Total	do.	3,150	500	1,200	1,500	8,400	250	400	450	15,850
Water shortage	Acres	2,250	500	1,200	1,500	5,125	200	300	450	11,525
Method of application:										
Sprinkling	Acres	3,150	500	1,200	1,500	7,550	250	400	450	15,000
Other	do.	...	...	...	...	850	...	...	...	850
Total	do.	3,150	500	1,200	1,500	8,400	250	400	450	15,850
Potentially irrigable land:										
Water source:										
Natural flows and ground water	Acres	200	100	100	100	700	100	100	100	1,500
Other	do.	17,800	17,900	9,900	7,900	56,400	900	2,400	2,900	116,100
Total	do.	18,000	18,000	10,000	8,000	57,100	1,000	2,500	3,000	117,600
STORAGE:										
Existing ponds	Number	8	5	8	2	23	...	4	4	54
Existing reservoirs	do.	2	4	8	...	17	...	1	1	33
Possible sites studied	do.	2	3	5	1	2	1	2	1	17
DRAINAGE:										
Arable land needing drainage	Acres	4,500	4,500	2,200	2,000	21,000	500	700	1,500	36,900
Needs:										
Improved surface	Acres	1,000	1,000	500	500	4,000	...	...	...	7,000
Subsurface:										
Open drains	Acres	1,000	1,000	500	500	4,000	100	100	200	7,400
Closed drains	do.	3,500	3,500	1,700	1,500	17,000	400	600	1,300	29,500
Flooded areas	Acres	2,400	1,500	1,800	800	8,400	300	200	100	15,500

Source: Based on data collected by the U. S. Department of Agriculture River Basin Survey Party. Estimates provided by local personnel of the Soil Conservation Service and Forest Service.

Table 12B.--Reconnaissance data on tributary areas studied, Clackamas, Subbasin 9, Lower Willamette River Basin, Oreg., 1963

Item	Unit	Deep Creek A	Beaver Creek B	Clear Creek C	Eagle Creek D	Clackamas River E	Abernethy Creek F	Total
Number of farms	Number	700	175	150	200	250	150	1,625
LAND USE:								
Forest land grazed	Acres	1,500	2,200	4,000	1,200	2,000	1,600	12,500
Forest land not grazed	do.	12,950	1,800	28,230	45,770	444,250	11,130	544,130
Cropland	do.	9,500	9,920	11,500	6,700	12,000	5,500	55,120
Rangeland	do.	4,150	6,100	1,800	2,400	3,400	2,500	20,350
Other	do.	2,000	500	500	1,000	14,200	3,000	21,200
Total watershed area	do.	30,100	20,520	46,030	57,070	475,850	23,730	653,300
Cropland use:								
Dryland	Acres	8,300	9,420	11,100	6,630	11,500	5,300	52,250
Irrigated	do.	1,200	500	400	70	500	200	2,870
Total	do.	9,500	9,920	11,500	6,700	12,000	5,500	55,120
Potential cropland	Acres	1,000	200	1,000	1,500	1,500	1,000	6,200
IRRIGATION:								
Water source:								
Pumped from streams	Acres	200	200	200	...	300	100	1,000
Pumped from wells	do.	700	150	150	70	150	50	1,270
Other	do.	300	150	50	...	50	50	600
Total	do.	1,200	500	400	70	500	200	2,870
Water shortage	Acres	400	200	100	...	...	50	750
Method of application:								
Sprinkling	Acres	1,200	500	400	70	500	200	2,870
Flooding	do.	...	...	...	...	...	...	...
Total	do.	1,200	500	400	70	500	200	2,870
Potentially irrigable land:								
Water source:								
Natural flows and ground water	Acres	6,500	100	400	2,000	4,450	300	13,750
Other	do.	500	400	100	...	50	200	1,250
Total	do.	7,000	500	500	2,000	4,500	500	15,000
STORAGE:								
Existing ponds	Number	27	15	25	1	4	12	84
Existing reservoirs	do.	...	5	...	...	3	4	12
Possible sites studied	do.	2	3	2	1	...	1	9
DRAINAGE:								
Arable land needing drainage	Acres	6,000	400	300	500	5,600	...	12,800
Needs:								
Improved surface	Acres	1,000	...	...	...	2,500	...	3,500
Subsurface:								
Open drains	Acres	...	...	...	...	600	...	600
Closed drains	do.	6,000	400	300	500	5,000	...	12,200
Flooded areas	Acres	100	100	100	...	300	200	800

Source: Based on data collected by the USDA River Basin Survey Party. Estimates provided by local personnel of the Soil Conservation Service and Forest Service.

Table 12C.--Reconnaissance data on tributary areas studied, Columbia, Subbasin 10, Lower Willamette River Basin, Oreg., 1963

Item	Unit	Milton Creek A	Scappoose Creek B	Portland C	Fairview D	Johnson Creek E	Total
Number of farms	Number	80	250	515	200	290	1,335
LAND USE:							
Forest land grazed	Acres	1,100	2,800	1,500	600	1,300	7,300
Forest land not grazed	do.	16,400	42,850	14,350	1,000	3,900	78,500
Cropland	do.	3,000	4,900	26,020	7,000	6,800	47,720
Rangeland	do.	600	950	4,900	2,000	2,800	11,250
Other	do.	1,000	900	108,430	5,000	14,000	129,330
Total watershed area	do.	22,100	52,400	155,200	15,600	28,800	274,100
Cropland use:							
Dryland	Acres	2,800	4,400	20,210	2,000	4,600	34,010
Irrigated	do.	200	500	5,810	5,000	2,200	13,710
Total	do.	3,000	4,900	26,020	7,000	6,800	47,720
Potential cropland	Acres	1,000	2,500	6,100	1,600	1,300	12,500
IRRIGATION:							
Water source:							
Pumped from streams	Acres	150	350	5,730	3,000	400	9,630
Pumped from wells	do.	...	50	80	1,600	1,400	3,130
Other	do.	50	100	...	400	400	950
Total	do.	200	500	5,180	5,000	2,200	13,710
Water shortage	Acres	150	300	100	...	700	1,250
Method of application:							
Sprinkling	Acres	200	450	5,510	5,000	2,200	13,360
Flooding	do.	...	50	300	...	...	350
Total	do.	200	500	5,810	5,000	2,200	13,710
Potentially irrigable land:							
Water source:							
Natural flows and ground water	Acres	200	2,200	15,000	3,600	500	21,500
Other	do.	1,000	2,800	200	...	500	4,500
Total	do.	1,200	5,000	15,200	3,600	1,000	26,000
STORAGE:							
Existing ponds	Number	1	10	12	5	15	43
Existing reservoirs	do.	1	3	1	2	1	8
Possible sites studied	do.	3	3	1	0	2	9
DRAINAGE:							
Arable land needing drainage	Acres	900	3,000	6,200	5,000	6,000	21,100
Needs:							
Improved surface	Acres	...	...	1,400	...	...	1,400
Subsurface:							
Open drains	Acres	...	1,000	1,100	...	...	2,100
Closed drains	do.	900	2,000	5,100	5,000	6,000	19,000
Flooded areas	Acres	400	1,000	7,100	200	1,500	10,200

Source: Based on data collected by the USDA River Basin Survey Party. Estimates provided by local personnel of the Soil Conservation Service and Forest Service.

Table 12D.--Reconnaissance data on tributary areas studied, Sandy, Subbasin 11, Lower Willamette River Basin, Oreg., 1963

Item	Unit	Bonneville A	Bull Run River B	Sandy River C	Total
Number of farms	Number	20	7	380	407
LAND USE:					
Forest land grazed	Acres	1,200	...	9,800	11,000
Forest land not grazed	do.	39,570	86,790	193,200	319,560
Cropland	do.	400	450	12,730	13,580
Rangeland	do.	1,800	160	4,300	6,260
Other	do.	4,000	2,000	17,000	23,000
Total watershed area	do.	46,970	89,400	237,030	373,400
Cropland use:					
Dryland	Acres	360	410	10,430	11,200
Irrigated	do.	40	40	2,300	2,380
Total	do.	400	450	12,730	13,580
Potential cropland	Acres	500	400	4,000	4,900
IRRIGATION:					
Water source:					
Pumped from streams	Acres	40	40	500	580
Pumped from wells	do.	...	...	1,300	1,300
Other	do.	...	...	500	500
Total	do.	40	40	2,300	2,380
Water shortage	Acres	...	...	...	...
Method of application:					
Sprinkling	Acres	40	40	2,300	2,380
Flooding	do.	...	...	...	...
Total	do.	40	40	2,300	2,380
Potentially irrigable land:					
Water source:					
Natural flows and ground water	Acres	100	...	1,500	1,600
Other	do.	...	...	500	500
Total	do.	100	...	2,000	2,100
STORAGE:					
Existing ponds	Number	...	2	10	12
Existing reservoirs	do.	...	3	3	6
Possible sites studied	do.	...	...	3	3
DRAINAGE:					
Arable land needing drainage	Acres	...	...	10,000	10,000
Needs:					
Improved surface	Acres	...	...	...	...
Subsurface:					
Open drains	Acres	...	...	...	...
Closed drains	do.	...	...	10,000	10,000
Flooded areas	Acres	600	...	2,000	2,600

Source: Based on data collected by the USDA River Basin Survey Party. Estimates provided by local personnel of the Soil Conservation Service and Forest Service.

Table 12E.--Reconnaissance data on tributary areas studied, Lower Willamette River Basin, Oreg., 1963

Item	Unit	Subbasin 8 Tualatin	9 Clackamas	10 Columbia	11 Sandy	Total
Number of farms	Number	3,125	1,625	1,335	407	6,492
LAND USE:						
Forest land grazed	Acres	22,050	12,500	7,300	11,000	52,850
Forest land not grazed	do.	202,210	544,130	78,500	319,560	1,144,400
Cropland	do.	151,580	55,120	47,720	13,580	268,000
Rangeland	do.	17,440	20,350	11,250	6,260	55,300
Other	do.	54,720	21,200	129,330	23,000	228,250
Total watershed area	do.	448,000	653,300	274,100	373,400	1,748,800
Cropland use:						
Dryland	Acres	135,730	52,250	34,010	11,200	233,190
Irrigated	do.	15,850	2,870	13,710	2,380	34,810
Total	do.	151,580	55,120	47,720	13,580	268,000
Potential cropland	Acres	21,100	6,200	12,500	4,900	44,700
IRRIGATION:						
Water source:						
Pumped from streams	Acres	13,500	1,006	9,630	580	24,716
Pumped from wells	do.	1,000	1,270	3,130	1,300	6,700
Other	do.	1,350	600	950	500	3,400
Total	do.	15,850	2,870	13,710	2,380	34,810
Water shortage	Acres	11,525	750	1,250	...	13,525
Method of application:						
Sprinkling	Acres	15,000	2,870	13,360	2,380	33,610
Flooding	do.	850	...	350	...	1,200
Total	do.	15,850	2,870	13,710	2,380	34,810
Potentially irrigable land:						
Water source:						
Natural flows and ground water	Acres	1,500	13,750	21,500	1,600	38,350
Other	do.	116,100	1,250	4,500	500	122,350
Total	do.	117,600	15,000	26,000	2,100	160,700
STORAGE:						
Existing ponds	Number	54	84	43	12	193
Existing reservoirs	do.	33	12	8	6	59
Possible sites studied	do.	17	9	9	3	38
DRAINAGE:						
Arable land needing drainage	Acres	36,900	12,800	21,100	10,000	80,800
Needs:						
Improved surface	Acres	7,000	3,500	1,400	...	11,900
Subsurface:						
Open drains	Acres	7,400	600	2,100	...	10,100
Closed drains	do.	29,500	12,200	19,000	10,000	70,700
Flooded areas	Acres	15,500	800	10,200	2,600	29,100

Source: Based on data collected by the U. S. Department of Agriculture River Basin Survey Party. Estimates provided by local personnel of the Soil Conservation Service and Forest Service.

Table 13.--Agricultural land use, Lower Willamette River Basin, Oreg., 1963

Agricultural land use	Subbasin 8 Tualatin	9 Clackamas	10 Columbia	11 Sandy	Total
	Acres	Acres	Acres	Acres	Acres
Grazing land:					
Forest	22,050	12,500	7,300	11,000	52,850
Range	17,440	20,350	11,250	6,260	55,300
Total	39,490	32,850	18,550	17,260	108,150
Cropland:					
Small grain	65,890	11,930	3,980	800	82,600
Hay and silage	23,730	10,370	13,680	3,450	51,230
Pasture	16,930	11,990	15,400	4,260	48,580
All fruits, nuts, and vineyards	17,950	5,480	3,690	1,830	28,950
Vegetable crops	2,790	1,660	4,470	1,000	9,920
Grass seed	3,530	3,030	240	300	7,100
Clover seed	4,890	1,210	170	100	6,370
Field corn	2,680	1,540	240	50	4,510
Other crops	1,930	910	1,730	750	5,320
Cropland harvested or pastured	140,320	48,120	43,600	12,540	244,580
Cropland not harvested or pastured	11,260	7,000	4,120	1,040	23,420
Total	151,580	55,120	47,720	13,580	268,000

Source: Compiled from data collected by the USDA Survey Party and the U. S. Census of Agriculture.

The 108,150 acres of rangeland and grazed forest land constitute 16 percent of the basin area. 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 is in a belt between the valley cropland and the higher elevation forest lands. Much of the rangeland is cutover forest land that has been seeded to grass. The grazed forest land generally consists of scattered patches of brush or timber within or adjacent to agricultural areas.

About 15 percent of the basin area, or 268,000 acres, is cropland. Pasture, hay, and silage are the most extensively grown crops in the basin, occupying 37 percent of the cropland, and providing the feed base for the dairy and livestock farms. Grasses, oats, vetch, clover, and alfalfa are the major forage crops harvested for hay and silage. Because of the difficulty of drying, early spring cuttings are often stored as silage, and subsequent cuttings are stored as hay. Pasture is also often cut for hay.

Second in acreage only to forage crops are small grains. Although considered marginal crops by some farmers in this area, small grains occupy 31

percent of the cropland in the basin. The more intensive crops such as fruits, nuts, and vegetables account for a minor part of the cropland but are the major source of farm income.

Trends in farmland use for the three principal counties in the basin are shown in figure 13. Total acreage in farms and cropland acreage have both increased slightly since 1929. Although a considerable amount of farmland has been shifted to other uses such as residences and roads, acquisition and clearing of land by farmers for agricultural purposes has evidently more than compensated for this loss. From 1929 to 1959, cropland pasture more than doubled. During this period grazed forest land increased significantly. This reflects the increase in the value of wood products, which has made timber a more competitive crop.

Photo 16.--Cropland pasture, one of the most widely grown crops in the basin. SCS photo. F-64-7

Trends in use of harvested cropland are shown in figure 14. Land in small grains has remained relatively stable at about 100,000 acres while hay land has decreased by about 25 percent. Acreage in vegetable crops increased from 7,700 acres in 1929 to 13,600 acres in 1949 and then decreased again to 10,000 acres in 1959. The acreage in fruits, nuts, and berry crops followed a similar pattern. Acreage in other crops has been decreasing since 1929. Several once important crops such as Austrian Winter peas have almost disappeared.

Farmland use for three principal counties in the Lower Willamette River Basin, Oregon, 1929-1959.[1/]

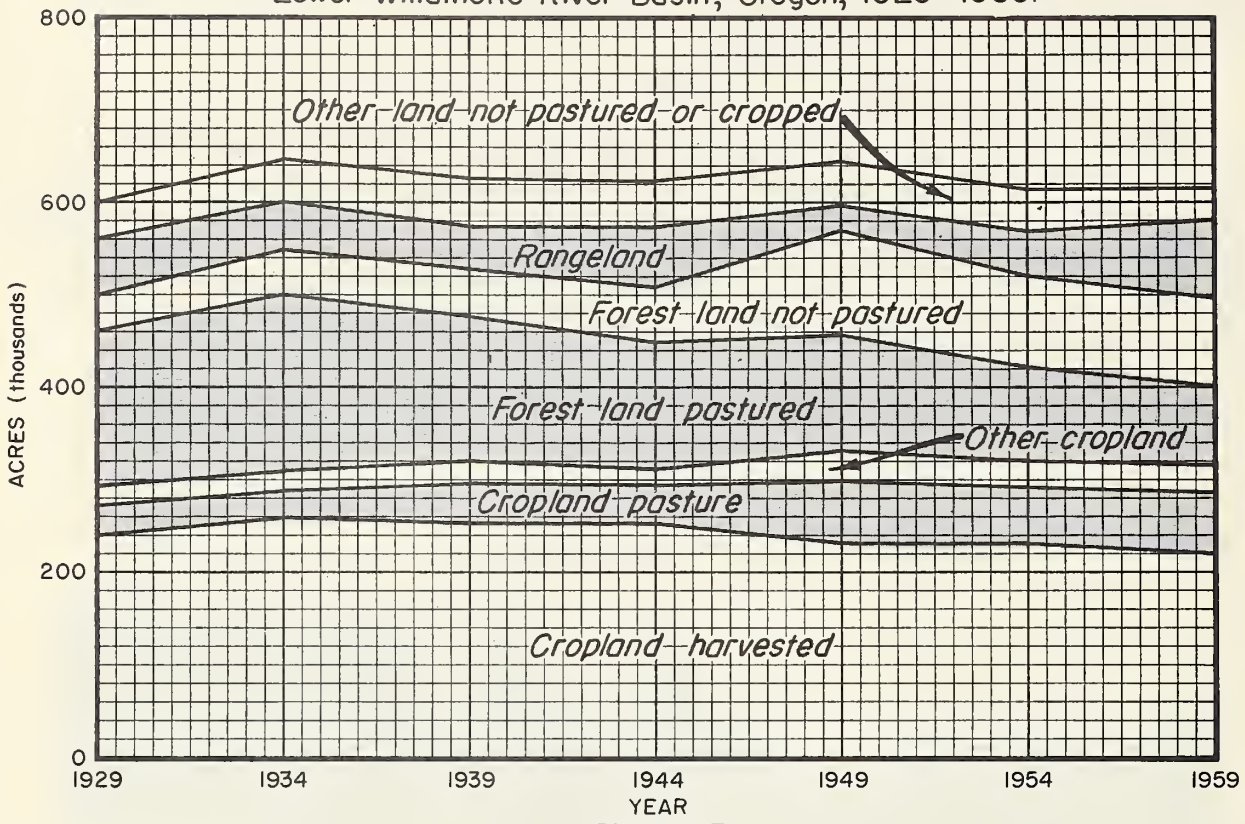
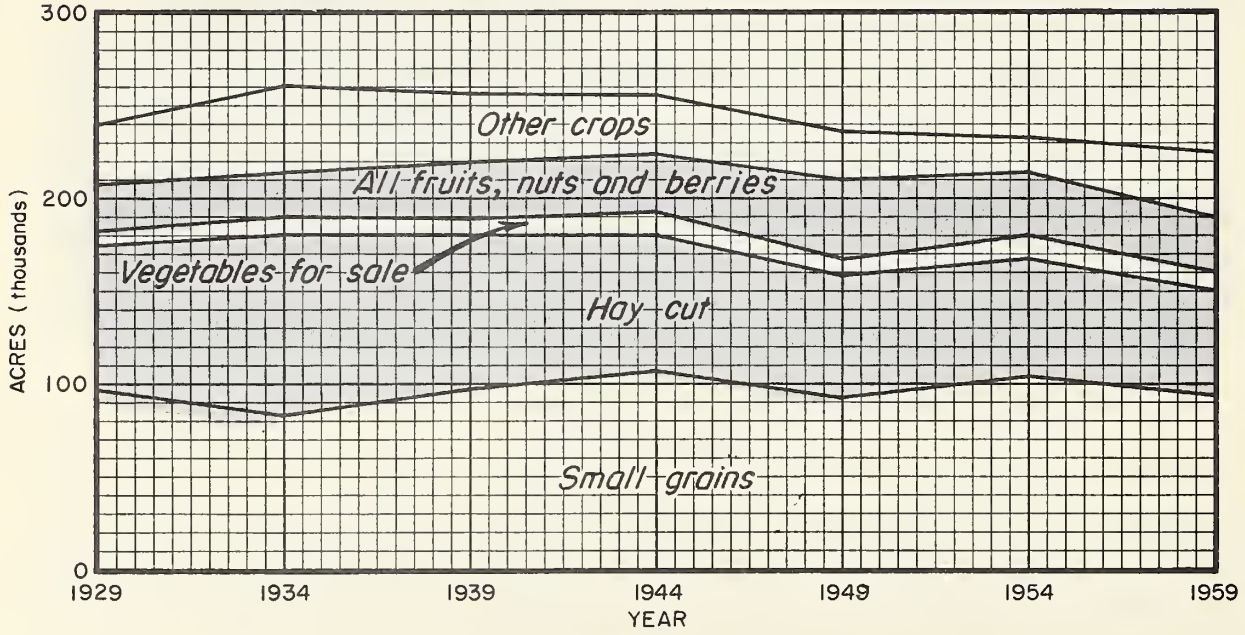


Figure 13

Harvested cropland use for three principal counties in the Lower Willamette River Basin, Oregon, 1929-1959.[1/]



1/ Source: U. S. Census of Agriculture data for Clackamas, Multnomah and Washington Counties.

Figure 14

Photo 17.--Douglas-fir coming into an old pasture in subbasin 9. Survey Party photo. 7-1424-7

CHARACTERISTICS OF AGRICULTURE

Number and Size of Farms

There are 6,492 farms in the basin. According to the 1960 Census of Agriculture, 43 percent are commercial; 43 percent are part-time; and 14 percent are part-retirement. 1/ There are 3,125 farms in the Tualatin Subbasin, 1,625 in the Clackamas Subbasin, 1,335 in the Columbia Subbasin, and 407 in the Sandy Subbasin.

Farms in the basin average 76 acres, with 39 acres of cropland. The distribution of farms by size groups for the three principal counties in the basin is shown in table 14. Note that 63 percent of the farms are less than

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1/ Commercial farms are defined in the census report as farms with a value of sales amounting to $2,500 or more. Part-time farms are 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 older.

50 acres in size, and 88 percent are less than 139 acres. Many of the small farms are either operated part-time or are intensive fruit, vegetable, or specialty farms. Those producing beef, sheep, grain, and grass are usually larger than 140 acres, and although comparatively few in number, increase the average size for all farms. Also, some farmers own sizable tracts of commercial timberland which are included in the census figures as farmland.

Table 14.--Percentage distribution of farms by size, for three principal counties in the Lower Willamette River Basin, Oreg., 1959

Size of farm	Percentage distribution of farms
	Percent
Under 50 acres	63
50 to 139 acres	25
140 to 259 acres	8
260 acres or more	4
Total	100

Source: U. S. Census of Agriculture data for Clackamas, Multnomah, and Washington Counties.

Agriculture in the basin, as in the Nation, is changing in a number of ways. Many of these changes are a result of improved technology which tends to be associated with large specialized farm units and with greater production per acre and per animal unit. This contributes to the merging of small farms into larger units.

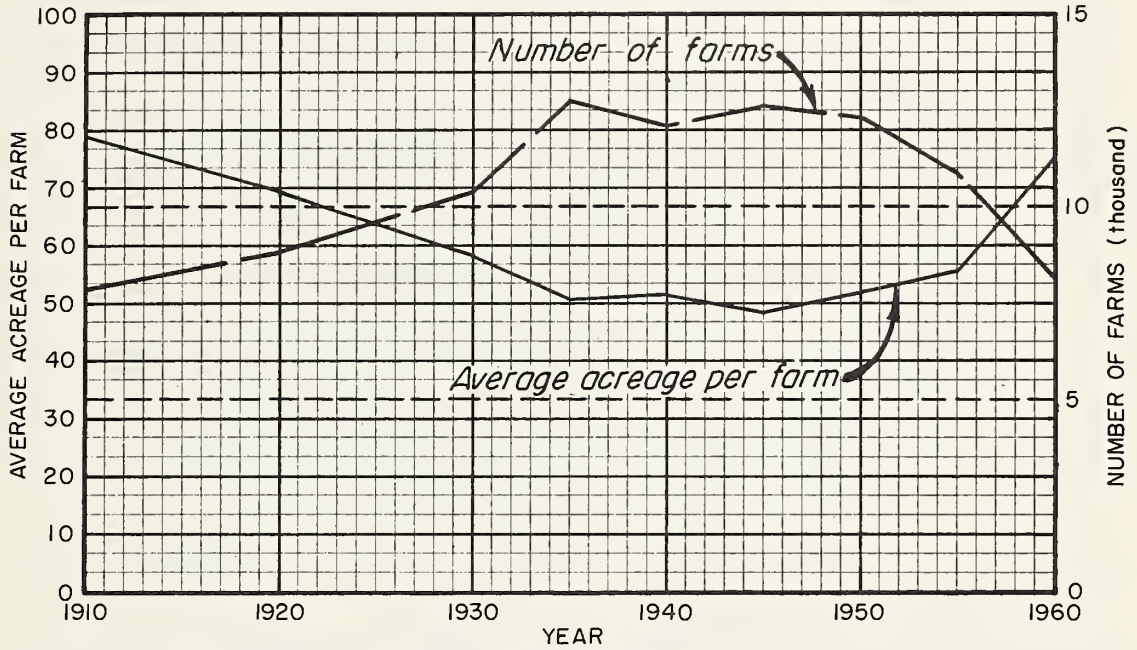
The trend in number of farms and average farm size in the basin is illustrated in figure 15. Since 1945, the number of farms has decreased while average size has increased. At the same time, the average value of land and buildings has increased from $9,230 to $29,340 per farm and from $188 to $455 per acre.

Counteracting the trend toward fewer and bigger farms is the trend toward part-time farming. In 1950, half of the farms were commercial operations, and half were part-time operations. By 1960, commercial farms had decreased to 43 percent of the total, and the rest were part-time farms. The fact that farm families are also engaged in other activities is further reflected by 1959 census data which show that 60 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. According to the 1959 Census of Agriculture, 79 percent of the farmers were full owners; 16 percent were part owners; and 5 percent were tenants.

Number of farms and average acreage per farm for three principal counties in the Lower Willamette River Basin, Oregon, 1910–1960.



Source: U. S. Census of Agriculture data for Clackamas, Multnomah and Washington Counties.

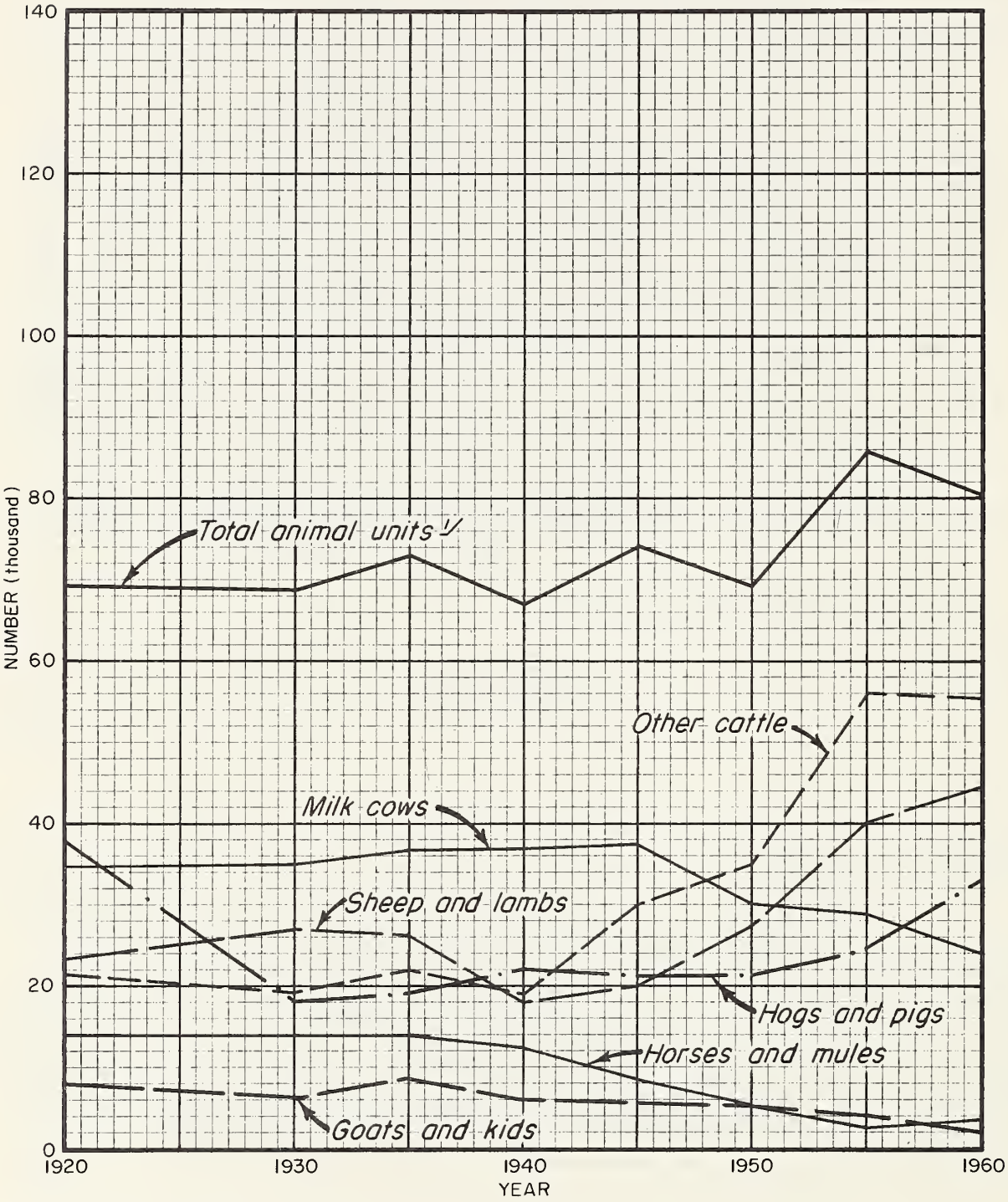
Figure 15

Livestock and Poultry

The estimated numbers of livestock and poultry are shown in table 15. The changes in livestock numbers since 1920 are shown in figure 16. The number of milk cows has decreased significantly since 1945, which is consistent with the national trend. The decline in consumption of dairy products and the rapid rise in milk production per cow are two of the most important factors contributing to this decrease. The number of cattle other than milk cows has more than doubled in number since 1940. Sheep have followed a similar trend. The number of hogs was relatively stable from 1930 until 1950 but has been increasing since then. Goats have been gradually decreasing in numbers since 1920. Horses and mules, no longer needed for power, are also decreasing in number.

The net effect of changes in numbers of livestock since 1920 is shown in terms of animal units (fig. 16). Total animal units remained around 70,000 from 1920 until 1950. Since 1950, the trend has been up sharply.

Livestock numbers for three principal counties in the Lower Willamette River Basin, Oregon, 1920-1960.



1/ FACTORS USED TO CONVERT LIVESTOCK INTO ANIMAL UNITS ARE: MILK COWS, 1.0 AU, OTHER CATTLE, HORSES AND MULES .8, GOATS AND SHEEP .2, AND HOGS .01.

Source: U. S. Census of Agriculture data for Clackamas, Multnomah and Washington Counties.

Figure 16

Table 15.--Livestock numbers, Lower Willamette River Basin, Oreg., 1959

Type of livestock	Total
	Number
Milk cows	20,100
All other cattle	37,100
Sheep and lambs	17,100
Goats and kids	800
Hogs and pigs	20,000
Horses and mules	2,300
Turkeys raised	117,000
Broilers raised	2,362,800
Chickens on hand	694,700

Source: Compiled from data collected by the USDA Survey Party and the U. S. Census of Agriculture.

Agricultural Income

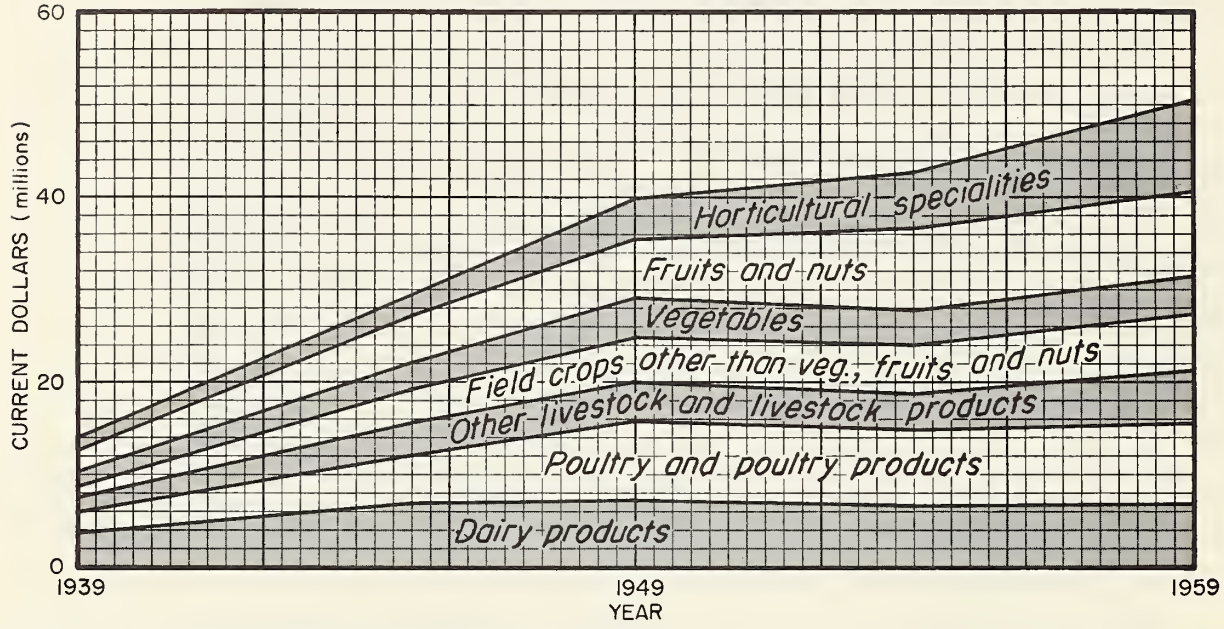
The income received by farmers in the basin contributes to the economy in several ways. In addition to providing returns to farm labor inputs, the income from sales of farm products is used for payment of land investment and a multitude of other farm expenditures. About two-thirds of the gross farm income is spent to cover production expenses. Farms also provide the raw products that contribute to transportation, processing, and other industries in the basin.

In 1959, the value of all farm products sold in the basin was 40.3 million dollars (table 16). Farm crop sales were 61 percent of the total; livestock products, 37 percent; and forest products, 2 percent. Farmers in the basin received more income from fruits and nuts than any other product. Horticultural specialties were second in importance followed by dairy products, poultry products, field crops, and vegetables.

Trends in value of farm products sold for Clackamas, Multnomah, and Washington Counties are illustrated in figure 17. Figure 18 illustrates the value of production in constant dollars. By adjusting the value of production to constant dollars the effects of inflation or deflation in the purchasing power of the dollar is eliminated, and the real change in production can be observed.

Historically, livestock receipts, as a percentage of all farm receipts, have declined from 52 percent in 1939 to 42 percent in 1959. Dairy and poultry have been the most important source of income from sales of livestock products (fig. 17). A comparison of figures 17 and 18 illustrates the receipts from sales of dairy products have increased somewhat since 1949 while production has decreased. Since 1949, receipts from sales of poultry products have declined due to a decline in the price of poultry products; production has increased as shown by the increase in value in constant dollars (fig. 18). Other livestock receipts have increased due to higher production and prices.

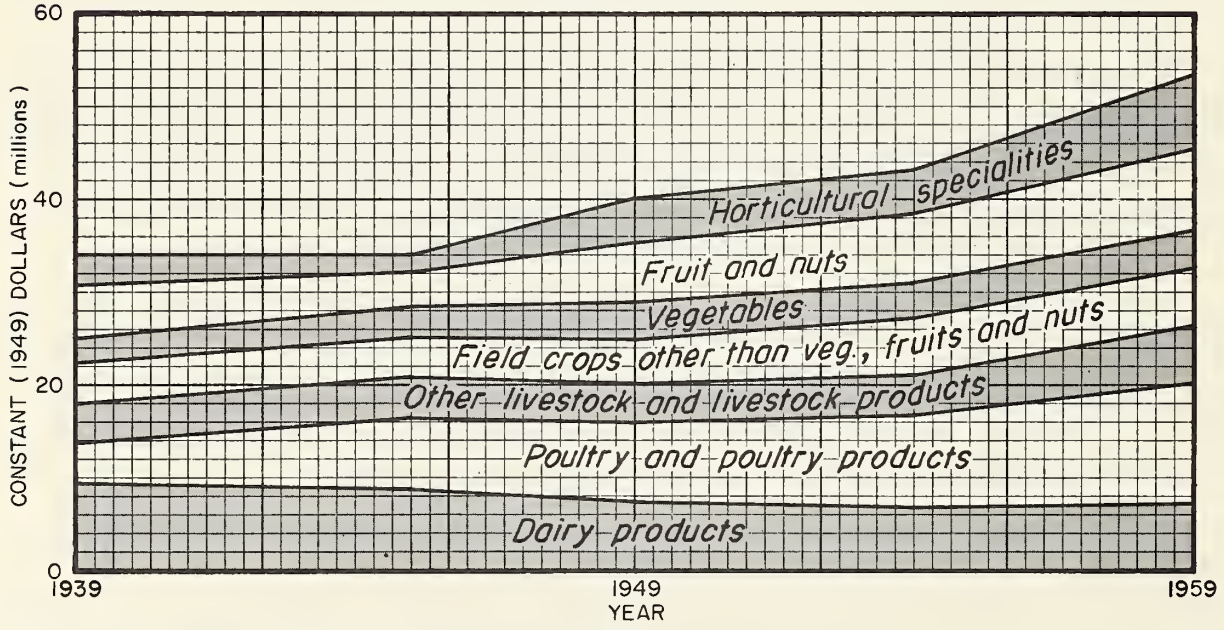
Value of farm products sold for three principal counties in the Low Willamette River Basin, Oregon, 1939-1959.



Source: U. S. Census of Agriculture data for Clackamas, Multnomah and Washington Counties.

Figure 17

Value of farm products sold in constant 1949 dollars for three principal counties in the Lower Willamette River Basin, Oregon, 1939-1959.



Source: U. S. Census of Agriculture data for Clackamas, Multnomah, and Washington Counties, and Statistical Reporting Service data.

Figure 18

Table 16.--Estimated farm income, Lower Willamette River Basin, Oreg., 1959

Commodity sold	Gross income	Percentage distribution
	Thousand dollars	Percent
Livestock:		
Dairy products	6,060	15.0
Poultry products	5,140	12.7
Cattle and calves	2,480	6.2
Other livestock products	1,240	3.1
Total	14,920	37.0
Crops:		
Field crops 1/	4,630	11.5
Fruits and nuts	8,630	21.4
Vegetables	3,350	8.3
Horticultural specialties	7,840	19.4
Total	24,450	60.6
Total crops and livestock	39,370	97.6
Forest products	980	2.4
Total farm products	40,350	100.0

1/ Other than vegetables, fruits, and nuts.

Receipts from crops were 47 percent of receipts from all farm products in 1939; in 1959 crops receipts had risen to 56 percent of the total. Receipts from horticultural specialties have shown the greatest increase. Both prices and production have risen (figs. 17 and 18). Receipts from fruits and nuts have also increased by a somewhat lesser amount. Larger receipts from fruits and nuts have been due in part to higher prices for these products. Vegetables have provided about the same receipts since 1949 although there was a considerable increase between 1939 and 1949. Vegetable production almost doubled between 1939 and 1949, declined slightly from 1949 to 1954, then increased from 1954 to 1959. Receipts from field crops and crops other than those just discussed increased substantially between 1939 and 1949 due to higher prices. Between 1949 and 1959 production of field crops other than vegetables, fruits, and nuts increased, but prices were lower.

Marketing

A market for many of the farm products raised in the basin exists locally. The population of the basin is about 723,000; some 85 percent is urban.

Fresh market outlets for fruits and vegetables include U-pick, roadside stands, sales through brokers, sales to retailers direct, and sales to wholesalers.

Processing is another outlet for fruits and vegetables. Most sales to processors are made on contracts before the harvesting season. A high proportion of some of the fruits, nuts, and vegetables is shipped out of Oregon

to meet national and international requirements. For instance, 92 percent of national filbert production comes from Oregon; Clackamas and Washington are major filbert producing counties.

Milk is sold to local processors and marketed locally as fresh milk, ice cream, cheese, and butter. A large local market exists for poultry and eggs. Most cattle, hogs, and sheep are processed locally and marketed in the area.

IRRIGATION

Due to the dry summer months, irrigation has become an important practice in the Lower Willamette River Basin. The balance between normal precipitation and plant requirements is illustrated in figure 19. Note that plant requirements for pasture are highest in July, the month of lowest rainfall. Since soils are well saturated with water in the spring, the moisture deficit for April and May is usually met by water accumulated in the soil during the winter months.

Natural rainfall is usually adequate to mature some crops such as grass seed and small grains. Small grains can be seeded in the fall in the well drained soil. The ensuing fall rains are ideal for sprouting, and accumulated winter moisture and spring rains are ordinarily adequate for the grains to mature. The dry season following is suitable for harvesting. Other deep-rooted crops such as filberts, prunes, and walnuts can live through the dry months of July and August without irrigation.

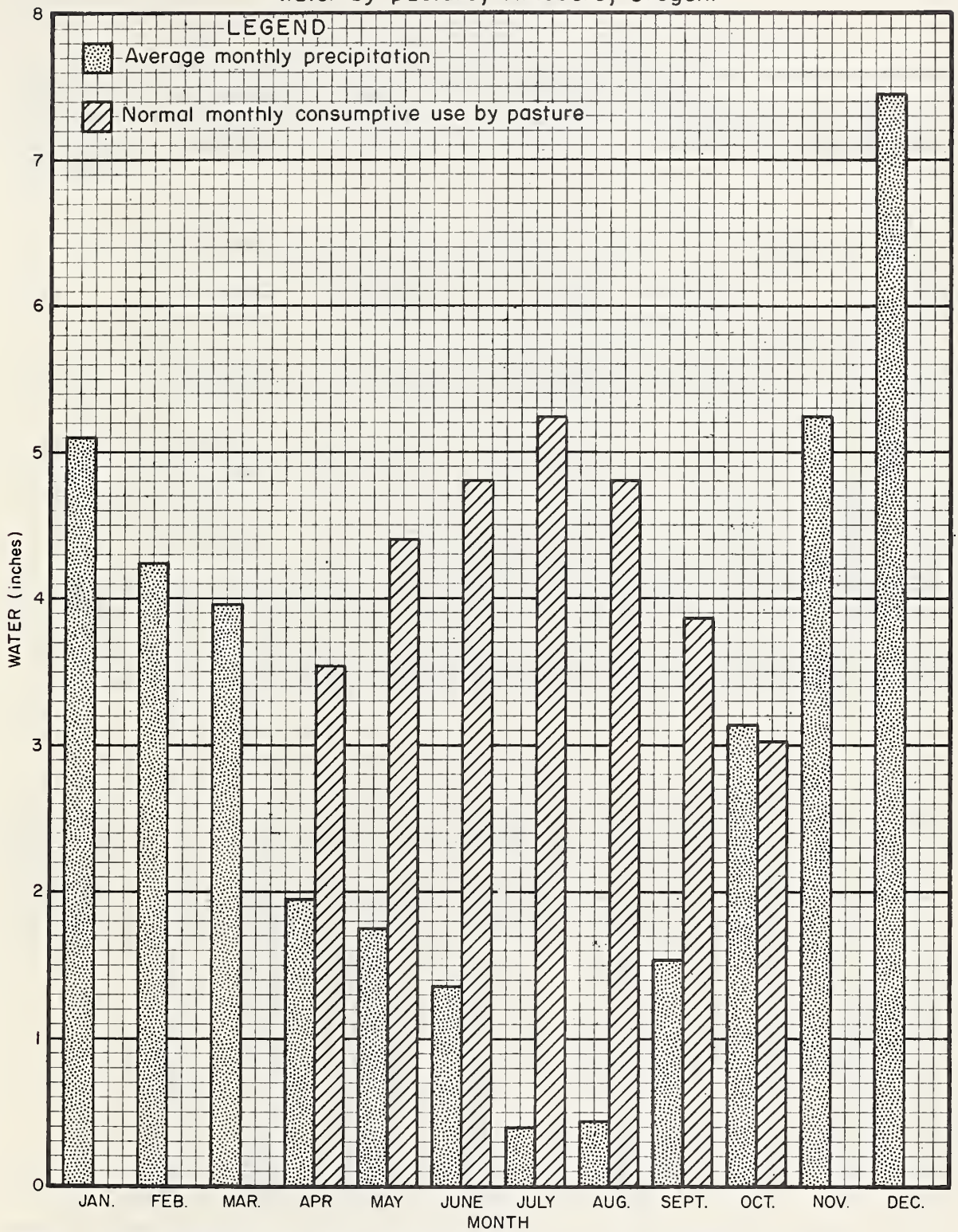
Crops such as vegetables and pasture require irrigation to sustain maximum growth throughout the summer months. The length of the irrigation season varies considerably depending on crops grown and production practices. H. H. Stippler found in a study of irrigation practices in the Willamette Valley in 1950 that the average length of irrigation seasons varied from 5 days for grain crops to 102 days for pastures (table 17). 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.

Irrigated Acreage

In 1963, 34,810 acres were irrigated in the Lower Willamette River Basin. About 46 percent of the irrigated acreage was in the Tualatin Subbasin; 39 percent was in the Columbia Subbasin; 8 percent was in the Clackamas Subbasin; and 7 percent was in the Sandy Subbasin (table 18).

More than half of the irrigated land was used for growing forage crops. Pasture was grown on 33 percent of the irrigated land, and hay and silage crops were grown on 21 percent. Vegetable crops were the third most widely grown irrigated crop followed by fruits and nuts. Note that 62 percent of the land in vegetable crops was irrigated. Processors will not award contracts for most vegetable crops unless they are irrigated.

Average monthly precipitation and consumptive use of water by pasture, Hillsboro, Oregon.



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

Figure 19

Table 17.--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, U. S. Dept. of Agr. Infor. Bul. 166, November 1956.

Table 18.--Irrigated land use, Lower Willamette River Basin, Oreg., 1963

Irrigated crop	Subbasin 8 Tualatin	Subbasin 9 Clackamas	Subbasin 10 Columbia	Subbasin 11 Sandy	Total	Percentage of crop irrigated
	Acres	Acres	Acres	Acres	Acres	Percent
Pasture	6,750	550	3,800	460	11,560	24
Hay and silage	2,010	550	4,500	450	7,510	15
Vegetables	2,380	820	2,430	500	6,130	62
All fruits, nuts, and vineyards	2,750	620	1,860	640	5,870	20
Field corn	1,190	130	...	...	1,320	29
Small grain	330	20	580	100	1,030	1
Irish potatoes	200	50	340	70	660	29
Other crops	340	130	200	160	730	4
Total	15,850	2,870	13,710	2,380	34,810	13

Source: Compiled from data collected by the USDA Survey Party and the U. S. Census of Agriculture.

Source of Water and Method of Application

With some exceptions, irrigation is practiced on the better soils along or near the rivers and streams. Streams are the direct source of water for 71 percent of the irrigated acreage; ground water is the source for 19 percent; and stored ground and surface water are the sources for 10 percent (table 19).

Table 19.--Source of irrigation water and method of application, Lower Willamette River Basin, Oreg., 1963

Item	Subbasin 8 Tualatin	9 Clackamas	10 Columbia	11 Sandy	Total
	Acres	Acres	Acres	Acres	Acres
Source of water:					
Pumped from stream	13,500	1,000	9,630	580	24,710
Pumped from wells	1,000	1,270	3,130	1,300	6,700
Other	1,350	600	950	500	3,400
Total	15,850	2,870	13,710	2,380	34,810
Method of application:					
Sprinkling	15,000	2,870	13,360	2,380	33,610
Flooding	850	...	350	...	1,200
Total	15,850	2,870	13,710	2,380	34,810

Source: USDA Survey Party data.

Streams are the major source of water in the Tualatin and Columbia Subbasins while ground water is the chief source in the Clackamas and Sandy Subbasins.

Sprinkler irrigation is used on 97 percent of the irrigated land. A typical sprinkler system is shown in photo 18. 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.

Photo 18.--Pasture, the most widely irrigated crop in the basin. Survey Party photo. 7-1424-10

Size of Irrigated Acreage

In 1959, the average acreage irrigated by farmers reporting irrigation was 25 acres. However, 47 percent of the farmers reporting irrigation had less than 10 acres under irrigation, and 75 percent had less than 30 acres (table 20).

Cost of Irrigation

Because most of the irrigation is accomplished by sprinkler systems, irrigation costs per acre in the Lower 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 21).

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.

1/ Sprinkler Irrigation in the Pacific Northwest, by Henry H. Stippler, U. S. Dept. of Agr. Infor. Bul. 166, November 1956.

Table 20.--Distribution of farms reporting irrigation by acreage irrigated, three principal counties in the Lower Willamette River Basin, Oreg., 1959

Irrigated acreage distribution	Number of farms reporting irrigation	Percentage distribution of farms
	Number	Percent
1 to 9 acres	669	47
10 to 19 acres	250	17
20 to 29 acres	159	11
30 to 49 acres	176	12
50 to 99 acres	128	9
100 to 199 acres	44	3
200 or more acres	23	1
Total	1,479	100

Source: U. S. Census of Agriculture data for Clackamas, Mulnomah, and Washington Counties.

Table 21.--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 1/

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

1/ Sprinkler Irrigation in the Pacific Northwest, by Henry H. Stippler, U. S. Dept. of Agr. Infor. Bul. 166, November 1956.

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 1939 to 1959 irrigated acreage in the three principal counties in the basin increased from 6,213 acres to 36,445 acres (table 22). During this period the percentage of farms reporting irrigation increased from about 3 percent to 18 percent.

Table 22.--Irrigated acreage and farms reporting irrigation for three principal counties in the Lower Willamette River Basin, Oreg., 1939-59

Year	Acres irrigated	Average acres irrigated per farm	Farms reporting irrigation	Percentage of farms reporting irrigation
	Acres	Acres	Number	Percent
1939	6,213	16	394	3.2
1944	2,821	18	158	1.2
1949	12,958	18	720	5.9
1954	29,509	25	1,199	10.9
1959	36,445	25	1,471	18.0

Source: U. S. Census of Agriculture data for Clackamas, Multnomah, and Washington Counties.

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 630,900 acres in land capability classes I through IV in the basin (table 23). On the basis of soils alone, this is the land that is generally susceptible to irrigation. However, only about 268,000 acres of this land are presently used as cropland or cropland pasture. The rest is in timber, brush, swamp, and other noncropland uses.

Table 23.--Estimated present and potential cropland and irrigated land, Lower Willamette River Basin, Oreg., 1963

Item	Subbasin 8 Tualatin	Subbasin 9 Clackamas	Subbasin 10 Columbia	Subbasin 11 Sandy	Total
	Acres	Acres	Acres	Acres	Acres
Land capability classes I-IV	266,900	142,300	172,400	49,300	630,900
Total cropland	151,580	55,120	47,720	13,580	268,000
Potential cropland	21,100	6,200	12,500	4,900	44,700
Potential land	15,850	2,870	13,710	2,380	34,810
Potentially irrigable land	117,600	15,200	26,000	2,100	160,700

Source: USDA Survey Party data.

Estimates obtained from the USDA reconnaissance survey of the basin indicate that there are about 44,700 acres that could easily be converted to cropland use. Almost half is in the Tualatin Subbasin. It was also estimated that an additional 160,700 acres, or over half of the existing and potential cropland, could be readily irrigated. Data obtained in the survey

indicate that present streamflows and ground water would be adequate to irrigate an additional 13,800 acres in the Clackamas Subbasin, 21,500 acres in the Columbia Subbasin, and 1,600 acres in the Sandy Subbasin. Storage facilities would be needed to irrigate a larger acreage.

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 29,000 acres are flooded annually in the basin, and about 80,800 acres of arable land have drainage problems. Much of this is potentially irrigable land.

The land and water resources are available for additional irrigation development in the basin. However, the degree to which irrigation 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.

One of the more important factors in many areas of the basin is the expanding population. As the population increases, so does the demand for land and water resources. Agriculture cannot successfully compete with urban development for these resources. Associated with the expanding population are higher taxes and inflated land values for adjacent agricultural lands, which may also deter irrigation development.

In order for irrigation to be economically feasible, irrigation water, like any other input used in producing agricultural products, must either result in a higher net profit to the user or must stabilize farm income. In the past, irrigation of vegetables and 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 processor's 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 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 many crops are successfully grown 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.

WATER RELATED PROBLEMS, NEEDS, AND OPPORTUNITIES

GENERAL

Crop, forest, and range lands each present problems peculiar to their individual uses and management practices. Individually and collectively these three major agricultural land uses and their problems influence water, wildlife, recreation and other human use, and create a host of additional problems. Chief among them are those concerned with water, in excess, in shortage, and in quality. Improvement or correction of land problems will usually result in improvement of the related water problems.

WATER SUPPLY AND REQUIREMENTS

Average precipitation in the Lower Willamette River Basin ranges from 36 to 140 inches annually (fig. 2), but generally less than 10 percent comes during June, July, August, and September. Thus, this basin has a summer period of water shortage and then a winter period of water excess both affecting water quality. There are great variations in the amount of water the streams carry, owing to both seasonal and geographic variations in precipitation within the basin. This means that there is an excessive amount of water in some sections at some times and a deficiency of water in sections at other times; this combination results in waste of water and necessitates extensive storage to improve efficiency of use.

Water resources influence all segments of the economy of the basin. Irrigation is becoming more important as a means of increasing crop yields, even though it is not a necessity for most crops. All industry is based upon a dependable water supply. Community existence and growth are dependent on good quality water for domestic and municipal use. Navigation, recreation, fish life, and pollution abatement are affected by the volume and depth of flow. Thus, yield and seasonal availability of water are of prime importance in all areas of use.

The total water resources of the Lower Willamette River Basin are more than adequate for present and future agricultural needs. The total average annual yield for this 1,748,800 acre basin is about 6 million acre feet after current consumptive use withdrawals. This basin receives additional benefits and damages from the excess water from the upper portions of the Willamette and Columbia Rivers.

Streamflow data indicates that the average annual runoff ranges from 15 inches to about 120 inches after current consumptive use withdrawals (fig. 20). The largest yields are produced by the Sandy Subbasin in the high area near Mount Hood. The average annual runoff for the entire Lower Willamette

FIGURE 20

AVERAGE ANNUAL RUNOFF IN INCHES, 1930-1957

LOWER WILLAMETTE RIVER BASIN

OREGON

SEPTEMBER 1963

SUBBASINS

8 TUALATIN

9 CLACKAMAS

10 COLUMBIA

11 SANDY

SCALE IN MILES 2 0 2 4 6 8 10

RIVER BASIN LOCATION

COUNTY LOCATION

LEGEND

+10 Average Annual Runoff in Inches

River Basin Boundary

Subbasin Boundary

National Forest and/or Indian Reservation Boundary

Source: U S Geological Survey

River Basin is about 44 inches; or in other words, about two-thirds of the precipitation is not consumptively used in the basin at the present time.

Porous lavas of the high Cascades store large quantities of snow melt and release the water gradually, thereby causing higher, more uniform streamflows through the summer months. Little is known of the extent, storage capacities, and annual recharge of these lava formations, all of which are significant factors in the hydrology of the major streams flowing from the Cascades.

Alluvial deposits along streams, particularly those originating in the Cascades, hold varying quantities of ground water and add greatly to the local water supply for domestic, agricultural, and industrial needs.

The sedimentary formations of the Coast Range generally reject ground water infiltration because of compactness. Most wells, however, yield small quantities sufficient for domestic needs.

In general, it can be concluded that the summer season water shortages, all sources considered, are most severe in the smaller, low elevation watersheds west of the Willamette River.

Irrigation

The approximate irrigation water requirement for the 34,810 acres of irrigated crops (table 18) is 84,000 acre feet, or about 10 percent of the total surface water yield from the basin during the irrigation season. Some of the irrigation water is obtained from ground water. There is no serious shortage of water for irrigation in any area in the Lower Willamette River Basin that has easy access to the Willamette or Columbia Rivers. The U. S. Bureau of Reclamation has reserved about 835,000 acre feet of storage in five Corps of Engineers' reservoirs for irrigation. It is expected that at least another 600,000 acre feet of water will be made available for irrigation in four reservoirs that are under construction or authorized for construction. This water in reservoirs in the upper reaches of the river is available for use in the entire Willamette Valley. Small watershed projects with an irrigation aspect under Public Law 566 should consider this source of water along with others to determine the most practical source.

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, 16 of the 22 tributary watersheds studied have a summer water shortage at the present time (table 24).

There is an estimated 160,700 acres of potentially irrigable land in the Lower Willamette River Basin. This is nearly five times the present irrigated acreage, or about one-fourth of the land in capabilities I through IV (table 23). 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 500,000 acre feet of water would be used from all sources for irrigation. This is equal to about one-twelfth of the total annual yield of the basin and less than one-half of the yield of the basin during the irrigation

Table 24.--Summary of tributary watersheds with inadequate irrigation water supply, Lower Willamette River Basin, Oreg., 1963

		Subbasin				
	Unit	8 Tualatin	9 Clackamas	10 Columbia	11 Sandy	Total
Tributaries studied	Number	8	6	3	5	22
Tributaries with water shortages	Number	8	4	...	4	16
Presently irrigated land with water shortages	Acres	11,525	750	...	1,250	13,525
Tributaries with inadequate water for potential irrigable land	Number	8	5	2	4	19
Potentially irrigable land needing surface water development	Acres	117,600	1,250	2,100	4,500	123,850

Source: USDA Survey Party data (tables 12A through 12E).

season, June through September. It is obvious that ground water resources and reservoir storage within the basin would have to be developed in some areas before irrigation could expand to this extent.

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 is used. This has usually been adequate in this basin as the farms are usually small.

Forestry and Related Uses

There are few water supply problems on forest land in the Lower Willamette River Basin. Natural streamflows are generally adequate to meet all consumptive requirements. Some pollution and siltation problems have developed where careless timber harvesting has occurred or where forest fires have burned over 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 with increasing demand for water for agriculture and industry in the Willamette Valley. 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, wildlife, and recreation. Additional needs for larger water supplies for irrigation and industry will have to be met by

greater reservoir storage of water from forested watersheds. If reservoirs are drawn down during the season of heavy recreational use, the site becomes less attractive for recreation, pollution problems increase, and fish life may be 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.

WATERSHED MANAGEMENT PROBLEMS AND OPPORTUNITIES

The condition of all tributary watersheds in the basin should continue to be maintained and improved. In general, the optimum watershed conditions will prevail when all resources are managed for optimum sustained production. The most important management problems and opportunities for improvement pertaining to agriculture and forestry are outlined in the following sections.

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 Lower 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 potential. In order to do this there is a need for more control of the water supply. 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 hills, 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 water related problems and the measures needed to improve them follows.

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

The flood season for the basin streams 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, 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 in-

creases 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.

The peak discharge of the 1861 flood was estimated at 530,000 cubic feet per second for the Willamette River at Salem, Oregon. 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.

Highest runoff 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. 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, Oregon.

The Willamette River and its tributaries below Oregon City are also affected by the Columbia River at flood stage. Fortunately, it crests at a later date, usually around the first of June when the Willamette Basin streams are not at peak flow. However, the Columbia River backwaters cause many of the basin streams to flood low areas in the Lower Willamette River Basin as well as the areas along its banks.

The floods from the Columbia River have sometimes been the most devastating. On May 30, 1948, the dikes at Vanport, a wartime housing project for 40,000 people near Portland, broke and in a matter of 90 minutes it was reduced to a swirling mass of wreckage (photo 19). Eighteen thousand persons were left homeless but, miraculously, only 17 lives were known to have been lost. Other dikes were broken and topped during this flood causing additional loss of life and property. The total property damage in the Lower Willamette River Basin may have been as high as 50 million dollars. In addition, agricultural damages to crops were very severe because it occurred during the growing season and lasted for 36 days (photos 20 and 21). This was the second highest recorded flood. The flood of 1894 was greater; it lasted 52 days and crested at 34.4 feet elevation at Vancouver. This was 4.2 feet higher than in 1948.

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.

Floodwater damage is widespread in the valley areas of the Lower Willamette River Basin. The problems resulting from excessive streamflow range from erosion and sedimentation to losses of crops, property, and life. Figure 21 shows the major flood problem areas in the basin.

Agricultural damages consisting primarily of crop and property losses usually account for much of the total evaluated flood damage in the basin.

IL CONSERVATION DISTRICTS

SAUVIE ISLAND

SCAPPOOSE

SANTIAM

EAST MULTNOMAH

YAMHILL COUNTY

WASHINGTON COUNTY

NORTH CLACKAMAS

SOUTH CLACKAMAS

FIGURE 21

GENERALIZED FLOOD PROBLEM AREAS AND WATERSHED BOUNDARIES

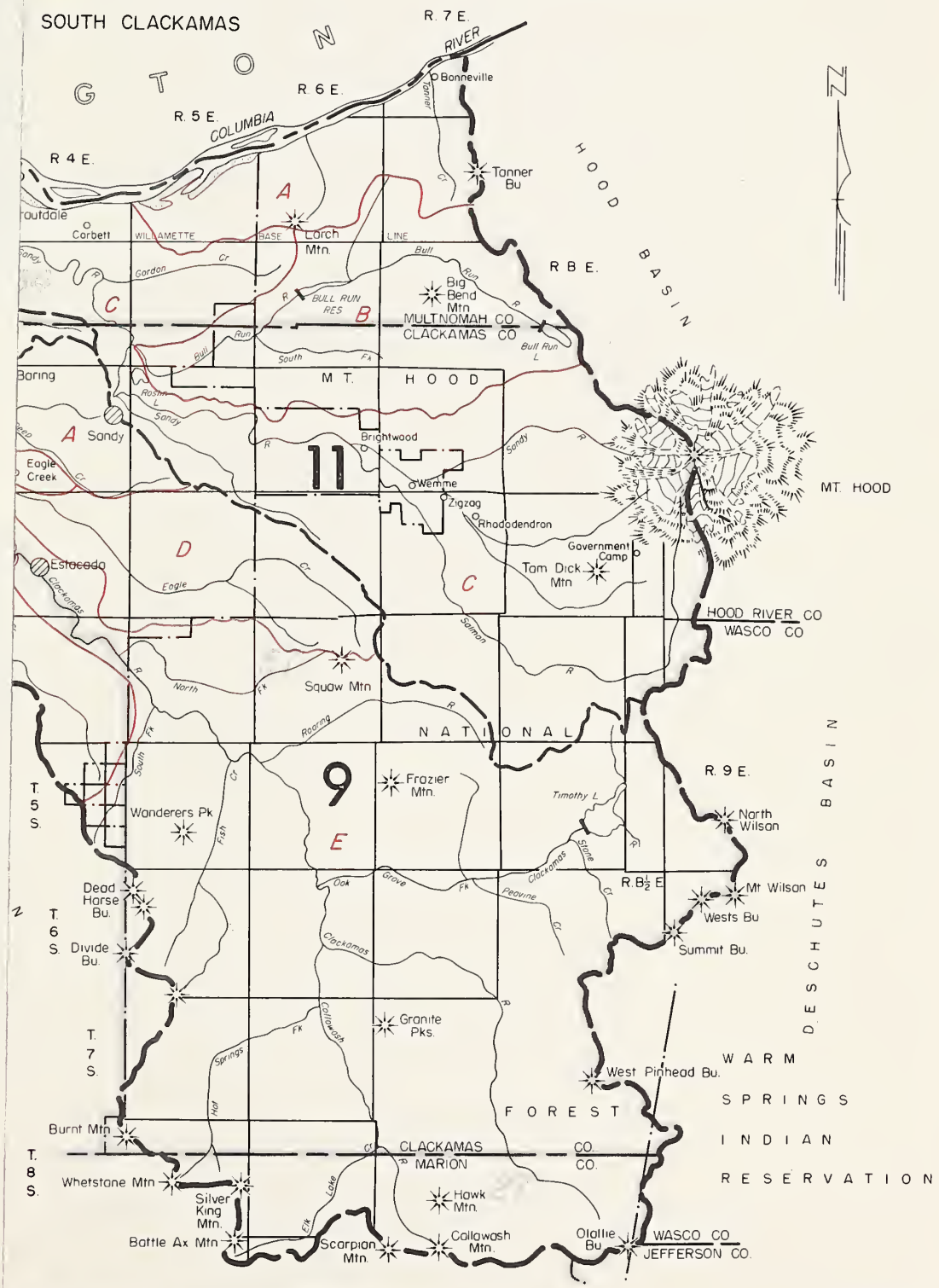
LOWER WILLAMETTE RIVER BASIN

OREGON

SEPTEMBER 1963

2 0 2 4 6 8 10

SCALE IN MILES



7-E-17483-N

FIGURE 21

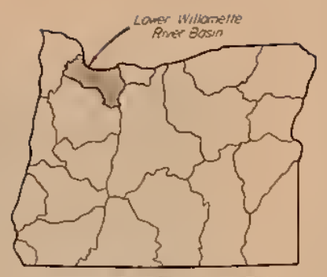
GENERALIZED FLOOD PROBLEM AREAS AND WATERSHED BOUNDARIES

LOWER WILLAMETTE RIVER BASIN

OREGON

SEPTEMBER 1963

SCALE IN MILES 2 0 2 4 6 8 10



RIVER BASIN LOCATION

SUBBASINS

8 TUALATIN
9 CLACKAMAS
10 COLUMBIA
11 SANDY

SOIL CONSERVATION DISTRICTS

9 SAUVIE ISLAND
SCAPPOOSE
SANTIAM
EAST MULTNOMAH
YAMHILL COUNTY
WASHINGTON COUNTY
NORTH CLACKAMAS
SOUTH CLACKAMAS

COUNTY LOCATION

LEGEND

- Flood Problem Areas
- A — Watershed Boundary and Letters
- River Basin Boundary
- Subbasin Boundary
- National Forest Boundary
- Soil Conservation District Boundary

U S DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE ... M-3905

7-E-17483-N

Photo 19.--This is all that remained of Vanport, Oreg., following the 1948 Columbia River flood, subbasin 10. SCS photo. B-358-A

Photo 20.--A view of Scappoose Drainage District showing ponded water covering hay, pasture, and row crops due to heavy seepage during the Columbia River flood in 1948, subbasin 10. SCS photo. B-301-15

Photo 21.--Five extra pumps were placed and operated in addition to the permanent ones in the Scappoose Drainage District to keep up with the increased seepage from the 1948 flood on the Columbia River. SCS photo. B-300-1

Crop damage is often a source of great loss to the farmer. Floods in late spring and early fall have caused many farmers to lose all or part of early and late crops (photo 22). Winter and spring floods damage crops by washing out roots and new plantings, by burying small plants and seed under sediment, and by drowning. Many acres of land along small streams have not been developed for cropland because of serious drainage problems and frequent flooding.

Man-made structures and improvements are often damaged by flooding. Many of the towns are located above ordinary flood stage, but larger floods cause damage to others. A few suffer flood damage almost every year and have been known to receive extensive damages several times in one year. Many country roads in the basin are frequently closed and damaged by high water (photo 23). 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.

It is very costly to remove sand, gravel, logs, and other debris deposited in channels, fields, ditches, and other improvements by major floods (photo 24). Sediment is harmful to fish life both in the main streams and

Photo 22.--This cropland in subbasin 8 was flooded on May 7, 1963. SCS photo. 7-1397-2

Photo 23.--A road slide is the result of heavy and prolonged rains and floodwaters, subbasin 8. SCS photo. 7-597-11

Photo 24.--The caneberry field was eroded and the silt deposited on the lower field, subbasin 11. SCS photo. F-64-4

in the tributaries. Streamflow characteristics may be seriously altered, spawning beds ruined, and food sources reduced.

There is a need for more stream channel work such as dredging and diking in the main river channels; removal of gravel bars, drift, and brush; and channel enlargement and realignment on the small streams (photo 25).

River and creek banks in many places need more protection by use of rock riprap or other protective measures (photo 26). Stream channel work is usually most beneficial when a complete unit of stream channel is improved in a single coordinated project rather than by piecemeal work by individual landowners.

Erosion. 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 in the entire Willamette River Basin 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 to the permanent detriment of the productive capacity of the valley.

Erosion on cultivated land is mainly the result of water action as erosion from wind action is usually negligible.

Photo 25.--A stream that needs channel work to help prevent flooding. SCS photo. 7-702-9

Photo 26.--A creek bank and rural road protected by wire-bound rock riprap, subbasin 9. Survey Party photo. 7-1378-8

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.

Sheet, gully, and rill erosion is a serious problem on cultivated land left fallow or otherwise unprotected by vegetative cover during the winter months (photo 27).

Photo 27.--Severe rill erosion resulted on cropland left uprotected during winter months, 1951, subbasin 8. SCS photo.
B-756-S

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 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 (photo 28).

Two other water erosion control practices that are needed to help protect land cropped to annuals are contour cropping and permanent grassed waterways (photo 29). Sloping land on which the many perennial row crops, such as strawberries, are grown in this basin needs to be protected by planting on the contour. Photo 30 shows one of the few fields of strawberries planted with the rows on a contour.

Photo 28.--The soil in this filbert orchard is protected by a winter cover crop, subbasin 8. SCS photo. 7-550-9

Photo 29.--A natural waterway is protected by a permanent grass cover, subbasin 11. SCS photo. F-64-9

Photo 30.--Strawberries can be planted on the contour to help prevent erosion, subbasin 10. SCS photo. B-847-2

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.

Sediment and debris deposition by flood waters from these eroded areas present serious problems in the basin as they reduce storage space in reservoirs; cut down capacity and increase maintenance on roads, stream channels, irrigation, and drainage ditches; damage crops and cropland; affect navigability of major streams; and lower the quality of water (photo 31).

While the overall rate of sediment production in the Lower 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 floodplain 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.

Photo 31.--A Multnomah County road crew is removing sediment from N. E. Halsey St., subbasin 11. SCS photo. F-128-8

Irrigation. Irrigation development in the Lower Willamette River Basin has been accomplished primarily on an individual farm basis. Most irrigation is on land near the major streams where water is readily available from streams or wells.

There is a limited amount of additional irrigable land that can be irrigated on an individual farm basis. Much of the remaining irrigable land lies on benches or in areas that are 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, which has not been true in the past. The chief reason underlying lack of interest by farmers 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 farmers within an area where group action is necessary to develop irrigation is to get a majority of the farmers interested. However, there seems to be more interest in recent years, making the probability of group projects more favorable.

The sprinkler method which is easy to manage for proper and best use of water under the existing conditions is used on about 97 percent of the irri-

gated land in the basin. 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.

Some types of controlled flooding are well adapted to part of the soils and crops of the basin and could be used more extensively. One of these is the border method shown in photo 32.

Photo 32.--This field in subbasin 10 is irrigated by the border method. SCS photo. 8-629-8

Drainage. Approximately 172,800 acres, or about 23 percent of the arable soils in the Lower 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 80,800 acres, or about 47 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 25.

Table 25.--Estimate of soils whose major problem is wetness within land capability classes I-IV and areas needing drainage, Lower Willamette River Basin, Oreg., 1963

		Subbasin				
		8	9	10	11	
	Unit	Tualatin	Clackamas	Columbia	Sandy	Total
I	Acres	...	...	...	...	...
II	Acres	50,200	9,400	24,700	1,600	85,900
III	Acres	26,800	7,600	32,800	13,000	80,300
IV	Acres	3,600	1,700	1,300	...	6,600
Total	Acres	80,600	18,700	58,800	14,700	172,800
Area needing drainage	Acres	36,900	12,800	21,100	10,000	80,800
Distribution of soils with major problem of wetness	Percent	46	11	34	9	100
Distribution of acres needing drainage	Percent	46	16	26	12	100

Source: USDA Survey Party and USDA Soil Conservation Service.

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 varies 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 26. Drainage would significantly increase the production on this land and would also increase the number of species and variety 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.

Often sufficient drainage for the desired use can be provided 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

Table 26.--Generalized drainage requirements for typical wet soils, Lower Willamette River Basin, Oreg., 1963

Soils	Internal drainage of the soil	Drainage impediment	Improved drainage outlets	Applicable surface drainage methods: Field ditches	Land smoothing	Land grading	Bedding	Applicable subsurface drainage methods: Closed inter-ception	Open inter-ception	Open random drains	Closed pattern drains
Soils derived from sedimentary rocks:											
Hazelair	Imperfectly drained	Seepage from higher areas	...	...	...	...	...	X	X	X	...
Dupee	Imperfectly drained	Seepage from higher areas	...	...	...	...	...	X	...	...	...
Panther	Poorly drained	Claypan, seepage from higher areas	...	X	X	...	...	X	...	X	...
Carlton	Moderately well drained	Seepage from higher areas	...	...	...	...	...	X	X	...	X
Chehalem	Moderately well to imperfectly drained	Seepage from higher areas	...	...	...	...	...	X	X	...	X
Crossett	Poorly drained	Claypan, seepage from higher areas	...	...	X	...	...	X	X	...	...
Soils derived from igneous materials:											
Viola	Poorly drained	Claypan, seepage from higher areas	...	...	X	...	...	X	X	...	...
Soils derived from loess on uplands:											
Kinton	Moderately well drained	Seepage from higher areas	...	...	...	...	...	X	...	X	X
Cascade	Imperfectly drained	Fragipan, seepage from higher areas	...	...	...	...	...	X	X	X	X
Delena	Poorly drained	Fragipan, depressional position	X	X	...	...	...	...	...	X	...
Soils derived from loess on terraces:											
Quatama	Moderately well drained	Seepage from higher areas	...	...	...	...	...	X	X	...	X
Aloha	Imperfectly drained	Fragipan, seepage from higher areas	...	...	...	...	...	X	X	...	X
Scholls	Poorly drained	Fragipan, seepage from higher areas	...	X	X	...	...	X	X	X	X
Helvetia	Moderately well to imperfectly drained	Depressional position, seepage from higher areas	...	...	...	...	...	X	X	X	...
Soils derived from silty materials on uplands:											
Cottrell	Moderately well drained	Seepage from higher areas	...	...	...	...	...	X	X	X	X
Bornstedt	Moderately well drained	Fragipan, seepage from higher areas	...	...	...	...	...	X	X	X	X
Dubois	Imperfectly drained	Fragipan, seepage from higher areas	...	X	X	...	...	X	X	X	X
Powell	Imperfectly drained	Fragipan, seepage from higher areas	...	X	X	...	...	X	X	...	X
Carver	Poorly drained	Depressional position, seepage from higher areas	X	X	...	...	...	X	X	X	X
Soils derived from silty materials on terraces:											
Woodburn	Moderately well drained	Fragipan	...	X	X	X	...	...	...	X	X
Amity	Imperfectly drained	Seasonal high water table	...	X	X	...	...	...	...	X	X
Dayton	Poorly drained	Claypan	X	X	...	X	X	...	...	...	X
Clackamas	Imperfectly drained	Compact gravels	...	X	...	X	...	...	...	X	X
Courtney	Poorly drained	Claypan over compact gravels	X	X	X	X	...	...	...	...	...
Soils derived from recent alluvium:											
Maytown	Moderately well drained	Seasonal high water table	X	X	X	X	...	...	...	X	X
Wapato	Imperfectly drained	Seasonal high water table	X	X	...	X	X	...	...	X	X
Reed	Poorly drained	Claypan	X	X	...	X	X	...	...	...	...
Cove	Poorly drained	Very fine textured profile	X	X	X	...	...	X	X	...	X
Sauvie	Poorly to imperfectly drained	Seasonal high water table	X	X	...	X	X	...	...	...	X
Mukilteo peat	Poorly drained	Seasonal high water table	X	X	...	X	...	...	...	...	X

Source: USDA, Soil Conservation Service, Technical Guide.

and crops require extensive pattern or random drainage systems (photo 33) based upon soil characteristics (table 26).

Photo 33.--Clay tile will be laid in these trenches located in a pattern for good drainage, subbasin 11. SCS photo. 7-472-6

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

In this basin many miles of tile, ditching, and diking have already been installed, but much more is needed.

Forested Land

Careful management of forest resources can bring about maximum economic and social benefits without impairment of soil and watershed values. However, improper management of forest resources can produce or intensify flood, erosion, and sedimentation problems. Forests are generally on steeper ground where the degree of water erosion is intensified. Water erosion by rapid runoff of precipitation may be very damaging if protecting vegetation is removed from large areas.

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 not be apparent for a long 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 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 is likely to provide for some soil protection. Higher standards of road construction and proper maintenance would minimize sources of erosion and sediment production.
2. Continuation and strengthening of Extension Service, Soil Conservation Service, and State Farm Forester programs to inform landowners and the general public of the value of water and watersheds and the importance of good watershed management would promote a gradual improvement in watershed management practices.
3. Increased public pressure from recreationists, fishermen, and other 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 meet their watershed management responsibilities. Regulation has often been necessary to control other sources of water pollution such as sewage and wastes from manufaturing 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 that minimize watershed damage need to be encouraged.

Planning and timing of logging operations without adequate regard for such factors as soil characteristics, steepness of slope, and moisture conditions magnifies the erosion hazards. Roads that are poorly located, improperly designed and constructed 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 (photo 34).

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 major erosion hazards and often need special measures such as adequate drainage and installation of a protective plant and mulch cover (photo 35).

Photo 34.--This jam of debris has restricted flow and caused streambank erosion. Field Party photo. 7-1378-11

Photo 35.--Inadequate ditches and cross drains cause this type of erosion on forest roads. Note small broken cross drain. Survey Party photo. 7-1397-4

Overgrazing of forest land and rangeland is a serious watershed management problem in areas near the 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. Some depleted forest lands and rangelands might be more profitably used for forest development, and the relatively small amount of forage which would be lost could be replaced through increased production from more suitable cropland pasture.

Fire prevention efforts in the basin are generally satisfactory. Additional measures such as improved weather forecasting would be beneficial. Present protection forces are adequate to control average fires. However, there is need for more capability to mobilize for rapid fire suppression to control fires resulting from severe lightning storms or extreme burning conditions.

Conflicts between big game management and other uses have been widespread. There has been deer damage to tree seedlings and to farm crops. Control is being attempted through special hunting seasons, issuance of permits for hunting antlerless deer, and by providing alternate sources of food for deer.

Many of the forest land 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. For these reasons, many small private forest holdings are rather poorly managed. For instance, data from the 1952 Timber Resources Review indicated that the timber on small private holdings is generally cutover at too small a size for maximum profits, and there is often inadequate provision for regeneration. Small forest holdings owned by farmers tend to be better managed than those owned by nonfarmers, but farmers tend to put their forest land to other uses such as pasture that will produce cash returns in a shorter time. Forest values for water, recreation, and wildlife are often not considered on small holdings because of indifference or economics.

Small forest landowners can get advice and assistance of trained foresters to help them realize much greater benefits from their land from a State Farm Forester or the Soil Conservation Service 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 are encouraged to follow good watershed management practices.

Large ownerships account for most of the land in the principal forest zone of the basin. Generally, watershed management conditions in this zone can be identified with the policies of the landowner or public agency. Most soils with forest cover have only moderate surface erosion hazards, but there are many large areas with slide or slump hazards. In these areas roads are a major source of sediment when located without consideration for adequate drainage structures, plant and mulch cover to protect cut and fill slopes, or adequate maintenance of surface and drainage structures. Erosion is likely to occur on logging areas when logging methods are used that do not fit

the terrain; when skid trails, fire lines, and landings are not given special treatment; or when broadcast slash burning destroys an undue amount of soil protecting litter.

Most of the upper slopes and alpine forest zones are in federal ownership. Overgrazing of mountain meadows by livestock and heavy use of trails by recreational visitors have contributed to some erosion problems. Problems associated with roads and logging areas may also occur. Since soils are shallower in these zones, their susceptibility to erosion remains high due to land form character, greater climatic extremes, and the more delicate biological balance of vegetation.

Along with additional knowledge and tools for better watershed management must go greater 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 forest land. Thus, foresters have an opportunity and responsibility to sell multiple use management of all forest resources.

WATER DEVELOPMENT

There is a great potential for development of the water resources of the Lower 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 expanding population. Providing adequate water supplies for agriculture will be a major purpose of future water development projects in the basin. For instance, an estimated 160,700 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.

For instance, there is an increasing need for recognition of fish life, wildlife, pollution abatement, and recreational values in the planning of water development projects throughout the basin. 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.

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 already uses considerable ground water. It has been estimated that nearly 7,000 acres, or about 20 percent of the total irrigated acreage, are presently irrigated from wells (table 19). It is the chief source of water in subbasins 9 and 11.

Ground water is still a good source for future development in some areas of the basin. The quality and quantity of 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 8 and 10 and part of subbasin 9 do not have a dependable ground water supply due to less favorable underlying rock formations. Ground water in the underlying bedrock strata, tapped by a few deep wells, is sometimes highly mineralized and unsatisfactory for general use.

Surface Water

Additional individual and group irrigation systems are needed to provide irrigation water for 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 them 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 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 37,000 additional acres could be irrigated in the basin from natural flow, ground water, 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 Lower Willamette River Basin (photo 36).

A summary of estimates from various parts of the basin has indicated that it would be necessary to construct both large and small reservoirs to supply water for about 124,000 irrigated acres for optimum agricultural development (table 12E). 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 27 summarizes reconnaissance data assembled by the Department of Agriculture on 38 sites that

Photo 36.--A typical medium sized reservoir constructed for multiple use in subbasin 8. SCS photo. 7-616-12

appear to have some merit and warrant future consideration. The location of these sites are shown on figure 22.

The Corps of Engineers, U. S. Army; Bureau of Reclamation; and Soil Conservation Service have dams under consideration which would 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 water.

Table 27.--Reconnaissance data on some reservoir sites, by subbasin, Lower Willamette Drainage Basin, Oreg., 1963

Subbasin and stream	Watershed index	Reservoir index	Location			Drainage area	Estimated annual yield	Storage capacity	Reservoir water depth	Reservoir surface area	Top length of embankment	Estimated embankment volume	Fill ÷ storage	Possibilities
	Letter	Number	Township	Range	Section	Sq. mi.	Ac. ft.	Ac. ft.	Ft.	Acres	Ft.	Cu. yds.	Cy/ac.ft. 1/	Uses 2/
8. Tualatin Subbasin:														
Gales Creek	D	1	2N	5W	20	13.7	33,700	15,930	152	262	750	1,209,500	76	I, R,S
West Fork Dairy Creek	C	2	2N	4W	5	2.5	3,400	970	70	31	620	200,700	207	I,F, S
Trib. West Fork Dairy Creek	C	3	2N	4W	5	5.0	8,000	1,580	60	58	525	147,300	93	I,F,R,S
Tolke Canyon	C	4	2N	4W	3	3.5	5,800	4,110	95	98	800	523,300	127	I,F,R,S
Sadd Creek	C	5	2N	4W	33	3.3	4,200	1,040	42	62	600	87,500	84	I,F,R,S
Park Farms Creek	C	6	2N	4W	34	3.7	4,700	2,400	30	200	850	66,800	28	I,F,R,S
East Fork Dairy Creek	A	7	3N	3W	28	24.9	46,500	7,200	120	150	950	821,500	114	I,F,R,S
Bledsoe Creek	A	8	2N	3W	27	5.2	6,700	2,740	22	311	1,000	49,800	18	I,F,R,S
McKay Creek	B	9	2N	3W	13	23.3	29,800	6,340	80	198	1,000	447,700	71	I,F,R,S
Do.	B	10	2N	3W	24	24.	30,700	6,800	71	210	1,240	506,700	75	I,F,R,S
Rock Creek	B	11	1N	1W	18	12.9	10,300	2,630	31	212	875	68,300	26	I,F,R,S
Trib. Beaverton Creek	E	12	1S	1W	17	3.0	2,600	850	30	71	1,075	76,000	89	I,F,R,S
Trib. Fanno Creek	F	13	1S	1W	34	5.5	5,300	800	19	105	800	40,000	50	F,R
Chicken Creek	H	14	2S	1W	19	15.5	14,900	950	22	108	400	20,800	22	F,R
Baker Creek	G	15	2S	2W	15	8.5	8,200	870	24	91	350	21,300	24	F,R
McFee Creek	G	16	2S	2W	18	9.3	10,900	1,200	45	67	950	201,400	168	I,F,R
Tualatin River	E	17	1S	5W	20	23.9	76,500	5,180	160	81	500	803,000	155	I,F,R,S
9. Clackamas Subbasin:														
Noyer Creek	A	1	2S	3E	2	1.3	1,900	560	35	40	475	46,900	84	I,F,R,S
Tickle Creek	A	2	2S	4E	8	12.1	31,000	1,850	70	66	780	260,300	140	I,F,R,S
Beaver Creek	B	3	3S	2E	18	12.1	14,200	1,090	25	109	700	45,000	41	I,F,R
Parrott Creek	B	4	3S	2E	31	6.4	6,800	330	22	37	300	16,600	51	I, R
Beaver Creek	B	5	3S	2E	22	5.4	6,700	1,560	30	130	530	45,400	29	I, R
Abernethy Creek	F	6	3S	3E	19	9.5	12,700	2,860	60	119	550	143,200	50	I,F,R
Trib. Clear Creek	C	7	3S	3E	4	2.1	3,700	500	40	31	550	64,500	129	I,F,R,S
Little Clear Creek	C	8	3S	3E	22	7.8	11,700	3,700	66	140	775	371,100	100	I, R
Eagle Creek	D	9	3S	5E	26	28.0	97,200	23,500	235	250	900	3,055,600	130	F,R,S
10. Columbia Subbasin:														
Milton Creek	A	1	5N	2W	16	9.3	11,800	2,170	67	81	300	120,600	56	F,R
Do.	A	2	5N	2W	27	12.8	16,400	2,200	52	106	1,250	244,900	111	I,F,R
Cox Creek	A	3	4N	2W	2	4.2	4,900	3,780	80	118	700	278,600	74	I,F,R
North Scappoose Creek	B	4	4N	2W	18	10.4	18,800	5,350	51	262	650	114,700	22	I,F,R
Do.	B	5	4N	2W	17	18.1	32,700	23,420	96	610	600	414,500	18	I,F,R
Trib. McNulty Creek	B	6	4N	2W	13	2.5	2,700	1,740	50	87	750	142,100	82	I,F,R,S
Mt. Scott Creek	C	7	2S	2E	3	3.6	4,200	2,210	70	79	500	159,700	72	I,F,R,S
Trib. Johnson Creek	E	8	1S	3E	26	3.9	5,500	1,960	40	132	750	59,500	30	I,F,R,S
Johnson Creek	E	9	1S	4E	28	1.5	3,300	530	35	38	580	57,900	109	I,F,R
11. Sandy Subbasin:														
Beaver Creek	C	1	1S	4E	7	4.4	7,000	750	40	47	500	58,700	78	I,F,R
Trout Creek	C	2	1S	4E	24	4.8	11,100	2,320	46	126	600	109,600	47	I, R
Gordon Creek	C	3	1S	5E	7 & 18	16.1	38,600	4,350	145	75	600	801,100	184	I, 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, S-water supply--industrial, municipal, and domestic.

Source: Based on data gathered by the U. S. Department of Agriculture River Basin Survey Party.

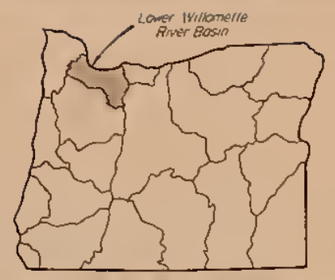
FIGURE 22

INDEX MAP OF WATERSHEDS AREAS AND POSSIBLE RESERVOIR SITES

LOWER WILLAMETTE RIVER BASIN

OREGON

SEPTEMBER 1963



RIVER BASIN LOCATION

SUBBASINS

8 TUALATIN

9 CLACKAMAS

10 COLUMBIA

11 SANDY

SCALE 10 MILES

COUNTY LOCATION

LEGEND

- Flood Problem Areas
- C — Watershed Boundary and Letters
- 6 — Possible Reservoir Sites Studied by USDA
- Possible Reservoir Sites Studied by Others
- River Basin Boundary
- Subbasin Boundary
- National Forest and/or Indian Reservation Boundary

WATERSHED CLASSIFICATION

- Best P.L. 566 Possibilities
- Application Approved P.L. 566
- Others Studied

MT. HOOD

U S DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE ... M-3905

7-E-17483-N

OPPORTUNITIES FOR WATERSHED PROTECTION AND FLOOD PREVENTION PROJECTS

DESCRIPTION OF PUBLIC LAW 566

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.

WATERSHED SURVEY

The USDA Oregon River Basin Survey Party made a study of the potential for P. L. 566 work in the Lower Willamette River Basin to provide information as a guide to long range coordination and planning of possible future projects. The basin was divided into 22 tributary watershed areas which are designated by letter and are delineated on figures 21 and 22. A preliminary survey was made of each watershed to gather basic reconnaissance data on land and water use and water related problems, which are summarized in tables 12A through 12E.

Information in these tables are estimates by local personnel of the Soil Conservation Service and the Forest Service. Although it is of a reconnaissance nature, published material such as the Census of Agriculture was used as a cross check on many items. Data from this survey are used throughout much of this report.

A field reconnaissance and an evaluation of available data for each watershed was made to obtain additional information on watershed area; physiographic conditions; land use; water yield and its seasonal distribution; water related problems, needs, and use; and opportunities for P. L. 566 action. Some of this material is limited because of a lack of time for making more detailed field observations. Further detailed investigations would be necessary to determine engineering and economic feasibility of a given project. The Survey Party's findings are presented in individual watershed reports summarized in table 28 and shown on figure 22.

Table 28.--Summary of watershed reports, Lower Willamette River Basin, Oreg.

Subbasin and watershed	Project possibilities under P. L. 566
8. Tualatin Subbasin:	
A. East Fork Dairy Creek..	A project including flood protection, irrigation, land treatment, recreation, and perhaps water development for municipal and industrial use appears to be feasible.
B. McKay Creek.....	An application for a P. L. 566 plan has been received and approved. A project including flood protection, land treatment, water development for irrigation, industrial, municipal, and recreation use appears to be feasible.
C. West Fork Dairy Creek..	An application for a P. L. 566 plan has been received, approved, and a field examination report prepared. A project including flood protection, land treatment, water development for irrigation, recreation, and perhaps municipal and industrial uses appears to be feasible.
D. Gales Creek.....	A project including irrigation, flood protection, land treatment, and perhaps water development for municipal, industrial, recreation, and wildlife appears to be feasible.
E. Tualatin River.....	A project for the entire area does not appear to be feasible under existing conditions and laws unless it is in cooperation with the Corps of Engineers or Bureau of Reclamation. A multiple purpose project could be feasible on some parts of the watershed.
F. Fanno Creek.....	A project including flood protection, recreation, pollution abatement, irrigation, channel alignment, and land treatment appears to be feasible.
G. Baker Creek.....	A project including irrigation, flood protection, land treatment, and recreation might be feasible.
H. Chicken Creek.....	A project including irrigation, flood protection, drainage, and recreation might be feasible.

Table 28.--Summary of watershed reports, Lower Willamette River Basin, Oreg.--Continued

Subbasin and watershed	Project possibilities under P. L. 566
9. Clackamas Subbasin:	
A. Deep Creek	A project including water development for irrigation, municipal, and recreation use along with some flood protection and land treatment might be feasible.
B. Beaver Creek	A project including water development for irrigation, recreation, and flood protection might be feasible.
C. Clear Creek	A project has little possibilities under existing conditions and laws.
D. Eagle Creek	A project has little possibilities under existing conditions and laws.
E. Clackamas River	The drainage area is too large with a high water yield and comparatively minor problems or benefits to offset heavy costs of improvements.
F. Abernethy Creek	A project including flood protection, irrigation, recreation, and land treatment could be feasible.
10. Columbia Subbasin:	
A. Milton Creek	A project including flood protection, irrigation, and recreation might be feasible.
B. Scappoose Creek	A project including flood protection, irrigation, and recreation might be feasible.
C. Portland	A project does not appear to be feasible under existing conditions and laws.
D. Fairview	An application for a plan under P. L. 566 has been received and approved. A project including flood protection, drainage, and irrigation appears to be feasible.
11. Sandy Subbasin:	
A. Bonneville	A project does not appear to be feasible under existing conditions and laws.

Table 28.--Summary of watershed reports, Lower Willamette River Basin, Oreg.--Continued

Subbasin and watershed	Project possibilities under P. L. 566
B. Bull Run River.....	A project does not appear to be feasible under existing conditions and laws.
C. Sandy River.....	A project for the entire watershed appears to have little possibilities under existing conditions and laws.

FACTORS THAT IMPROVE FEASIBILITY

Many of the water related problems of the Lower 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 Survey 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.
5. The watershed contains one or more storage sites which appear feasible for multipurpose development.

FACTORS THAT LIMIT FEASIBILITY

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.

FACTORS NOT CONSIDERED

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, recreation, 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.

8. TUALATIN SUBBASIN

Watershed A, East Fork Dairy Creek

Description. The East Fork Dairy Creek watershed, a tributary of the Tualatin River, contains 51,940 acres. It is in north central Washington County with a small portion of the upper watershed in Columbia County and is entirely in the Scappoose-Rainier and Washington County Soil Conservation Districts. The East Fork of Dairy Creek flows south from Tater Hill to its confluence with the West Fork at Schefflin; it continues as Dairy Creek to the Tualatin River near Cornelius. The East Fork Dairy Creek watershed which includes Dairy Creek is approximately 20 miles long and about 4.5 miles in width. Elevations range from 150 feet to 1,800 feet. Average annual precipitation ranges from 40 to 66 inches. The average growing season in the agricultural area is 180 days.

This watershed contains five general soil areas recognized on the basis of parent material, soil development, and physiography. Some hill soils such as Nekia and Olympic are formed from residuum from igneous materials, but most of the hill soils including Laurelwood, Kinton, Cascade, and Delena are formed from loess. Part of the terrace soils, Cornelius, Quatama, Helvetia, Aloha, and Huber, are formed from loess; the remainder are formed from Willamette silts and are called Hillsboro, Willamette, Woodburn, Amity, and Dayton. The floodplain soils are formed in recent alluvium, and they include Cloquato, Chehalis, Maytown, Wapato, and Reed.

There are approximately 27,500 acres of forest in this watershed; it is mainly Douglas-fir with alder and maple in the stream bottoms. There is generally a vegetative cover on the land, but in many areas brush overtops the Douglas-fir reproduction. There are scattered patches of small sawtimber and large areas of poles and saplings.

About 23,700 acres in 370 farms are used for agricultural production including 20,900 acres of crops, 1,800 acres of grazed forest, and 1,000 acres of range. Approximately 3,150 acres of cropland are irrigated to produce hay, pasture, vegetables, berries, and nursery stock. The nonirrigated cropland is cropped to grain, hay, and pasture with smaller acreages of fruits, nuts, berries, and nursery stock.

Watershed Problems and Needs. Approximately 2,400 acres are flooded annually damaging some land, crops, and creek banks. Irrigation facilities, farm buildings, roads, and bridges receive very little damage. There is need to improve channels through clearing, bank protection, and enlargement. Cropland is subject to some moderate field erosion on hillsides from winter runoff.

Estimates show that 4,500 acres of arable land needs subsurface or surface drainage through a combination of open and closed drains and improved outlets.

About 18,000 additional acres are suitable for irrigation. Nearly all must depend on stored water. Two reservoir sites (index numbers 7 and 8) were investigated in connection with this report with a total potential stor-

age capacity of about 10,000 acre feet. These sites could benefit irrigation and improve flood protection. Additional late season water is needed for the irrigated land.

There is also a need in this area for additional municipal and industrial water development.

Opportunities under P. L. 566. A project including flood protection, irrigation, land treatment, recreation, and perhaps water development for municipal and industrial use appears to be feasible.

Watershed B, McKay Creek

Description. The McKay Creek watershed, a tributary of Dairy Creek in northeastern Washington County and western Multnomah County, contains 61,940 acres. It is entirely in the Washington County and Sauvie Island Soil Conservation Districts. McKay Creek flows in a southerly direction to is confluence with Dairy Creek near Cornelius. The McKay Creek watershed which also includes the upper part of Rock Creek is about 18 miles long and averages 8 miles in width. Elevations range from 160 feet to 1,800 feet. Annual precipitation averages 50 inches, ranging from 40 to 60 inches. The average growing season in the agricultural area is 180 days.

This watershed contains five general soil areas recognized on the basis of parent material, soil development, and physiography. The hill soils including Laurelwood, Kinton, Cascade, and Delena are formed from loess; in addition there are some small interspersed areas of Nekia formed from igneous materials. Part of the terrace soils, Cornelius, Quatama, Helvetia, Aloha, and Huber, are formed from loess; the remainder are formed from Willamette silts and are called Hillsboro, Willamette, Woodburn, Amity, and Dayton. The floodplain soils are formed in recent alluvium, and they include Newberg, Cloquato, Chehalis, Maytown, Wapato, and Reed.

The 24,000 acres of forest land in this watershed are found mainly on the rough ground on the sides and upper end of the watershed. There are scattered patches and farm woodlots throughout the agricultural portion. Most of the timber is young, still in the sapling and pole size class. There are many areas where the Douglas-fir reproduction growth is slowed by competition from heavy brush. Douglas-fir is slowly coming into abandoned fields.

About 34,250 acres in 475 farms are used for agricultural production including 27,600 acres of crops, 3,500 acres of grazed forest, and 3,150 acres of range. Approximately 500 acres of cropland are irrigated producing pasture, hay, vegetables, berries, nursery, and specialty crops. The non-irrigated cropland produces pasture, hay, grain, fruits, nuts, berries, and nursery stock.

Watershed Problems and Needs. Approximately 1,500 acres are flooded annually in this watershed. The principal flood damage is to croplands from overflow and streambank erosion. Irrigation facilities, fences, roads, and bridges receive some minor damage from sediment and debris. Channel clearing and alignment would greatly reduce flooding. The forest cover is being

removed from the east side of the watershed to make hillside building lots. Unless some provision is made to control runoff, severe erosion can result.

It is estimated that 4,500 acres of arable land needs drainage. About 25 percent requires land shaping and outlets to reduce surface ponding. Open ditches and tile systems are required on the total acreage to lower the ground water in the root zone.

Estimates show that 18,000 acres of additional land are suitable for irrigation. All but about 100 acres would need storage for development. Storage is also needed for an adequate water supply for the presently irrigated land after the middle of July. Three reservoir sites (index numbers 9, 10, and 11) with a combined potential storage of 15,770 acre feet were investigated. One of the sites is on Rock Creek with the other two on McKay Creek. There is also a site proposed by another agency that has a large potential storage. The possibility of pumping water over the Portland Hills from Multnomah Slough has also been investigated as a water source.

There is a need for municipal and industrial water development.

Opportunities under P. L. 566. An application for a P. L. 566 plan has been received and approved. A project including flood protection, land treatment, water development for irrigation, industrial, municipal, and recreational use appears to be feasible.

Watershed C, West Fork Dairy Creek

Description. The West Fork Dairy Creek watershed contains 50,190 acres in the northern part of Washington County. It lies completely within the boundary of the Washington County Soil Conservation District. The watershed area, a tributary of the Tualatin River, is comprised of low to moderately high mountains bordering fairly broad and flat valley flood lands. Elevations range from 150 feet at the confluence with the East Fork of Dairy Creek to over 2,000 feet at the northwestern rim of the watershed. The normal annual precipitation is about 55 inches and varies from 36 inches in the lower reaches to more than 90 inches along the western edge of the basin. The climate is moderate with wet and cloudy winters and dry and warm summers. The average frost-free period is 180 days.

This watershed contains six general soil areas recognized on the basis of parent material, soil development, and physiography. The northern hill soils such as Nekia and Olympic are formed from residuum from igneous materials, but Peavine, Melbourne, Panther, and the associated fan soils -- Carlton and Chehalem -- are formed from residuum from sedimentary rock. The hills in the central section have soils formed from loess including Laurelwood, Kinton, Cascade, and Delena. Part of the terrace soils, Cornelius, Quatama, Helvetia, Aloha, and Huber, are formed from loess; the remainder are formed from Willamette silts and are called Hillsboro, Willamette, Woodburn, Amity, and Dayton. The floodplain soils are formed in recent alluvium, and they include Cloquato, Chehalis, Maytown, Wapato, and Reed.

There are approximately 33,700 acres of forest land located on the valley bottoms, rougher ground, and upper area of this watershed. With the exception of areas of heavy to severe brush competition, the stands are in

generally good condition. There are scattered patches of small sawtimber in the upper watershed, but the Douglas-fir is usually sapling or small pole size.

Approximately 16,500 acres in 270 farms are used for agricultural production including 13,500 acres of crops, 1,500 acres of range, and 1,500 acres of grazed forest. About 1,200 acres of cropland are irrigated and grow pasture, hay, berries, and nursery stock. The nonirrigated cropland produces grain, pasture, hay, fruits, nuts, and berries.

Watershed Problems and Needs. Approximately 1,800 acres are flooded annually. Flood damage results in sediment and debris deposits. Sediment deposited on fields materially reduces yields, increases expenses, slows operations, and is damaging to farm equipment. Very little damage has been incurred by flooding to roads and bridges. Flood control dams and channel work are needed to reduce flooding. Some erosion is occurring on cropland, particularly on fields where planting and tillage operations were performed up and down the slope. There is good forest cover with little erosion. Alder blowdown in the creeks adds to the debris problem.

Estimates indicate that 2,200 acres of arable land are in need of subsurface drainage. About 500 acres need land shaping and adequate outlets to improve surface drainage.

It has been estimated that 10,000 additional acres are suitable for irrigation; of this, only one percent can be irrigated from natural streamflow and underground water. Storage development would be needed for the remainder and supplemental water after the middle of July for the land already irrigated. A portion of this watershed is within the boundary of the proposed U. S. Bureau of Reclamation Tualatin Project area for which irrigation development is proposed. Five reservoir sites (index numbers 2, 3, 4, 5, and 6) have been investigated for flood protection and water storage. They have a combined storage exceeding 10,000 acre feet.

There is a need for water development for municipal and industrial uses in the watershed and adjacent areas.

Opportunities under P. L. 566. In 1958, a Field Examination Report for a P. L. 566 project did not appear to be feasible with the limitations of the law and conditions at that time. Under present conditions and laws a project that includes flood protection, land treatment, water development for irrigation, recreation, and perhaps municipal and industrial uses appears to be feasible.

Watershed D, Gales Creek

Description. The Gales Creek watershed, a tributary of the Tualatin River, contains 47,220 acres in western Washington County. It is entirely within the Washington County Soil Conservation District. Gales Creek flows in a southerly direction from Round Top Mountain to its confluence with the Tualatin River near Dilley. It is about 19 miles long and averages 4 miles in width. Elevations in the watershed range from 2,890 feet on Round Top

Mountain to 160 feet near Dilley. Average annual precipitation ranges from 90 inches in the mountains to 46 inches at Forest Grove. The average growing season in the agricultural area is 175 days.

This watershed contains five general soil areas recognized on the basis of parent material, soil development, and physiography. The northern hill soils such as Nekia and Olympic are formed from residuum from igneous materials, but Peavine, Melbourne, Panther, and associated fan soils -- Carlton and Chehalem -- are formed from residuum from sedimentary rock. The hills in the central section have soils formed from loess including Laurelwood, Kinton, Cascade, and Delena. The terrace soils, Cornelius, Quatama, Helvetia, Aloha, and Huber, are formed from loess. The floodplain soils are formed in recent alluvium, and they include Cloquato, Chehalis, Maytown, Wapato, and Reed.

The major portion of the 38,000 acres of timber in this watershed, which extends into the Tillamook burn, is less than 30 years old. With the exceptions of scattered patches and farm woodlots, the timber is growing on steep, rough ground. Douglas-fir grows well in this area after it overcomes heavy competition from red alder and vine maple.

About 9,300 acres in 225 farms are used for agricultural production including 7,600 acres of crops, 1,200 acres of grazed forest, and 500 acres of range. Approximately 1,500 acres of cropland are irrigated pasture, hay, and berries. The nonirrigated cropland is growing grain, hay, pasture, fruit, nuts, and berries.

Watershed Problems and Needs. Approximately 800 acres are flooded annually in this watershed. Flood damage is minor in woodlands, rangeland, and to irrigation facilities. Croplands are subject to moderate erosion, sedimentation, and debris deposition. Flooding damages fences, roads, and bridges with sediment and debris. There is a need for channel clearing, alignment and enlarging, and adequate outlets from tributary streams. In the forested area the major problem is caused by drainage water from roads. Particular attention to this problem in logging operations would reduce erosion and sedimentation.

Estimates show that 2,000 acres of arable land need drainage. About 25 percent needs surface drainage by land shaping and improved outlets. The other 1,500 acres require both open and closed subsurface drains with adequate outlets.

About 8,000 acres of additional land are suitable for irrigation development. Reservoir storage is needed for most irrigation development and supplemental water after the middle of July.

One reservoir site (index number 1) having a potential storage of about 16,000 acre feet was investigated. Another agency has investigated a large storage site just below the town of Gales Creek that could help eliminate flooding and supply water in this watershed. The need for additional sources of industrial and municipal water is increasing in this area.

Opportunities under P. L. 566. A project appears to be feasible that includes irrigation, flood protection, land treatment, recreation, and perhaps water development for municipal, industrial, and wildlife uses.

Watershed E, Tualatin River

Description. The Tualatin River watershed, a tributary of the Willamette River, contains 189,050 acres as delineated for this study. The watershed lies in southern Washington County with portions in Yamhill, Multnomah, and Clackamas Counties. It is in the Washington County, Yamhill County, Sauvie Island, and South Clackamas Soil Conservation Districts. The Tualatin River flows in a generally easterly direction from the Coast Range to its confluence with the Willamette River about 2 miles south of Oregon City. Scoggin Creek is the only major tributary included. The watershed is approximately 40 miles long and varies from 2 miles to 9 miles in width. Elevations range from 3,460 feet on Saddle Mountain to 75 feet. Average annual precipitation ranges from 48 inches to 100 inches. The average growing season in the agricultural area is 180 days.

This watershed contains six general soil areas recognized on the basis of parent material, soil development, and physiography. Soils such as Nekia and Olympic, formed from residuum from igneous materials, are found in the western part. Willakenzie, Peavine, Melbourne, Hazelair, Dupee, Panther, and the associated fan soils -- Carlton and Chehalem -- are formed from residuum from sedimentary rock and are also found in the western section. The hill soils in the eastern part include Laurelwood, Kinton, Cascade, and Delena are formed from loess. The terrace soils, Cornelius, Quatama, Helvetia, Aloha, and Huber, are formed from loess. Other terrace soils, Hillsboro, Willamette, Woodburn, Amity, and Dayton, are formed from Willamette silts. The floodplain soils are formed in recent alluvium, and they include Cloquato, Chehalis, Maytown, Wapato, Reed, and Cove.

Approximately 45 percent, or 86,410 acres, of the Tualatin River watershed is forested. The forests occur on every type of terrain in the watershed, with hardwoods in the stream bottoms and Douglas-fir and other conifers on the higher sites. Generally the timber is found on the land that is not suited to farming. In the upper portions of the watershed scars of the 30 year old Tillamook burn can be found, but there are still large areas with merchantable timber.

Approximately 85,030 acres in 1,345 farms are used for agricultural production including 65,740 acres of crops, 9,900 acres of range, and 9,300 acres of grazed forest. About 8,400 acres of cropland are irrigated to grow pasture, hay, vegetables, berries, and specialty crops. The remaining cropland is nonirrigated producing pasture, hay, grain, fruit, nuts, berries, specialty crops, and vegetables.

Watershed Problems and Needs. Approximately 8,400 acres are flooded annually. Damage is minor on range and forest lands with sedimentation and debris deposits being the main problem; there is also some streambank erosion. Brush is a problem in the forested area in the younger fir stands, but it doesn't cause an erosion hazard. Croplands receive moderate damage, but small areas receive severe damage from erosion, debris, and silt deposits. There is considerable damage to fences and some damage to irrigation pumping

plants, roads, bridges, and urban developments. Channel clearing, enlarging, and alignment are needed to reduce flooding as well as multi-purpose structures on main tributaries to control the floodwaters.

It is estimated that 21,000 acres of arable land need both surface and subsurface drainage. Land shaping, open ditches, tile drain systems, and adequate outlets are needed to reduce this problem.

Estimates show that 57,100 acres of additional land are suitable for irrigation; of this, only about 700 acres could be irrigated from natural streamflow or ground water. The remaining acreage would need storage developed. A large portion of this area is included in the proposed U. S. Bureau of Reclamation Tualatin Irrigation Project. One reservoir site (index number 17) in the upper watershed and one in the Beaverton area (index number 12) were investigated. They have a combined storage potential of 6,000 acre feet.

There is need in this area for more municipal and industrial water.

Opportunities under P. L. 566. Under existing conditions and laws, due to the magnitude of the problem and the yield of the watershed, a project for the entire area does not appear to be feasible unless in cooperation with other agencies. A multiple purpose project could be feasible on some parts of the watershed.

Watershed F, Fanno Creek

Description. The Fanno Creek watershed, a tributary of the Tualatin River in Washington, Multnomah, and Clackamas Counties, contains 22,800 acres. It is entirely within the Washington County, Sauvie Island, and South Clackamas Soil Conservation Districts. Fanno Creek flows from the Portland Hills to the west, then in a southerly direction to its confluence with the Tualatin River at Tualatin. It is 9 miles long and varies in width from 6 miles to less than 1 mile. Elevations in the watershed range from 125 feet to 1,000 feet. Average annual precipitation is about 44 inches. The average growing season in the agricultural area is 180 days.

This watershed contains four general soil areas recognized on the basis of parent material, soil development, and physiography. There is a small area of Nekia soils formed from residuum from igneous materials. The upland soils, Laurelwood, Kinton, Cascade, and Delena, are formed from loess. Terrace soils are formed from loess which includes Cornelius, Quatama, Helvetia, Aloha, and Huber. Cloquato, Chehalis, Maytown, Wapato, and Reed soils occur on the floodplains.

This watershed with its 4,000 acres of forest land is one of the contrasts. The eastern portion near the head of the watershed is being converted from forests to hillside view lots. The remaining trees are mainly providing shade and atmosphere for the residences. In the lower areas pole and small sawtimber stands are found in scattered patches and on the rougher ground. As in other drainages in the basin, hardwoods occupy the streambanks and provide competition for the conifers on other sites.

About 5,890 acres in 130 farms are used for agricultural production including 4,240 acres in crops, 1,250 acres of grazed forest, and 400 acres of range. Approximately 250 acres of cropland are irrigated pasture, hay, berries, and nursery. The nonirrigated cropland produces pasture, hay, grain, fruits, nuts, berries, and nursery crops.

Watershed Problems and Needs. Approximately 300 acres are subjected to annual flooding with minor damage. The flooding problem creates other problems in this watershed due to increasing urbanization. The areas flooded are generally not built upon but are a hazard to children and create health problems from pollution. Channels in the area need clearing and improving with adequate outlets. Problems associated with removal of vegetation from steep ground can be expected as more land is prepared for building sites.

Estimates show 500 acres need subsurface drainage including both ditches and tile lines with adequate outlets.

Approximately 1,000 acres of additional land are suitable for irrigation. Very little can be irrigated with natural streamflow and/or ground water. Stored water is also needed for 200 acres of irrigated land beginning about July 15. One small reservoir site (index number 13) with a potential storage of 800 acre feet was investigated. This site could offer some flood protection, pollution abatement, recreation, and minor irrigation benefits.

Opportunities under P. L. 566. A project that includes flood protection, recreation, pollution abatement, irrigation, channel alignment, and land treatment appears to be feasible.

Watershed G, Baker Creek

Description. The Baker Creek watershed, a tributary of the Tualatin River in Washington and Yamhill Counties, contains 14,820 acres. It is entirely in the Washington County and Yamhill County Soil Conservation Districts. The creek flows in a northerly direction from the Chehalem Mountains to its confluence with the Tualatin River near Scholls. McFee Creek is a major tributary to Baker Creek flowing from the west. The watershed is about 4 miles wide and 7 miles long. Elevations in the watershed range from 1,400 feet in the Chehalem Mountains to 125 feet near Scholls. Average annual precipitation is 42 inches. The average growing season in the agricultural area is 180 days.

This watershed contains four general soil areas recognized on the basis of parent material, soil development, and physiography. Nekia soils are formed on hills from residuum from igneous materials. Upland soils formed from loess include Laurelwood, Kinton, Cascade, and Delena. The terrace soils, Aloha and Huber, are formed from loess. Cloquato, Chehalis, Maytown, Wapato, and Reed soils occur on the floodplains.

The majority of the 7,600 wooded acres in this watershed are found on rougher ground. The stands are generally young; in many areas the fir is just starting to show through the brush overstory. It appears that no

thought was given to reforestation when the original forest was cut. More recently, young stands have been cut and the slender whips left, which in some areas have suffered considerable windthrow.

About 8,300 acres in 190 farms are used for agricultural production including 5,900 acres of crops, 2,000 acres of grazed forest, and 400 acres of range. Approximately 400 acres of cropland are irrigated pasture, hay, berries, and nursery crops. The nonirrigated cropland produces pasture, hay, grain, fruits, nuts, berries, and nursery crops.

Watershed Problems and Needs. Approximately 200 acres are flooded annually with damage confined to the area at the confluence of Baker Creek, McFee Creek, and the Tualatin River. Flooding is mainly to pasture and grazed forest land with minor damage. Croplands on moderate to steep slopes are subjected to erosion damage due to winter runoff. Windthrow and logging operations have left considerable debris in the streams which adds to the flooding problems downstream. These problems could be controlled through additional land treatment practices in the watershed.

It is estimated that 700 acres of arable land need subsurface drainage and outlets.

Approximately 2,500 acres of additional land are suitable for irrigation. Stored water would be required for 2,400 acres and to supplement present irrigation during the late season. Two reservoir sites (index numbers 15 and 16) were investigated. The site on McFee Creek has a storage potential of 1,200 acre feet and is located so it could benefit irrigation, flooding, and recreation. The other site could store 870 acre feet but due to location could provide few benefits for this watershed.

Opportunities under P. L. 566. It appears that a project might be feasible on this watershed with a program including flood protection, drainage, land treatment, irrigation, and recreation.

Watershed H, Chicken Creek

Description. The Chicken Creek watershed, a tributary of the Tualatin River, contains 10,040 acres in Washington and Yamhill Counties. It is entirely within the Washington County and Yamhill County Soil Conservation Districts. The creek flows in a northeasterly direction from the Chehalem Mountains to its confluence with the Tualatin River in Section 20, Township 2 South, Range 1 West. It is 6 miles long and about 3 miles wide. Elevations in the watershed range from 1,200 feet to 150 feet. Average annual precipitation is 42 inches. The average annual growing season is 180 days.

This watershed contains three general soil areas recognized on the basis of parent material, soil development, and physiography. The hill soils formed from loess includes Laurelwood, Kinton, Cascade, and Delena. The terrace soils, Cornelius, Quatama, Helvetia, Aloha, and Huber, are formed from loess. Cloquato, Chehalis, Maytown, Wapato, and Reed occur on the floodplains.

Most of the 2,800 acres of timbered land in this watershed is found on the rougher ground in the upper reaches with scattered patches in the lower

part. It has been cutover and generally has a good stand of second-growth Douglas-fir ranging in size from small sawtimber down to seedlings. Heavy stands of hardwoods are found in the stream bottoms.

About 8,100 acres in 120 farms are used for agricultural production including 6,100 acres of crops, 1,500 acres of grazed forest, and 500 acres of range. Approximately 450 acres of cropland is irrigated pasture, hay, berries, and nursery crops. The nonirrigated cropland produces pasture, hay, grain, fruits, and nuts and small acreages of berries and nursery crops.

Watershed Problems and Needs. Approximately 100 acres are flooded annually at the confluence of Chicken Creek and the Tualatin River. This land is pasture and grazed forest land with minor damage. Some cropland on moderate to steep slopes is subjected to moderate erosion from winter runoff. Some of the forest land has a heavy blowdown problem. Channel clearing and rectification work would help relieve the flooding.

Estimates show 1,500 acres of arable land needs subsurface drainage and adequate outlets.

Approximately 3,000 acres of additional land are suitable for irrigation. About 2,900 acres would require water storage. One storage site (index number 14) was investigated but due to location could provide few benefits for this watershed.

Opportunities under P. L. 566. It appears that a project including irrigation, flood protection, drainage, and recreation might be feasible.

9. CLACKAMAS SUBBASIN

Watershed A, Deep Creek

Description. The Deep Creek watershed, a tributary of the Clackamas River, contains 30,100 acres in north central Clackamas County and is entirely within the North Clackamas Soil Conservation District. It flows in a northwesterly direction from the Clackamas-Sandy divide to its confluence with the Clackamas River near Barton. The watershed is about 10 miles long and averages about 4 miles wide. Elevations range from 200 to 1,600 feet. Average annual precipitation ranges from 90 inches to 52 inches. The average annual growing season in the agricultural area is 180 days.

This watershed contains four general soil areas recognized on the basis of parent material, soil development, and physiography. Cascade and Delena soils on hills in the northwestern part are formed from loess. Most of the upland soils including Cazadero, Cottrell, Dubay, Carver, and Bornstedt are formed from residuum from glacial and other material. The terrace soils, Sifton and Clackamas, are formed from silty and gravelly material. Camas, Newberg, Cloquato, Chehalis, Maytown, Wapato, and Reed soils occur on the floodplains.

Almost one-half of this watershed is forested. The 14,400 acres of forested land can be described as having scattered patches of good quality second-growth Douglas-fir in the lower and middle part of the drainage.

There are scattered patches of ragged old-growth Douglas-fir on the ridges in the upper end. Hardwoods are found in the valley bottoms. This watershed is in generally good condition. Douglas-fir is coming into abandoned fields while timbered areas are being cleared for fields and homesites.

About 15,150 acres in 700 farms are used for agricultural production including 9,500 acres of crops, 4,150 acres of range, and 1,500 acres of grazed forest. Approximately 1,200 acres of cropland are irrigated and produce pasture, hay, vegetables, berries, and nursery crops. The nonirrigated cropland produces pasture, hay, berries, nursery crops, vegetables, and nuts.

Watershed Problems and Needs. Approximately 100 acres are flooded annually, mostly on pasture land where damage is minor. There is minor damage to road culverts due to debris and sediment deposits. Channel alignment and clearing would reduce the flooding in this watershed.

The forested part of the watershed is in good condition, but the disturbed areas need to be vegetated promptly to reduce erosion and siltation. There are places where the windthrow and logging debris can create a major problem.

Estimates show that 6,000 acres of arable land needs surface or subsurface drainage.

An estimated 7,000 acres of additional land are suitable for irrigation. About 500 acres require water storage; the remaining 6,500 acres could probably be irrigated from existing sources. Two reservoir sites, one on Tickle Creek (index number 2) and one on Noyes Creek (index number 1), were investigated with a total storage of 2,400 acre feet. Approximately 400 acres of irrigated land experience a water shortage after the first of July.

There is need for additional municipal water in the area that could be supplied from this creek.

Opportunities under P. L. 566. A multi-purpose project including irrigation, municipal and recreational water development, land treatment measures, and flood protection might be feasible.

Watershed B, Beaver Creek

Description. The Beaver Creek watershed in Clackamas County, a tributary of the Willamette River, contains 20,520 acres and is entirely within the South Clackamas Soil Conservation District. It flows in a westerly direction to its confluence with the Willamette River at New Era. The watershed averages about 7 miles in both length and width. Elevations range from 800 feet to 75 feet. Average annual precipitation is about 44 inches. The average growing season is 200 days.

This watershed contains three general soil areas recognized on the basis of parent material, soil development, and physiography. The eastern three-fourths of the watershed are upland soils including Cazadero and Cottrell formed from residuum from glacial and other material. Terrace soils formed from silty and gravelly material of Willamette silts and Linn gravels includes Hillsboro, Willamette, Woodburn, Amity, Dayton, Sifton, and Clackamas.

Camas, Newberg, Cloquato, Chehalis, Maytown, Wapato, and Reed occur on the floodplains.

Four thousand acres in this watershed on hilltops, valley bottoms, and rough ground are timbered. These timber stands were cutover, removing high quality material and leaving the decadent and low quality trees. The thrifty young stands are the result of natural seeding from trees left after logging. In some places the brush is offering heavy competition to the Doulgas-fir seedlings and saplings. Douglas-fir is coming into some abandoned fields.

About 18,220 acres in 175 farms are used for agricultural production including 9,920 acres of crops, 6,100 acres of range, and 2,200 acres of grazed forest. Approximately 500 acres of cropland are irrigated. Pasture, hay, vegetables, and berries are the primary crops. The nonirrigated cropland produces pasture, hay, grain, berries, vegetables, fruits, and nuts.

Watershed Problems and Needs. Approximately 100 acres are flooded annually. Minor damage occurs to crops, soils, and irrigation and farm facilities.

An estimated 400 acres of arable land needs subsurface drainage.

Approximately 500 acres of additional land are suitable for irrigation. Water storage is needed for most of this land and about 200 acres of the presently irrigated land after August 1. Three reservoir sites were studied, two on Beaver Creek (index numbers 3 and 5) and one on Parrott Creek (index number 4). Total storage for the three sites is about 3,000 acre feet.

Opportunities under P. L. 566. A program including water development for irrigation, recreation, and flood protection might prove feasible.

Watershed C, Clear Creek

Description. The Clear Creek watershed in Clackamas County, a tributary of the Clackamas River, contains 46,030 acres and is in the South Clackamas and North Clackamas Soil Conservation Districts. It flows in a northwesterly direction from Goat Mountain to its confluence with the Clackamas River at Carver. The watershed is about 20 miles long and averages 4 miles wide. Elevations range from 4,200 feet on Goat Mountain to 100 feet near Carver. Average annual precipitation varies from 50 inches to 70 inches. The average growing season is 180 days.

This watershed contains four general soil areas recognized on the basis of parent material, soil development, and physiography. A small area in the south has soils including Estacada formed from residuum from igneous materials. Most of the soils on uplands are formed from residuum from glacial and other material; they include Cazadero, Cottrell, Dubay, Carver, and Bornstedt. In the north are terrace soils, Sifton and Clackamas, formed from silty and gravelly material. Camas, Newberg, Cloquato, Chehalis, Maytown, Wapato, and Reed occur on the floodplains.

Approximately 32,000 acres in this watershed are forested. As with other watersheds in the basin, most of the timbered areas are not generally

suited to farming. There are large areas of conifer seedlings overgrown with brush, but the pole-sized stands are relatively brush free and growing well.

About 17,300 acres in 150 farms are used for agricultural production including 11,500 acres of crops, 4,000 acres of grazed forest, and 1,800 acres of range. Approximately 400 acres of the cropland are irrigated pasture, hay, vegetables, nursery crops, and berries. The nonirrigated cropland produces pasture, hay, grain, berries, nursery crops, fruits, and nuts.

Watershed Problems and Needs. Approximately 100 acres of pasture and range land are flooded annually with some minor streambank erosion. Flooding damage is very minor to both land and improvements. Channel alignment and clearing are needed.

It is estimated that 300 acres of arable land need subsurface drains and outlets.

Estimates show that an additional 500 acres of land are suitable for irrigation. To accomplish this water storage development would be required for about 100 acres and supplementary late season water for presently irrigated land. In connection with this study two storage sites (index numbers 7 and 8) with a combined storage of about 4,200 acre feet were investigated.

Opportunities under P. L. 566. Under existing conditions and laws it appears that a project would have little possibility under P. L. 566.

Watershed D, Eagle Creek

Description. The Eagle Creek watershed in Clackamas County, a tributary of the Clackamas River, contains 57,070 acres and is entirely within the North Clackamas Soil Conservation District. It flows in a northwesterly direction from Squaw Mountain to its confluence with the Clackamas River near Eagle Creek. The watershed is about 20 miles long and averages about 5 miles in width. Elevations range from 4,770 feet on Squaw Mountain to 200 feet at the confluence with the Clackamas River. Average annual precipitation ranges from 55 inches to 106 inches. The average growing season is 184 days.

This watershed contains four general soil areas recognized on the basis of parent material, soil development, and physiography. Approximately two-thirds of the watershed has soils formed from residuum from igneous materials including Estacada and Viola. The upland soils, including Cazadero and Cottrell, are formed from residuum from glacial and other material. The terrace soils which include Multnomah, Sifton, and Clackamas are formed from silty and gravelly material. Camas, Newberg, Cloquato, Chehalis, Maytown, Wapato, and Reed occur on the floodplains.

This watershed has approximately 47,000 acres of forest land. The upper third within the Mount Hood National Forest has timber approximately 70 years old. This area has no roads and only a few trails, and no logging has been done. The middle third has been generally cutover in what amounted to a cut-out and get-out method. This section has finally started to restock with Douglas-fir and western hemlock which are growing well except where

overtopped by brush. The lower portion has farm woodlots and scattered patches of Douglas-fir on the more unfavorable land. The old logging areas are now revegetated and stable.

About 10,300 acres in 200 farms are used for agricultural production including 6,700 acres of crops, 2,400 acres of range, and 1,200 acres of grazed forest. Approximately 70 acres are irrigated berries. The nonirrigated cropland produces pasture, hay, fruits, nuts, and berries.

Watershed Problems and Needs. Flooding is a minor problem in this watershed. There is some minor damage in the area of the fish hatchery. There is some erosion to croplands, but soil loss is minor. Debris in the streams from logging and storms cause some damage when there is higher than usual runoff.

Estimates show 450 acres of arable land needs subsurface drainage and outlets.

It is estimated that 2,000 acres of additional land are suitable for irrigation and that existing streamflows and underground water is adequate to irrigate it.

The federal fish hatchery on Eagle Creek needs more uniform flow during certain periods. A reservoir site (index number 9) with a storage capacity in excess of 20,000 acre feet could supply this need and provide recreation.

Opportunities under P. L. 566. It appears that under existing conditions and laws a P. L. 566 project would have little possibility.

Watershed E, Clackamas River

Description. The Clackamas River watershed in Clackamas and Marion Counties, a tributary of the Willamette River, contains 475,850 acres and is in the Santiam, North Clackamas, and South Clackamas Soil Conservation Districts. It flows in a northwesterly direction from the Willamette-Deschutes divide to its confluence with the Willamette River at Gladstone. The watershed is quite wide in the upper reaches ranging from 20 to 30 miles and narrowing to about 2 miles upstream from Estacada. It is approximately 60 miles long. Elevations range from 7,210 feet on Olallie Butte to 50 feet at Gladstone. Average annual precipitation varies from 120 inches in the Burnt Mountain area to 50 inches at Gladstone. Average growing season is 184 days at Estacada.

This watershed contains five general soil areas recognized on the basis of parent material, soil development, and physiography. Approximately 90 percent of the watershed has soils formed from residuum from igneous materials including Estacada, McCully, Nekia, Kinney, Keel, and Viola. The west upland soils formed from residuum from glacial and other material include Cazadero, Cottrell, Dubay, Carver, and Bornstedt; those formed from loess include Cascade and Delena. Terrace soils including Hillsboro, Willamette, Woodburn, Amity, Dayton, Sifton, Multnomah, and Clackamas are formed from silty and gravelly material of Willamette silts and Linn gravels. Camas, Newberg, Cloquato, Chehalis, Maytown, Wapato, and Reed occur on the floodplains.

This watershed, the largest in the Lower Willamette River Basin, contains 444,000 acres of forest land. A very large portion is in the Mount Hood National Forest and constitutes the major area of three ranger districts. There are all sizes of timber including large areas of old-growth. All timber harvesting is on a sustained yield basis, and cutover areas are planted or seeded after cutting. In the lower watershed most of the forests are found on land unsuited for farming and occur in quite extensive areas, some of which are well managed. There are significant areas with heavy brush competition.

About 17,400 acres in 250 farms are used for agricultural production including 12,000 acres of crops, 3,400 acres of range, and 2,000 acres of grazed forest. Approximately 500 acres are irrigated producing pasture, hay, vegetables, berries, and nursery crops. The nonirrigated cropland produces pasture, hay, vegetables, berries, fruits, and nuts.

Watershed Problems and Needs. Approximately 300 acres are flooded annually. Damage is minor to croplands, rangeland, irrigation and farm facilities, and riverbanks in urban areas. There is need for streambank stabilization and some debris clearance.

Estimates show 5,640 acres of arable land that need subsurface drainage and improved outlets.

It is estimated that 4,500 acres of additional land are suitable for irrigation. The majority of this acreage could be irrigated from existing streamflows and underground water.

Opportunities under P. L. 566. This watershed is too large for a P. L. 566 project. Under existing conditions and laws a project does not appear feasible on any of the tributaries.

Watershed F, Abernethy Creek

Description. The Abernethy Creek watershed in Clackamas County, a tributary of the Willamette River, contains 23,730 acres and is entirely within the South Clackamas Soil Conservation District. It flows in a northwesterly direction to its confluence with the Willamette River at Oregon City. The watershed is about 10 miles long and averages about 3 miles in width. Elevations range from 1,300 feet to 50 feet. Average annual precipitation is about 48 inches, and the average growing season is 200 days.

This watershed contains three general soil areas recognized on the basis of parent material, soil development, and physiography. Approximately three-fourths of the watershed have upland soils including Cazadera, Cottrell, and Bornstedt formed from residuum from glacial and other material. Terrace soils formed from silty and gravelly material of Willamette silts and Linn gravels include Hillsboro, Willamette, Woodburn, Amity, Dayton, Sifton, Multnomah, and Clackamas. Camas, Newberg, Cloquato, Chehalis, Maytown, Wapato, and Reed occur on the floodplains.

Approximately one-half of this watershed, 12,700 acres, is forested. The wooded area is found along the stream in the lower drainage and covers

the major part of the upper drainage. Douglas-fir is the principal species, but large areas are covered with hardwood brush. Some of the abandoned fields are being invaded by Douglas-fir seedlings.

About 9,600 acres in 150 farms are used for agricultural production including 5,500 acres of crops, 2,500 acres of range, and 1,600 acres of grazed forest. Approximately 200 acres are irrigated. Berries, pasture, hay, and vegetables are the primary crops. The nonirrigated cropland produces pasture, hay, fruits, nuts, berries, and vegetables.

Watershed Problems and Needs. Approximately 200 acres are flooded annually, with minor damage to cropland and farm facilities. Some streambank erosion occurs on the rangeland. Approximately 20 homes and some roads and bridges are subject to flooding and resulting damage. Some sections of the channel are badly congested with growth and debris and need clearing.

Estimates show that an additional 500 acres are suitable for irrigation with 200 acres requiring water storage development. After the middle of August, there is a water shortage for land irrigated from reservoir storage. One reservoir site (index number 6) was investigated with a potential storage of 2,800 acre feet.

Opportunities under P. L. 566. It appears that under existing conditions and laws a project including flood protection, irrigation, land treatment, and recreation could be feasible.

10. COLUMBIA SUBBASIN

Watershed A, Milton Creek

Description. The Milton Creek watershed in southeastern Columbia County contains 22,100 acres. It is entirely in the Scappoose-Rainier Soil Conservation District. The creek flows in a southeasterly and easterly direction to St. Helens where it enters Multnomah Channel. The watershed is approximately 12 miles long and ranges from 1 to 5 miles in width. Elevations range from 1,100 feet to 20 feet. Average annual precipitation ranges from 44 inches to 52 inches. The average growing season is 280 days.

This watershed contains three general soil areas recognized on the basis of parent material, soil development, and physiography. In the hill area in the west Laurelwood, Kinton, Cascade, and Delena soils are formed from loess. Soils on terraces formed from loess include Quatama, Helvetia, Aloha, and Huber. Newberg, Cloquato, Chehalis, Maytown, Wapato, and Reed occur on the floodplains.

The 17,500 acres of forests are in the upper portion with scattered patches throughout the lower one-third. The old-growth has been logged, and the young-growth is mainly small sawtimber (11" to 21" DBH) and poles. Large areas are brush covered, but the Douglas-fir is growing well where it has overtopped the brush.

About 4,700 acres in 80 farms are used for agricultural production; this includes 3,000 acres of crops, 600 acres of range, and 1,100 acres of

grazed forest. About 200 acres of the cropland are irrigated and produce hay, pasture, and berries. The nonirrigated cropland produces hay, pasture, and berries with some fruits, nuts, and holly.

Watershed Problems and Needs. Approximately 400 acres are flooded annually in the lower reaches of the watershed. Damage is minor to some cropland, farm facilities, roads, and bridges. There is also some urban flooding in the St. Helens area. Channel clearing and enlarging are needed to reduce damage from flooding.

Estimates show that approximately 900 acres of arable land need closed drains to remove excess water from the plant root zone.

Irrigation water is often short around the first of July. An additional 1,200 acres have been estimated as being suitable for irrigation, but an adequate supply of water would have to be developed from storage or ground water. Two reservoir sites on Milton Creek (index numbers 1 and 2) and one site on Cox Creek (index number 3) with a total potential storage of around 8,000 acre feet were investigated. The Columbia River is also a possible source of irrigation water.

Opportunities under P. L. 566. It appears that under present conditions and laws a project including flood protection and water development for irrigation and recreation might be feasible.

Watershed B, Scappoose Creek

Description. The Scappoose Creek watershed contains 52,400 acres. It is located in southeastern Columbia County with small portions in Washington and Multnomah Counties and is in the Scappoose-Rainier, Washington County, and Sauvie Island Soil Conservation Districts. Scappoose Creek forks at the town of Scappoose, forming North Scappoose Creek and South Scappoose Creek. The main creek flows in a northeasterly direction into Scappoose Bay which enters Multnomah Channel. The watershed averages about 8 miles in both an east-west and a north-south direction. Elevations in the watershed range from 2,000 feet to 20 feet. Average annual precipitation is around 50 inches ranging from 40 inches to 60 inches. The average frost-free period is about 280 days.

This watershed contains three general soil areas recognized on the basis of parent material, soil development, and physiography. In a large hill area in the west Laurelwood, Kinton, Cascade, and Delena soils are formed from loess. Soils on terraces formed from loess include Quatama, Helvetia, Aloha, and Huber. Newberg, Cloquato, Chehalis, Maytown, Wapato, Reed, Columbia, Burlington, and Sauvie occur on the floodplains.

Small Douglas-fir sawtimber and poles are the main forest type on the 45,600 acres of forest in this watershed. There is some large sawtimber in scattered fringes and small patches on the hill tops near the edges of the watershed. Hardwoods are found in dense stands along most streambanks and on some of the old cutover areas where they are competing with the conifers. The general appearance is one of thrifty pole stands with patches of brush scattered throughout the drainage.

Approximately 4,900 acres are used for agricultural crops. About 500 acres are under irrigation growing berries, vegetables, hay, and pasture. The nonirrigated 4,400 acres produce pasture, hay, berries, grain, fruit, nuts, and specialty crops. Around 950 acres are range, and 2,800 acres are grazed forest. There are approximately 250 farms in the Scappoose watershed.

Watershed Problems and Needs. Estimates show that 1,100 acres are flooded annually. Flooding occurs along the main stem of Scappoose Creek and in the lower reaches of North and South Scappoose Creeks. The town of Scappoose, roads, and bridges in the low areas are subjected to some flood damage. Cropland and crops suffer some damage by sediment and debris. Bank erosion occurs along portions of the creeks.

Approximately 3,000 acres of arable land need subsurface drainage.

An additional 5,000 acres are estimated as being suitable for irrigation. At present, there is a shortage of irrigation water from streams early in July and from wells and reservoirs by mid August. Three potential reservoir sites were investigated, two sites (index numbers 4 and 5) on North Scappoose Creek and one (index number 6) on a tributary to McNulty Creek. Total storage ranges from 7,000 acre feet to 25,000 acre feet depending on which site on North Scappoose Creek was developed. Irrigation water is also available from the Columbia River.

Opportunities under P. L. 566. Under present conditions and laws it appears that a project including flood protection, irrigation, land treatment, and recreation might be feasible.

Watershed C, Portland

Description. The Portland watershed in Columbia, Multnomah, and Clackamas Counties contains 155,200 acres. It is entirely in the Scappoose-Rainier, Sauvie Island, East Multnomah, South Clackamas, and North Clackamas Soil Conservation Districts. The watershed consists of the Willamette River downstream from Gladstone, Multnomah Channel, and miscellaneous small drainages entering the Columbia River from St. Helens upstream to the Fairview watershed. Elevations range from 10 feet on Sauvie Island to over 1,400 feet. Average annual precipitation varies from 36 inches to 50 inches. The average growing season is 280 days at Portland.

This watershed contains four general soil areas recognized on the basis of parent material, soil development, and physiography. The Portland Hills and the hills east of Milwaukie have soils formed from loess including Laurelwood, Kinton, Cascade, and Delena. A small area on the north terraces has Quatama, Helvetia, Aloha, and Huber soils formed from loess. In the Portland and Milwaukie area terrace soils, Hillsboro, Willamette, Woodburn, Amity, Dayton, Multnomah, Sifton, and Clackamas are formed from silty and gravelly material of Portland sands and gravels, Willamette silts, and Linn gravels. Camas, Newberg, Cloquato, Chehalis, Maytown, Wapato, Reed, Columbia, Burlington, Sauvie, and Mukilteo peat occur on the floodplains.

Approximately 16,000 acres in this watershed are timbered. Almost half is in Forest Park within the city limits of Portland. The remainder is also along the West Hills or on other hills and buttes in and near the city. The

West Hills area has a long history of logging and fire. Most of the timber and brush land is in areas unsuited to agriculture. Douglas-fir is found on the higher ground, and hardwoods (alder and maple) are found in the valley bottoms.

About 32,420 acres in 515 farms are used for agricultural production; this includes 26,020 acres of crops, 4,900 acres of range, and 1,500 acres of grazed forest. Approximately 5,810 acres of the cropland are irrigated producing pasture, hay, vegetables, and nursery crops. The nonirrigated cropland produces pasture, hay, grain, nursery, and vegetables.

Watershed Problems and Needs. The fire hazard in this area is great because of the extensive areas of brush and fern. Another problem associated with removal of cover and changes in runoff patterns concerns clearing hillside view lots and construction of homes, roads, and driveways. This black topping of the watershed accelerates runoff with its attendant problems.

Approximately 7,100 acres are flooded annually. Damages include sedimentation, debris deposits, crop limitations, riverbank cutting, and general debris deposition around ditches, fences, roads, bridges, and farm facilities. Diking, improved channels, channel clearing, and revetment are some of the needs in this watershed.

Estimates show that 6,200 acres of arable land needs surface and subsurface drainage and outlets.

It is estimated that 15,200 acres of additional land are suitable for irrigation. All but 200 acres could be irrigated from natural streamflow and underground water. One reservoir site (index number 7) was investigated in the Milwaukie area that could supply irrigation, industrial and municipal water, and recreational facilities.

Opportunities under P. L. 566. Because of the complexity and size of this area, a project does not appear to be feasible under existing conditions and laws. A project could be feasible in some portions of the area.

Watershed D, Fairview

Description. The Fairview watershed contains 15,600 acres in Multnomah County. It is entirely within the East Multnomah Soil Conservation District. The watershed consists mainly of Fairview Creek and some minor drainages terminating in drainage ditches of the Multnomah No. 1 Drainage District; it is an irregular area as shown in figure 22. Elevations range from 658 feet on Grant Butte to around 40 feet. Average annual precipitation varies from 40 inches to 46 inches with an average of about 43 inches. The average growing season is approximately 280 days.

This watershed contains two general soil areas recognized on the basis of parent material, soil development, and physiography. The soils on terraces including Multnomah are formed from silty and gravelly materials of Portland sands and gravels. Columbia, Burlington, and Sauvie occur on the floodplains.

Only 10 percent, 1,600 acres, of this watershed is forested. The stand is composed of young-growth Douglas-fir in scattered patches throughout the area. Quite frequently there are many houses found in the timber. The trend in this area is from timber land to homesites.

About 9,600 acres in 200 farms are used for agricultural production; this includes 7,000 acres of crops, 2,000 acres of range, and 600 acres of grazed forest. Approximately 5,000 acres of the cropland is irrigated producing vegetables, pasture, hay, berries, bulbs, and nursery crops. The non-irrigated cropland produces pasture, hay, vegetables, berries, bulbs, and nursery stock.

Watershed Problems and Needs. Approximately 200 acres are flooded annually with minor damage to cropland and irrigation and farm facilities. Major damage is to homes, roads, bridges, and other buildings. The high water table, a result of flooding, cause cropping problems and problems with sewage systems. Adequate channels would help to correct this problem.

Approximately 5,000 acres of arable land need surface and subsurface drainage and outlets. The improperly drained areas are detrimental to crops and cropping patterns.

Estimates show that 3,600 acres of additional land are suitable for irrigation. This acreage could be irrigated from natural streamflow and underground water.

This area is fast becoming urbanized. The water that flows off streets and roofs adds to the flooding and runoff problems and increases the quantity of water that must be handled by the pumps of the drainage district.

Opportunities under P. L. 566. An application for a watershed plan under P. L. 566 has been received and approved. It appears that a project including flood protection, drainage, and irrigation is feasible.

Watershed E, Johnson Creek

Description. The Johnson Creek in Multnomah and Clackamas Counties, a tributary of the Willamette River, contains 28,800 acres. It is entirely in the East Multnomah and North Clackamas Soil Conservation Districts. The creek flows in a westerly direction from the watershed divide with the Sandy River to its confluence with the Willamette River at Milwaukie. Elevations range from 25 feet to 1,060 feet. The average annual precipitation varies from 42 inches to 68 inches. The average growing season exceeds 250 days in the agricultural area.

This watershed contains four general soil areas recognized on the basis of parent material, soil development, and physiography. The hills have Laurelwood, Kinton, Cascade, and Delena soils formed from loess. A small area of upland soils includes Cazadero, Cottrell, Dubay, Carver, Bornstedt, and Powell which are formed from residuum from glacial and other material. The terrace soils are formed from silty and gravelly materials of Portland sands and gravels, Willamette silts, and Linn gravels and include Hillsboro,

Willamette, Woodburn, Amity, Dayton, Multnomah, Sifton, and Clackamas. Camas, Newberg, Cloquato, Chehalis, Maytown, Wapato, and Reed occur on the floodplains.

This suburban watershed has about 5,200 acres of forest land. The timber is mainly Douglas-fir, red alder, and big leaf maple. The alder and maple are found in dense stands along the streams while the Douglas-fir is found on drier sites. Most of the Douglas-fir is less than 21 inches in diameter and is found in rather large stands on the rougher ground at the southern edge of the watershed. The younger stands are receiving heavy competition from brush.

About 10,900 acres in 290 farms are used for agricultural production; this includes 6,800 acres of crops, 2,800 acres of range, and 1,300 acres of grazed forest. Approximately 2,200 acres of the cropland are irrigated producing berries, vegetables, hay, pasture, and nursery stock. The nonirrigated cropland produces pasture, hay, vegetables, berries, fruit, nuts, potatoes, and nursery crops.

Watershed Problems and Needs. Hillsides cleared for homesites, roads, and industry increase runoff and are increasing the flooding problems of the area.

Approximately 1,500 acres are flooded annually with considerable damage to houses and other buildings, roads, bridges, and fences. Land and irrigation facilities receive minor damage from silt, debris, and erosion. Channel clearing and rectification is badly needed in this watershed; the U. S. Corps of Engineers have an active project on various sections to a point above Gresham. Work is also needed on the upstream portions of this channel.

Estimates show that 6,000 acres of arable land need subsurface drainage and outlets.

About 1,000 acres of additional land are suitable for irrigation; half could be irrigated from existing flows and underground water. Water storage development is needed for the irrigated land after the first of August. Two reservoir sites (index numbers 8 and 9) with a total storage of 1,500 acre feet were investigated. There are additional smaller sites in the watershed that were not investigated.

Recreational development is also needed in this area.

Opportunities under P. L. 566. It appears that a project supplementing the U. S. Corps of Engineers project which would include flood protection, drainage, irrigation, and recreation would be feasible.

11. SANDY SUBBASIN

Watershed A, Bonneville

Description. The Bonneville watershed in northeast Multnomah County contains 46,970 acres. It is made up of small drainages, the major ones being Tanner Creek, Oneonta Creek, Multnomah Creek, and Bridal Veil Creek, all

draining into the Columbia River. This watershed is entirely within the East Multnomah Soil Conservation District. It extends from Rooster Rock to Bonneville Dam, a distance of about 18 miles along the Columbia River, and varies from about 2 miles to 7 miles in width. Elevations range from 4,056 feet on Larch Mountain to 50 feet. The watershed is mostly on higher ground with the creeks dropping over falls just before entering the Columbia River. The average annual precipitation ranges from 56 to over 100 inches. The average growing season exceeds 220 days.

This watershed contains three general soil areas recognized on the basis of parent material, soil development, and physiography. In most of the watershed soils are formed from residuum from igneous materials. The uplands have Cazadero, Cottrell, Powell, and other soils formed from residuum from glacial and other material. Columbia, Burlington, and Sauvie occur on the floodplains.

More than 41,000 acres in this watershed are forested, and 65 percent of it is within the Mount Hood National Forest. Mature Douglas-fir sawtimber is the dominant type, with minor amounts of western hemlock and noble fir. The timber is usually located on steep ground with a large area in the Columbia Gorge Recreation Area where it is valuable as scenery. There are several areas of nonstocked rock ledges included in the forest category. Outside the national forest the land is not so rugged, and the privately owned timber is being harvested more rapidly.

About 3,400 acres in 20 farms are used for agricultural production including 400 acres of crops, 1,800 acres of range, and 1,200 acres of grazed forest. Approximately 40 acres of the cropland are irrigated pasture and hay. The nonirrigated cropland produces pasture and hay.

Watershed Problems and Needs. Approximately 600 acres are flooded annually by the Columbia River with minor damage. The main damage is to crops due to the reduction of the period of use. The drainage problem is also minor as long as the land use remains pasture and range.

Approximately 100 acres of additional land are suitable for irrigation. Ground water and natural streamflow are adequate to supply the water requirements.

The main use of the river frontage along the Columbia River is for recreation.

Opportunities under P. L. 566. A project does not appear to be feasible under existing conditions and laws.

Watershed B, Bull Run River

Description. The Bull Run River watershed, a tributary of the Sandy River in Multnomah and Clackamas Counties, contains 89,400 acres. It is entirely within the East Multnomah and North Clackamas Soil Conservation Districts. The watershed is roughly triangular in shape and is approximately 17 miles in an east-west direction and 10 miles in a north-south direction. Elevation ranges from 320 feet to 4,500 feet. Average annual precipitation ranges from 76 inches to over 140 inches; the average at the Portland Water-

works is 86 inches at an elevation of 748 feet. The average growing season at the Waterworks is 216 days.

This watershed contains three general soil areas recognized on the basis of parent material, soil development, and physiography. In approximately three-fourths of the watershed soils are formed from residuum from igneous materials. Less than one-fourth of the watershed has soils formed from residuum from glacial and other material. The floodplain soils are formed in recent alluvium from residual hills and glacial material.

Ninety-seven percent, 86,800 acres, of this watershed is forested, and approximately 90 percent is located in the Mount Hood National Forest. Mature Douglas-fir is the dominant tree species with true firs found at higher elevations. When timber harvest was started, the following policy was adopted: "Success of the timber harvest depends upon success in maintaining unimpaired, clear flow of streams and rivers in the watershed." Because it is the source of water for Portland, this is probably the most intensively controlled watershed of its size in the state.

About 610 acres in 7 farms are used for agricultural production including 450 acres of crops and 160 acres of range. The primary crops are hay and pasture. Approximately 40 acres are irrigated.

Watershed Problems and Needs. The Bull Run River watershed is managed under an intensive program by the Forest Service to supply water for Portland. There is very little private ownership in the area, and problems from flooding, erosion, and drainage are very minor. There is no additional land suitable to be developed for irrigation.

Opportunities under P. L. 566. Under existing laws and conditions a project in this watershed does not appear to be feasible.

Watershed C, Sandy River

Description. The Sandy River watershed in Multnomah and Clackamas Counties, a tributary of the Columbia River, contains 237,030 acres and is entirely within the East Multnomah and North Clackamas Soil Conservation Districts. It varies from 2 to 18 miles in width and is approximately 42 miles in length. Elevations range from 11,245 feet on Mount Hood to 36 feet at Troutdale Airport. Average annual precipitation ranges from 46 inches to over 130 inches; the average at Zigzag is 74 inches at elevation 1,400 feet. The average growing season in the agricultural area is about 250 days.

This watershed contains four general soil areas recognized on the basis of parent material, soil development, and physiography. In the eastern and southern section soils are formed from residuum from igneous materials. In the western and northern section on uplands Cazadero, Cottrell, Dubay, Carver, Bornstedt, Powell, and other soils are formed from residuum from glacial and other material. In the north is a small area of Multnomah, Sifton, and other soils formed from silty and gravelly material of Portland sands and gravels. The floodplains of the Sandy River and its tributaries have soils formed in recent alluvium from residual hill and glacial material while the floodplains of the Columbia have Columbia, Burlington, and Sauvie soils formed in recent alluvium.

There are about 203,000 acres of forest and alpine land in this watershed. The forests vary from lush stream bottom hardwoods to very hardy, slow growing alpine firs. Between these extremes are some stands of very good mature Douglas-fir, western hemlock, western red cedar, and various true firs. This area has had a long history of fire. There is still a large area near Zigzag Mountain which was deforested by fire several years ago.

The upper end of this watershed (Mount Hood) is a heavily used recreation area. Roughly 88,000 acres of forest and alpine area are identified primarily with this use. In these areas timber harvest is restricted or modified according to the area classification.

About 26,830 acres in 380 farms are used for agricultural production including 12,730 acres of crops, 9,800 acres of grazed forest, and 4,300 acres of range. Approximately 2,300 acres of the cropland are irrigated producing vegetables, berries, pasture, hay, nursery, and specialty crops. The nonirrigated cropland produces the same crops. About 90 percent of the irrigated cropland is in Multnomah County.

Watershed Problems and Needs. There are areas where bank cutting by streams is a major problem. Attempts are being made to reduce this damage by use of riprap and retaining walls.

Approximately 2,000 acres flood annually, mostly near the mouth of the river. Erosion is not severe with some sedimentation occurring on range and pasture lands.

Approximately 10,000 acres of arable land need subsurface drainage and outlets.

Estimates show an additional 2,000 acres are suitable for irrigation. About 1,500 acres could be irrigated with ground water and natural streamflows, but 500 acres would require the storage of irrigation water. Three reservoir sites (index numbers 1, 2, and 3) with a total potential storage of about 7,500 acre feet were investigated. There are also recreational advantages.

Opportunities under P. L. 566. A project for the entire watershed appears to have little possibilities under existing conditions and laws. Some parts of the watershed may have better possibilities if considered separately.

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 Lower 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 39 percent of the basin that is in the Mount Hood National Forest. The U. S. Department of Interior is responsible for the administration of about 2 percent of the area. Therefore, the Federal Government is directly responsible for the administration of approximately 41 percent of the Lower 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.

The Bureau of Reclamation is authorized at the public request to locate, construct, operate, and maintain works for storage, diversion, and development of waters for the reclamation of arid and semiarid lands in the Western States. Projects constructed by the Bureau should be coordinated with other land and water developments 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 secure a diminishment of mutual problems instead of their compoundment. Notable coordination has occurred and should be continued. This coordination 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 Lower Willamette River Basin.