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WILLAMETTE BASIN

COMPREHENSIVE STUDY

Water and Related Land Resources

APPENDIX G

LAND MEASURES AND WATERSHED PROTECTION

WILLAMETTE BASIN TASK FORCE - PACIFIC NORTHWEST RIVER BASINS COMMISSION

1969

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The WILLAMETTE BASIN

COMPREHENSIVE STUDY of

Water and Related Land Resources

APPENDIX G

LAND MEASURES AND WATERSHED PROTECTION

WILLAMETTE BASIN TASK FORCE - PACIFIC NORTHWEST RIVER BASINS COMMISSION

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CREDITS

This is one of a series of appendices to the Willamette Basin Comprehensive Study main report. Each appendix deals with a particular aspect of the study. The main report is a summary of information contained in the appendices plus the findings, conclusions and recommendations of the investigation.

This appendix was prepared by the Land Measures and Watershed Protection Committee under the general supervision of the Willamette Basin Task Force. The committee was chaired by the Soil Conservation Service and included representation from the agencies listed below:

U. S. Forest Service

Bureau of Land Management

Bureau of Outdoor Recreation

Oregon State University

Bureau of Reclamation

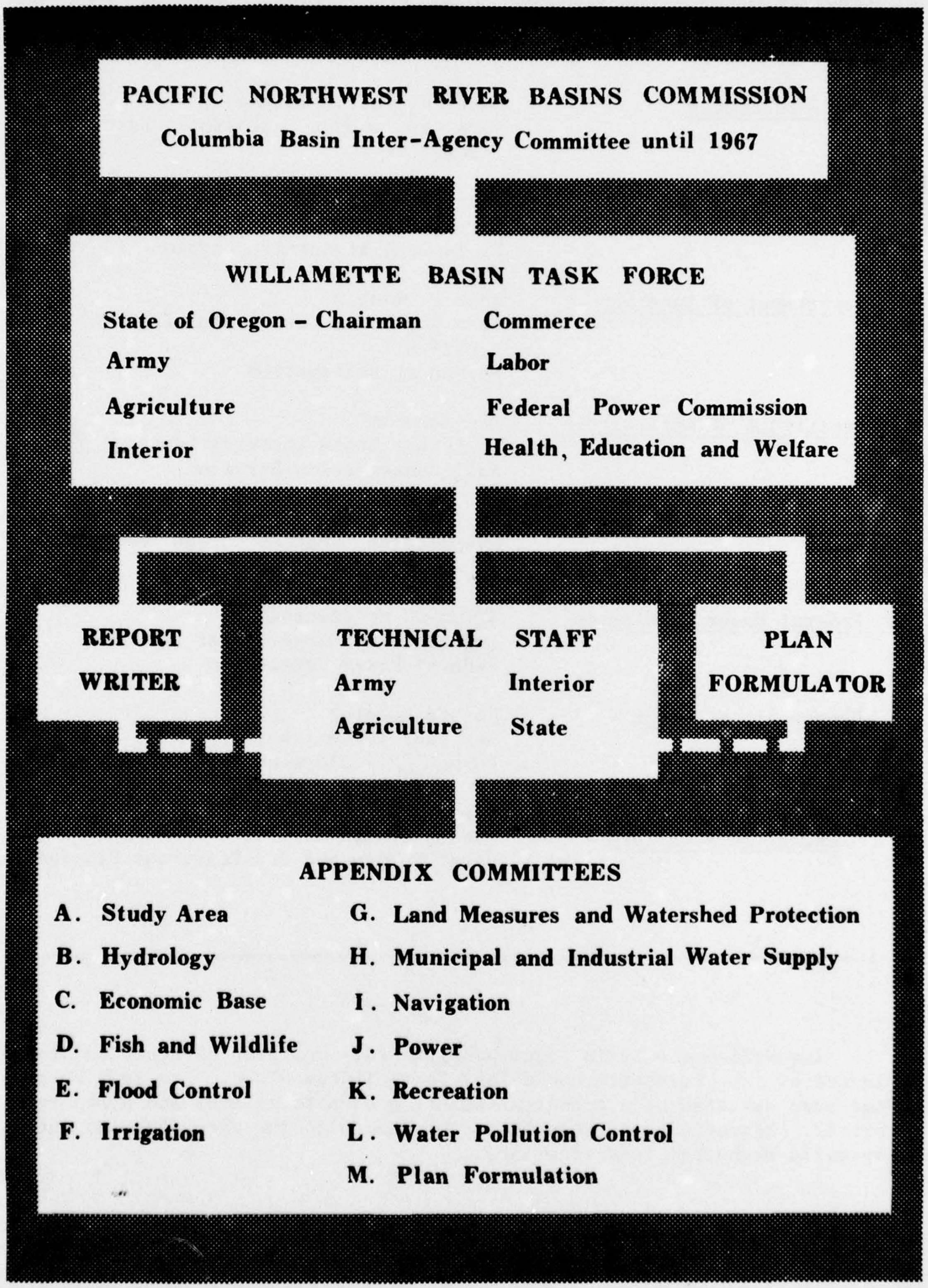
Oregon State Board of Forestry

Federal Water Pollution Control Administration

Bureau Sport Fisheries and Wildlife

Bureau of Commercial Fisheries

ORGANIZATION



WILLAMETTE BASIN TASK FORCE

State of Oregon	Donel J. Lane, Chairman Director, Oregon State Water Resources Board
Department of Army	Henry Stewart Chief, Planning Branch U. S. Army Engineers, Portland District
Department of Interior	John F. Mangan Area Engineer, Lower Columbia Development Office Bureau of Reclamation
Department of Agriculture	Oke Eckholm Assistant State Conservationist Soil Conservation Service
Department of Commerce	David J. Bauman Hydrologist, Weather Bureau Forecast Center
Federal Power Commission	Allan J. Meadowcroft Engineer-in-Charge, River Basins Federal Power Commission
Department of Labor	Horace Harding Regional Economist Bureau of Employment Security
Department of Health, Education & Welfare	Francis L. Nelson Public Health Service Water Supply and Sea Resources Program

The Willamette Basin Comprehensive Study has been directed and coordinated by the Willamette Basin Task Force listed above. The Task Force has been assisted by a technical staff, a plan formulator and a report writer. Appendix committees listed on the following page, carried out specific technical investigations.

APPENDIX COMMITTEES

Appendix-Subject		
A - Study Area	OSWRB - Chairman:	FWPCA, USBPA, USBLM, USBM, USBOR, USBR, USBSF&WL, USCE, USERS, USFS, USGS, USNPS, USSCS, OSDC, OSDF, OSDG&MI, OSS&WCC, OSU
B - Hydrology	USGS - Chairman:	FWPCA, USBPA, USBR, USCE, USSCS, USWB, OSE, OSWRB
C - Economic Base	USCE - Chairman:	FWPCA, USBPA, USBCF, USBM, USBOR, USBR, USBSF&WL, USDL, USERS, USFS, OSDC, OSU, UO, PSC-PR&C
D - Fish & Wildlife	USBSF&WL - Chairman:	FWPCA, USBCF, USBLM, USBOR, USCE, USDA, USFS, USGS, USSCS, OSFC, OSGC, OSWRB, USHEW
E - Flood Control	USCE - Chairman:	FWPCA, USBR, USDA, USGS, USSCS, USWB, OSDC, OSE, OSWRB, UO
F - Irrigation	USBR - Chairman:	USSCS, OSDC, OSWRB, OSU
G - Land Measures and Watershed Protection	USSCS - Chairman:	FWPCA, USBCF, USBLM, USBOR, USBR, USBSF&WL, USFS, OSU
H - M&I Water Supply	FWPCA - Chairman:	USBR, USBSF&WL, USGS, USSCS, OSBH, OSDC, OSWRB, USHEW
I - Navigation	USCE - Chairman:	OSDC, OSMB, POP, OSU
J - Power	USBPA - Chairman:	FPC, FWPCA, USBCF, USBR, USCE, USFS, USGS, OSE, OSWRB
K - Recreation	USBOR - Chairman:	FPC, FWPCA, USBLM, USBSF&WL, USCE, USFS, USNPS, USSCS, OSBH, OSDC, OSFC, OSGC, OSHD-PD, OSMB, OSWRB, LCPD, OCPA, USHEW
L - Water Pollution Control	FWPCA - Chairman:	USBCF, USBLM, USBOR, USBR, USBSF&WL, USGS, USSCS, OSBH, OSE, OSFC, OSGC, OSWRB, OSU, USHEW
M - Plan Formulation	Plan Formulator - Chairman:	USCE, USDA, USDI, OSWRB

FPC - Federal Power Commission
FWPCA - Federal Water Pollution Control Administration
USBPA - Bonneville Power Administration
USBCF - Bureau of Commercial Fisheries
USBLM - Bureau of Land Management
USBM - Bureau of Mines
USBOR - Bureau of Outdoor Recreation
USBR - Bureau of Reclamation
USBSF&WL - Bureau of Sport Fisheries and Wildlife
USCE - Corps of Engineers
USDA - Department of Agriculture
USHEW - Department of Health, Education and Welfare
USDI - Department of Interior
USDL - Department of Labor
USERS - Economic Research Service
USFS - Forest Service
USGS - Geological Survey
USNPS - National Park Service
USSCS - Soil Conservation Service
USWB - Weather Bureau

OSBH - Oregon State Board of Health
OSDC - Oregon State Department of Commerce
OSDF - Oregon State Department of Forestry
OSDG&MI - Oregon State Department of Geology and Mineral Industries
OSE - Oregon State Engineer
OSFC - Fish Commission of Oregon
OSGC - Oregon State Game Commission
OSHD-PD - Oregon State Highway Department - Parks Division
OSMB - Oregon State Marine Board
OSS&WCC - Oregon State Soil and Water Conservation Committee
OSWRB - Oregon State Water Resources Board
OSU - Oregon State University
PSC-PR&C - Portland State College - Center for Population Research and Census Service
UO - University of Oregon
LCPD - Land County Parks Department
OCPA - Oregon County Parks Association
POP - Port of Portland

BASIN DESCRIPTION

Between the crests of the Cascade and Coast Ranges in northwestern Oregon lies an area of 12,045 square miles drained by Willamette and Sandy Rivers--the Willamette Basin. Both Willamette and Sandy Rivers are part of the Columbia River system, each lying south of lower Columbia River.

With a 1965 population of 1.34 million, the basin accounted for 68 percent of the population of the State of Oregon. The State's largest cities, Portland, Salem, and Eugene, are within the basin boundaries. Forty-one percent of Oregon's population is concentrated in the lower basin subarea, which includes the Portland metropolitan area.

The basin is roughly rectangular, with a north-south dimension of about 150 miles and an average width of 75 miles. It is bounded on the east by the Cascade Range, on the south by the Calapooya Mountains, and on the west by the Coast Range. Columbia River, from Bonneville Dam to St. Helens, forms a northern boundary. Elevations range from less than 10 feet (mean sea level) along the Columbia, to 450 feet on the valley floor at Eugene, and over 10,000 feet in the Cascade Range. The Coast Range attains elevations of slightly over 4,000 feet.

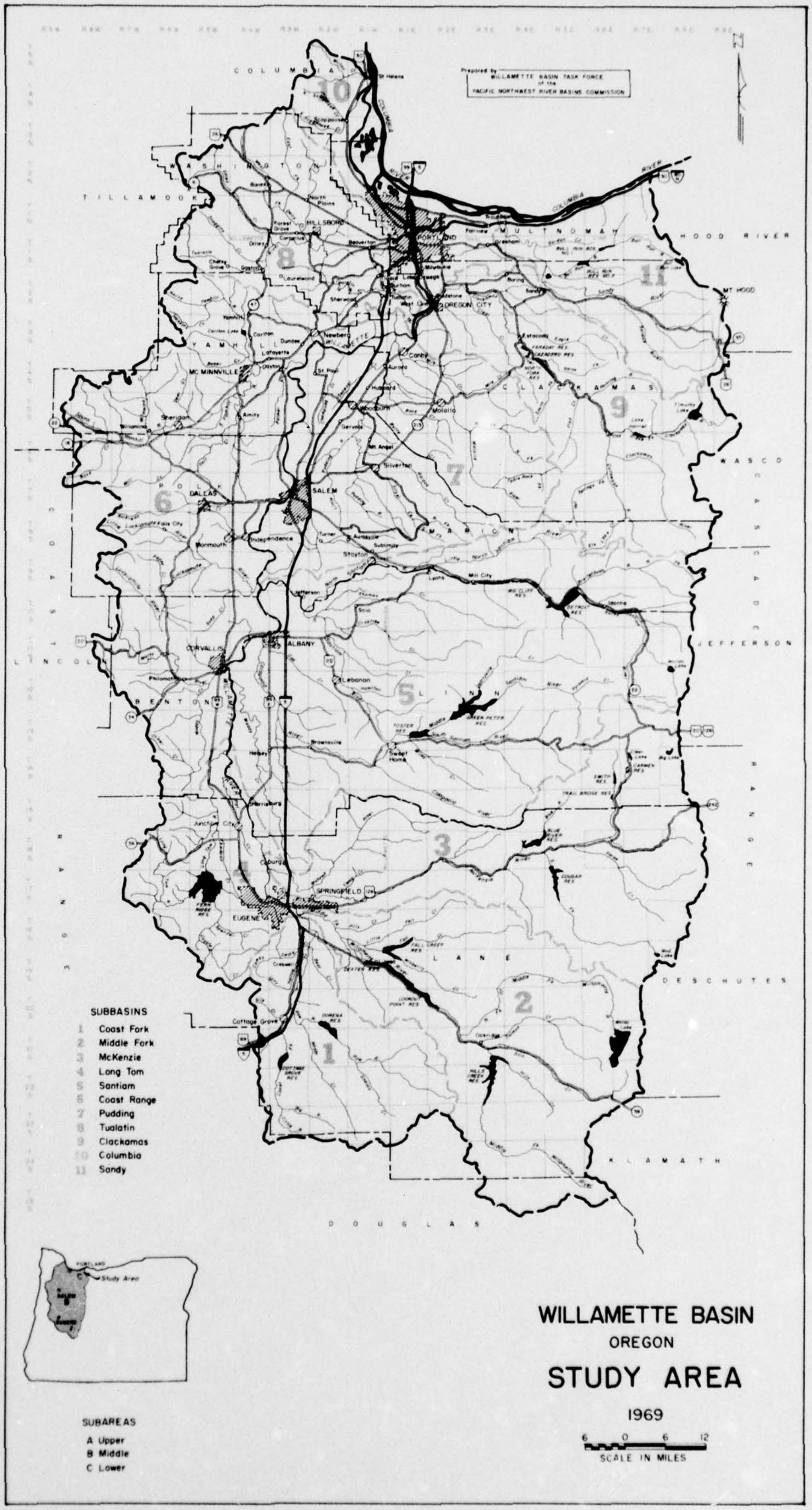
The Willamette Valley floor, about 30 miles wide, is approximately 3,500 square miles in extent and lies below an elevation of 500 feet. It is nearly level in many places, gently rolling in others, and broken by several groups of hills and scattered buttes.

Willamette River forms at the confluence of its Coast and Middle Forks near Springfield. It has a total length of approximately 187 miles, and in its upper 133 miles flows northward in a braided, meandering channel. Through most of the remaining 54 miles, it flows between higher and more well defined banks unhindered by falls or rapids, except for Willamette Falls at Oregon City. The stretch below the falls is subject to ocean tidal effects which are transmitted through Columbia River.

Most of the major tributaries of Willamette River rise in the Cascade Range at elevations of 6,000 feet or higher and enter the main stream from the east. Coast Fork Willamette River rises in the Calapooya Mountains, and numerous smaller tributaries rising in the Coast Range enter the main stream from the west.

In this study, the basin is divided into three major sections, referred to as the Upper, Middle, and Lower Subareas (see map opposite). The Upper Subarea is bounded on the south by the Calapooya Mountains and on the north by the divide between the McKenzie River drainage and the Calapooia and Santiam drainages east of the valley floor and by the Long Tom-Marys River divide west of it. The Middle Subarea includes all lands which drain into Willamette River between the mouth of Long Tom River and Fish Eddy, a point three miles below the mouth of Molalla River. The Lower Subarea includes all lands which drain either into Willamette River from Fish Eddy to its mouth or directly into Columbia River between Bonneville and St. Helens; Sandy River is the only major basin stream which does not drain directly into the Willamette.

For detailed study, the three subareas are further divided into 11 subbasins as shown on the map.


Prepared by WILLAMETTE BASIN TASK FORCE of the PACIFIC NORTHWEST RIVER BASINS COMMISSION
COLUMBIA
TILLAMOOK
WASHINGTON
MULTNOMAH
HOOD RIVER
YAMHILL
CLACKAMAS
POLK
MARION
WASCO
LINCOLN
BENTON
LINN
JEFFERSON
LANE
DESCHUTES
KLAMATH
DOUGLAS
COAST RANGE
CASCADE RANGE
PORTLAND
OREGON CITY
HILLSBORO
McMINNVILLE
SALEM
DALLAS
CORVALLIS
ALBANY
EUGENE
SPRINGFIELD
MT HOOD
SUBBASINS
1 Coast Fork
2 Middle Fork
3 McKenzie
4 Long Tom
5 Santiam
6 Coast Range
7 Pudding
8 Tualatin
9 Clackamas
10 Columbia
11 Sandy
SUBAREAS
A Upper
B Middle
C Lower
Study Area
WILLAMETTE BASIN
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STUDY AREA
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SCALE IN MILES

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INTRODUCTION

PURPOSE AND SCOPE

The Land Resources and Watershed Protection Appendix is designed to [illegible] measures that modify land and water resources use to avoid impairment of the environment and to repair physical damage already done. These general goals involve the prevention of excessive erosion, control of flood and sediment damages and improvement of quantity and quality of water runoff. The opportunity for increasing [illegible] on lands having problems of drainage, flooding, lack of irrigation water, or lack of adequate management systems [illegible] for agriculture and forest lands.

The primary purpose of the appendix is to identify measures and programs that insure [illegible]

[illegible] quality of the agricultural and forest environment [illegible] maintained or enhanced by modifying present use to [illegible] long term resource capability.

[illegible] resource base ([illegible] water, vegetation) is capable of [illegible] [illegible]

[illegible]

[illegible]

[illegible]

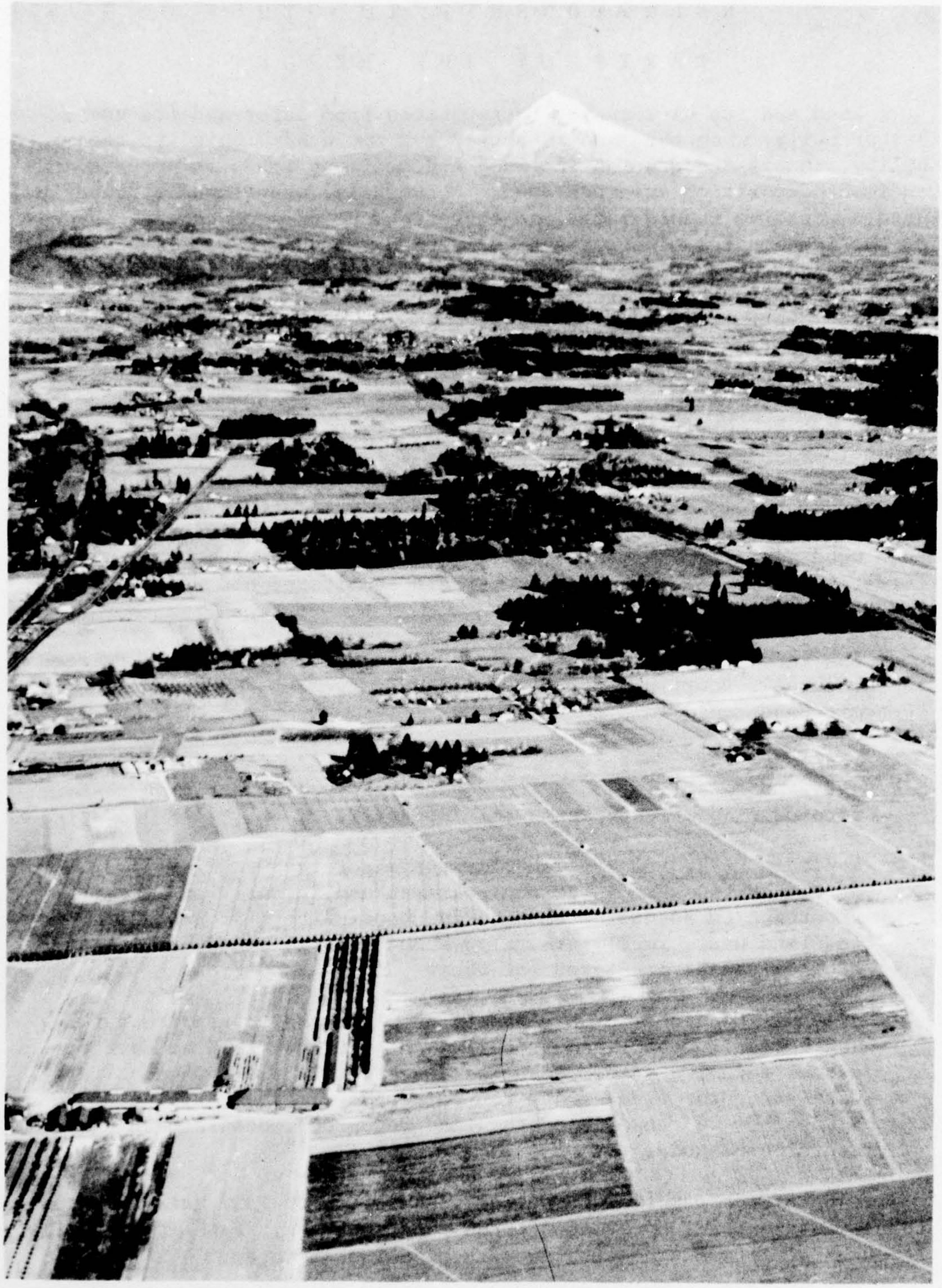

Photo I-1. Whatever happens on Willamette Basin land affects quantity, quality or use of the water resource. Multnomah County looking east toward Mt. Hood. (SCS Photo B-465-4)

RELATIONSHIP TO OTHER PARTS OF THE REPORT

Land and its uses cannot be separated from water and its uses. Historically, when the land is abused and not used within its capability, runoff and erosion increase and sediment loads in streams and sediment deposition are increased. Conversely, when land is properly used, excessive runoff rates and the attendant damages can be reduced or the frequencies of occurrence held to a reasonable level. Changes in the quantity, quality and distribution of water relate directly to other appendices of the report.

Forest land uses and treatment practices either directly or indirectly affect all water uses and related land resource activities in the Willamette Basin. Current forest watershed management programs may or may not be compatible with the water uses delineated in the other appendices. Emphasis in this appendix is towards improvement of the capability of the watershed to produce good water for meeting the many downstream uses. Alternative forest land management programs are analyzed wherein water production may be the primary consideration rather than wood fiber or other use. All competing and complementary uses for forest land and its effects on water are considered and related to water use demands.

The Land Measures and Watershed Protection Appendix G is related to the three supporting Appendices A, Study Area; B, Hydrology; and C, Economic Base, only in a general way.

Appendix A--Study Area--contains the land use inventory, soils and land capability data and forest land use information that were developed in depth in this appendix.

Appendix B--Hydrology--contains the water resource inventory of the basin. Precipitation patterns and intensities are important in assessing changes in runoff with different soils and land use. Total streamflow amounts by location and season of flow can be predicted for these varying conditions.

Appendix C--Economic Base--contains a forecast of agricultural and forest industry manufacturing outputs, but limited data on actual resource uses. There is a negligible use of agricultural data since the nine-county economic study area was evaluated in Appendix C rather than the land resources contained in the hydrologic basin.

Each of the functional appendicies deals with land uses affected to some degree by land treatment and land measures. This is primarily through quantity and quality and distribution of water.

Appendix D--Fish and Wildlife--Manipulation of vegetative cover and soil disturbance can modify, destroy or enhance fish and wildlife environment. Debris and sediment in streams bars fish passage, reduces water flow, depletes oxygen content, increases sediment loads and increases water temperatures often above that suitable for sport fish. Fish spawning areas can be destroyed by sediments resulting from abusive farming or by poor logging or road building methods. Areas may erode to the extent that their value as wildlife habitat is reduced. On the other hand, planned crop and timber harvest systems may permit habitat improvement by providing needed cover, water and vegetative growth to sustain or increase wildlife populations.

Appendix E--Flood Control--Land use and land treatment have a material influence on flooding--its effects and its control. Upstream the problem is primarily on forest lands. Improper logging and streambank management leave logs and debris which move out during storms and block channels, lodge against bridges and other structures and litter valley bottom farmlands and roads with logs, stumps and other debris which must be removed. It is vital that forest and agriculture lands subject to flooding be in adequate vegetative cover to avoid severe soil loss. Frequent flooding in the smaller tributaries can be reduced by maintaining a good vegetative cover on the watershed. The combined effects of improved cover on several tributaries can reduce peak flows during the lesser storms on even the major streams. Critical area stabilization is needed to protect expensive structural investments against debris accumulation, siltation and physical damage.

Appendix F--Irrigation--Irrigation is highly dependent upon land drainage in most areas of the basin. Drainage, in turn, may be dependent first on adequate flood control. Irrigation may be necessary on some lands before it will pay to drain them. These major problems then are very closely related with many interdependencies. Excessive amounts of silts and debris clog ditches, pipes, spray nozzles, reduce capacity of storage reservoirs, interfere with operation of entrance gates to canals and pumping stations and increase the cost of operation and maintenance of irrigation projects and systems.

Appendix H--Municipal and Industrial Water Supply--Forested watersheds are the major source of supply for the municipal and industrial water for the cities of the Willamette Basin. Soil or site disturbance during road building, logging or farming in the lower elevations may affect the water quality. Muddy water from abusive land use pollutes streams and creates problems in filtering water supplies for urban areas and has serious adverse impacts on industries needing high quality water.

Appendix I--Navigation and Appendix J--Power--These appendicies are not closely related. Navigation is affected, however, if sediment must be dredged from the channels. Power generation is affected if reservoir storage is reduced by sediment. The abrasive effect of sediment on turbines may be a significant factor.

Appendix K--Recreation--The forested mountains provide one of the greatest outdoor recreational attractions to the people of the basin. Munipulation of the forest cover can enhance or destroy recreation values. Increasing recreational use is also being made of agricultural lands--farm pond construction has provided many new opportunities for recreation focus. Land measures are needed to develop, restore or to protect the lovely views of some areas. Other measures protect the purity of the water for recreational enjoyment. Still other measures guarantee that the watershed is protected from excessive contamination due to the sheer bulk of more uses.

Appendix L--Water Pollution Control--Land management activities can affect the taste, color and temperature of water or result in chemical contamination. Because water quality is directly related to forest, agricultural or other land management, protective and remedial measures assist in meeting the water quality standards set by the State of Oregon.

The relationship of land measures to all other functions of multipurpose resource development is covered in detail in the Plan Formulation Appendix. Information from the Land Measures and Watershed Protection Appendix provides a background and an inventory of physical alternatives for the land measures discussion in the main report.

H I S T O R Y

AGRICULTURAL LAND MEASURES

The threat of floods along the Willamette and major tributaries and the large land areas with restricted drainage in the main valley floor set the pattern for the early agricultural development of the Willamette Valley. Evidence of recurring floods and wetness caused early settlers to pass up the fertile flood plains in favor of the then open foot slopes of the hills. The grassy main valley floor prairies were inaccessible during the late fall, winter and early spring months because of the interspersed wet lands.

The hill soils, though not subject to flooding or severe wetness, were found to have some limitations due to shallowness, low natural fertility and acidity. Crop production was largely limited to wheat and other cereals harvested as either hay or grain. There was little opportunity for a crop rotation for the general farmer. The rolling hills were plowed in late fall or winter preparatory to early spring seeding. Thus, much of the land was unprotected during winter months. Erosion in some places was severe.

A summer fallow system of farming was adopted to reduce depletion of natural fertility. Under this system, fair yields of grain were maintained for a while by cropping in alternate years with summer fallow in between. However, soil erosion continued to be severe.

Photo I-2. Soil losses reduce productivity and contribute to sediment loads in streams. (SCS Photo 0-1802-5)

A major justification for the Oregon Agricultural Experiment Station (established in 1887) was the recognized need for the development of a system of farming that would eliminate summer fallow. It was not until the early 1900's that techniques for growing clover, vetch and other legumes had developed to a point where rotation of crops replaced the summer fallow system. In the meantime, some areas of the shallower, steeper hill soils had been abandoned and reverted to brush and trees.

Despite this early history of depleted production on the hill lands, agriculture in the basin as a whole continued to expand and intensify. Wheat production moved from the hills to the better drained areas of the valley floor. Cropping systems were developed to permit utilization of the fertile alluvial soils subject to annual floods. By 1915, summer fallow production of grain on the hill soils had been largely replaced by a crop rotation, including legume hay to support a growing dairy industry.

Beginning about 1910, a valley-wide orchard boom left another permanent erosive scar on Willamette Valley hill lands. Thousands of acres of orchards, largely apples and prunes, were established. Part of the development was promotional; low priced land was purchased and orchards were established with the intent of selling small tracts of producing orchards. Many tracts were sold, but few became productive. Individual farmers followed the trend and set out orchards, particularly prunes, on land that was recognized as being too shallow and infertile to produce grain. Largely clean cultivated, orchards tended to suffer serious erosion and to be permanently damaged, as were the summer fallow grain lands.

A major change in land use began to take place in the early 1930's that reversed the trend of soil depletion and erosion losses on many hill soils of the basin. This was the development of the seed industry. Through the 1930's, the production of hairy vetch for seed largely replaced grain production on general farms in the hills. It was necessary that hairy vetch be seeded in the fall. This provided a cover during the rainy season. The straw was left on the land following harvest, adding organic matter. On the deeper, more fertile soils, Austrian winter peas were produced in a similar manner. As markets for hairy vetch and winter peas dwindled, much of the same land was used for production of perennial grass seed, a crop that provides cover over most of the year.

Bottom lands along the Willamette and its major tributaries have undergone considerable change in the past 50 years. Natural vegetation was removed and the cleared land was used for general farming. With the development of irrigation, this area now supports an important share of the fruit, berry and vegetable processing industry. It likewise supports specialty crop production, including mint, hops and certain seed crops. A large part of the area was severely damaged during the record floods of December 1964 and January 1965. There was severe loss of soil on areas that were not adequately protected by cover crops, and a great monetary expense resulted from the deposition of logs and other debris. It is not known how much the extensive clearing of these bottom lands has aggravated flood damage, though obviously development has created greater potential for damage.

Drainage is a special land measure and constitutes one of the greatest problems in the basin. With the development of farming in the valley floor areas, drainage improvements were made by farmers working alone and in cooperation with neighbors. Many shallow, surface outlet ditches were constructed primarily to carry water away from substantial areas of Dayton and Amity soils. Farmers had learned that fair crops could be grown on these soils by shaping the fields into lands, or beds, separated by shallow ditches at intervals of 60 to 70 feet. These practices were followed until the 1930's, when ryegrass and other wetland grasses replaced alsike clover, oats and other cereals on the wetter lands. As the seed industry developed, beds were leveled because they interfered with the operation of heavy power equipment.

Early farmers' efforts at drainage were not adequate to solve the serious problem of providing outlets for major wet land areas. Poor surface drainage was further complicated by recurring floods from nearby streams. There is evidence of attempts to construct outlet channels by hand or with horses and scrapers for extensive areas of poorly drained land south of Salem in Linn, Benton and Lane Counties. Some of these channels have grown up with trees and now serve no useful purpose. Others, such as Sodom Ditch and Spoon Creek in Linn County, were somewhat self-maintaining and are now generally accepted as natural stream channels.

While removal of surface water was of major importance, farmers learned that some lands had suitable outlet for subsurface drainage. On these lands, production could be increased and a greater selection of crops could be grown by installing underground pipes or conduits, commonly known as drain tile, at depths of 2 to 5 feet below the ground surface. This early interest in subsurface drainage led to establishment of a tile factory at Scholls in Washington County, which has operated continuously since 1870. Drainage work accomplished in the early years was substantial. At least six tile factories have operated continuously in the Willamette Basin for more than 50 years.

Technical and financial assistance available through the Department of Agriculture has substantially aided the application of the drainage program in the past 25 years. Drainage improvement is a major part of the work of the Soil and Water Conservation Districts which now cover most of the valley. Records show that under these programs, 67 million feet of open and closed drains were installed between 1937 and 1963. About 430,000 acres have been partially or totally drained. Oregon State University and the Agricultural Experiment Station have conducted drainage research for a number of years. This work is documented in various publications and reports and has had a major influence on the installation of tile drainage in the basin.

Photo I-3. Major drainage outlets are often necessary before on-farm drainage can function. Clackamas County near Butteville. (SCS Photo 0-1211-2)

FOREST LAND MEASURES

Fire seems to have been the greatest disruptive element destroying watershed values throughout the history of the Willamette Basin. Fire interferes with the normal hydrologic functions of the forest through removal of the protective vegetation, burning the litter and mulch soil cover, and destroying soil humus. Erosion is prevalent in badly burned areas, contributing both sediment and ash to streams. Not only does water quality suffer, but the entire ecological habitat of a forest is changed by fire.

Early settlers considered the trees a "weed" and burned many acres of timber in clearing land for cultivation, for livestock grazing, and to remove vegetation to expose mineral ore. For almost a century, the supply of timber was considered inexhaustible and little effort was made to protect it. The 1865 Silverton fire burned a million acres of watershed and covered the surrounding country with ashes to a depth of 5 inches. Heat was so great that it dried up Silver and Abiqua Creeks which were streams large enough for driving logs to the mill. Until 1920, fires were commonplace on logged-over lands and little effort was made to control them.

The loss of life and property from uncontrolled fire finally became a public concern in Oregon, resulting in creation of the State Board of Forestry in 1907. Federal support for forest fire protection came with passage of the Weeks Law of 1911. An effective fire control program did not develop, however, until Congress passed the Clarke-McNary Act of 1924 which brought much needed funds for fire control to private as well as State forest lands. Existing forest fire control organizations and new methods of attacking fires have reduced the possibility for occurrence of catastrophic fires. However, State law encourages burning of slash after logging. Slash fires often become hot enough to affect hydrologic site factors such as soil structure and infiltration capacity by destruction of organic matter and soil cover. Fire caused by lightning and by man's acts have been and will continue to be with us.

Historically, timber harvesting is second only to fire in its effect on the sediment yields of the watersheds. It is generally accepted that forest cover, water runoff, erosion and percolation are interrelated, particularly in regions of rough topography, as is found in the Cascades and Coast Range.

The first powered sawmill in Oregon was built at Oregon City in 1832. The first steam powered mill was built at Portland in 1850 and commercial logging was underway. Due to the large size of the trees and lack of roads or railroads, the first transportation of logs was by water. Trees along the bank were felled directly into the water. Those back from the shore were felled, limbed, and put into the water by the use of hand jacks and then towed to the mill. As logging moved away from the rivers, the gulches and gullies were cleared of vegetation, and skid trails were built down which the logs were dragged by yokes of

Photo I-4. Fire damage to protective forest cover. Sediment production can increase 250 times that of an undisturbed area. (SCS Photo 0-2180-13) oxen. These became sluiceways for the erosive action of winter and spring runoff, and sedimentation problems multiplied. The early steam donkey engines yarded the logs downhill, plowing incipient stream channels and gullies as they came. Subsequent adoption of high lead logging from a spar tree did much to alleviate these problems.

Of all the timber harvest actions affecting water quality, transportation of the logs to the mill has created the most problems. Along with the early "skid roads" were the splash dams in the streams for floating the logs to the mill. These were an elaborate system of log dams on the rivers to back up water sufficient to provide the flow needed to carry the logs downstream. The man-made flood caused by instantaneous removal of the splash dams, tore and scoured the river banks and its protective vegetation, increasing the silt load of the water and leaving the area more susceptible to future erosion. When logging railroads replaced water transportation, water quality impairment continued in the form of washing and erosion of the many cuts and fills along the freshly built rights-of-way. Fire danger was increased both from cinders from the locomotive and sparks from brake shoes on the steel wheels.

The advent of trucking as the major method of hauling logs has not lessened the forest management problem in protection from transportation effects. Not only is there soil disturbance during road construction, but the more or less impervious road surface accelerates water runoff. Roadside slopes may be too steep or lack treatment measures to prevent washing, and fill material is sometimes placed directly into natural channels.

Up until World War II, little thought or action was given to sustained yield timber management on private lands. Huge areas were cut over without regard for a second crop of trees. The general practice was to let the land revert to the county as tax delinquent as soon as the timber was harvested. No effort was made to protect the watershed since the land itself was deemed to have no value. This was changed by World War II which brought a huge demand for timber. Stumpage prices rose to a level which made sustained yield timber management economically feasible. Large timber companies increased their forest holdings, began intensive forest management and took needed measures to protect the site.

The flood of Christmas 1964 demonstrated the "off site" damage caused by the accumulation in stream channels of logging slash plus debris from unlogged areas. Logs and debris jammed against bridges and caused many of them to wash out. After the flood subsided, some farm lands and roads on the flood plain were scattered with logs and stumps which had to be removed. Watershed practices that kept logging trash away from stream channels could have greatly reduced these problems.

Another aspect of forest management is related to recreation. Since World War II there has been a constantly increasing demand for outdoor recreational use of the forested areas of the Willamette Basin.

The result has been an accelerating need for sanitation measures for protection of the watershed and water quality. Over the years, public and private forest managers have attempted to meet this problem by developing and maintaining recreational sites to better control the use.

Photo I-5. *Rolling fields, bales of hay, oak woodlands south of Salem.* (Oregon State Highway Dept. Photo)

The soils, topography and water relationships of land influence its potential both as a resource and as a problem source. How that land is used now and in the future determines the extent of this [illegible]-based potential. To clarify the relationship of land and water consider the following statement in the Interdepartmental Staff Committee of Water Resources Council Memorandum for Guidelines for Framework Studies [illegible]:

Related land is:

1. Shore land

on which present and projected use or [illegible] would cause significant effects on the quantity and/or quality of the water resources;

2. and that land

the use and management of which is significantly affected by the demands on the quantity and proposed measures for managing, development aspects of the water resources.

[illegible]

agriculture

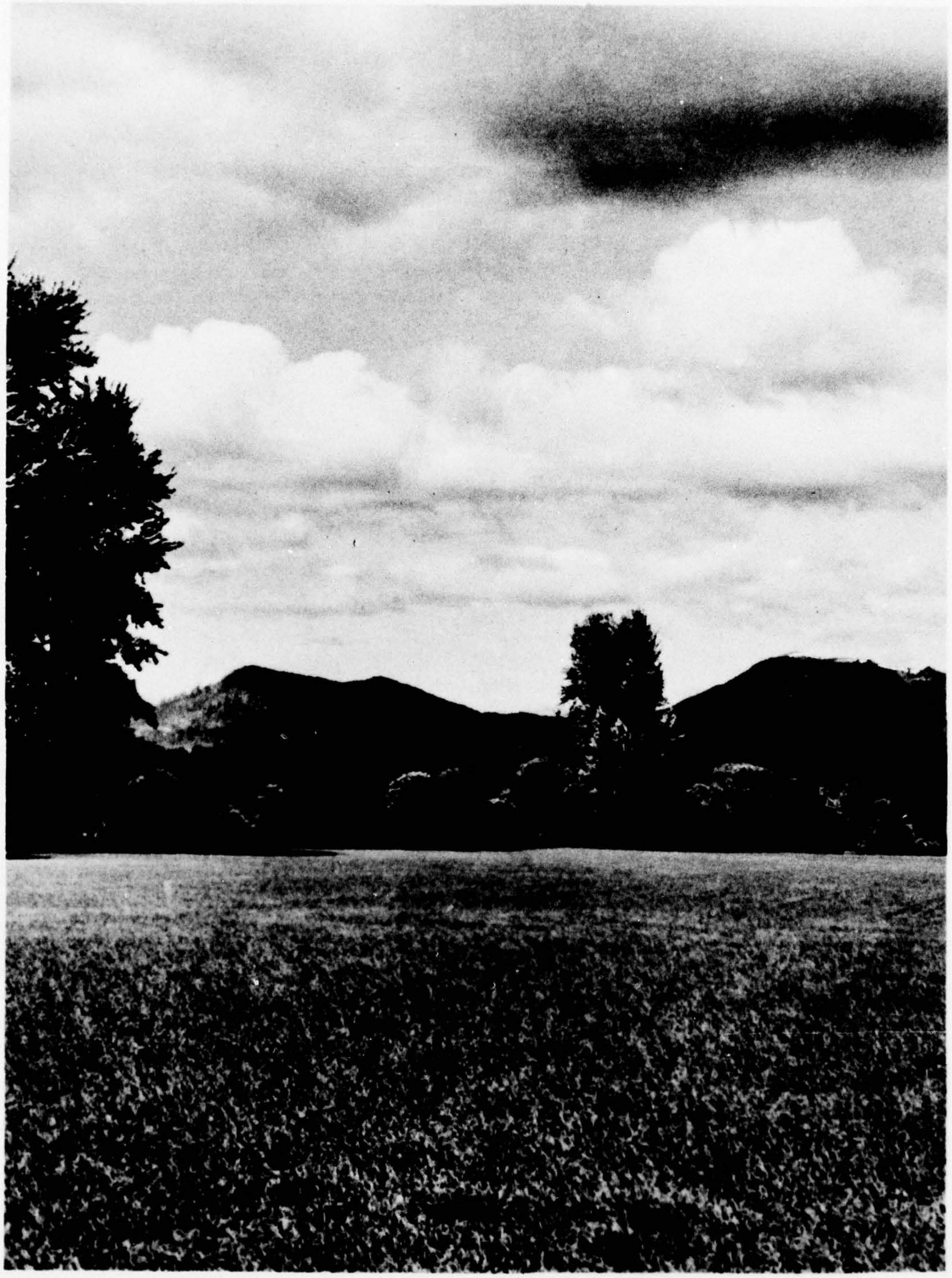

Photo II-1. Forest and agriculture resources combine in a scene typical of the Coast Range - Kings Valley, Benton County. (Oregon State Highway Dept. Photo)

Watershed protection and required land treatment measures are based on the soil, its capability and limitations, and the use being made of the land. These agricultural land characteristics are the basis for the present status of the conservation land measures currently being applied to the land.

S O I L S

Soil, the surface mantle that can be penetrated by roots and water, is basic because it is the source for growing food and fiber. It serves as a storage reservoir for plant food and water. Soil consists of about 45 percent mineral matter, 5 percent organic matter, 25 percent air space, and under optimum conditions for plant growth 25 percent water. Of course, the air and water content of soils are interrelated and the relative amounts are continually changing. The nature and distribution of soils depends on climate, vegetation, parent material, topography and time. The interaction among these factors results in a soil having a unique set of properties. In most cases, the factors themselves are interdependent and not necessarily balanced. For example, the influence of topography on climate; the close association of major vegetation types with climate; and the relationship between topographic position and age of soil or kind of parent material. Many factors of the environment can be inferred from soil characteristics. Basic soil characteristics are the building blocks for soil classification units (soil series). Soil associations as shown on Map II-1 are combinations of classification units combined into practical segments suited to the scale of the map and the detail of consideration. They include only soils that are intermingled or adjacent in the landscape.

Soil series are in the lowest category of the natural system of soil classifications and each series consists of soils essentially uniform in differentiating characteristics, including depth, texture, structure, sequence and arrangements of horizons. Soil series used to define each association as shown in Table II-1 and on Map II-1 were chosen to portray the range of contrast as well as the dominant composition of the landscape. The information in the tables includes mainly the factors important to the use and management of land in the basin. Soil associations are generalized from, and consistent with, descriptions and definitions of soils at the state, county or survey area level. Many of the series that characterize soil associations here are benchmark soils, many are defined in published reports, and many have complete physical, chemical and engineering characterization. In summary, the soil associations in this report define soil areas that are:

1. Associated in the landscape.

2. Referrable directly to the field level of detail when more information is needed.

3. Important to cropland, rangeland, forest land, and "other" uses in the Willamette Basin.

Evaluation of the soil is based upon standard Land Capability interpretative groupings in use by the Soil Conservation Service, relating soil characteristics and qualities to soil behavior and response to management.

Map II-1 is the Soil Association Map for Willamette Basin. It shows the location and relative extent of each soil association in the basin. The associations are numbered in a general relationship to position in the landscape--bottomlands and low terraces have the lowest numbers and alpine areas on mountain tops have the highest numbers. The name of each association relates to the soil series representing general kinds of soils that are most extensive in the landscape. Wherever possible, established soil series are used in the name; however, where the soil series have not been established they are identified with an asterisk. Up to 15 percent of any single soil association may consist of inclusions of soils other than those identified. Such inclusions may be similar soils or they may be highly contrasting.

Table II-1 contains information about each soil association shown on the map. Land characteristics, qualities and some interpretations of the soil series representing the dominant and the contrasting kinds of soils in each association are shown. Table II-1a shows the estimated acreage and proportionate extent of the soil associations for the Willamette Basin. Other interpretations of the capability of the soil are shown in Maps II-2 through 5.

Interpretation Map, II-2, shows soil associations having broad similarities in kinds of parent material in which they are formed. It relates the soils somewhat to the geology of the area, the soil depth and the physiography.

Interpretation Map, II-3, shows broad soil areas with general similarities in the amount of gravel, cobbles and stones in the soil profile. Presence of these is important to the water-holding capacity, permeability of the soil, use of the land, and to many other practical implications of land management.

Interpretation Map, II-4, shows soil associations having general similarities in the rate at which water will run through the soil profile. This is particularly important to sewage disposal and the use of the soil for a filter field or a sewage lagoon type of disposal system. Of course, this map is generalized so specific projects would need more detailed investigation.

Interpretation Map, II-5, shows groups of soil associations that have generally similar suitability for cropland use. This is a composite evaluation of all the characteristics and qualities of the land and soil.

Photo II-2. Garden peas being harvested by specially built harvesters near Woodburn, Oregon. (SCS Photo 0-2386-8)

Table II-1

Characteristics and Qualities of Soils

Soil groups	Soil association: Map symbol	Elevation (Feet)	Precip. (Inches)	Freeze-free season (Days)	Major land use	Classification: Subgroup	Family
Very deep, loamy soils on nearly level bottom lands.	1a	30-300	38-55	200-212	Cropland (cereals, vegetables, tree fruits, cane fruits, forage crops, and specialty crops) - dryland and irrigated	Cumulic Ultic Haploxerolls	Fine-silty, mixed, mesic
						Cumulic Ultic Haploxerolls	Coarse-silty, mixed, mesic
						Fluventic Haplaquolls	Fine-silty, mixed, noncalcareous, mesic
						Fluventic Haploxerolls	Coarse-loamy, mixed, mesic
	1b	0-100	30-45	200-215	Cropland (vegetables, cane fruits, strawberries, nursery crops, and pasture)-irrigated	Fluventic Haplaquolls (Typic)	Fine-silty, mixed, noncalcareous, mesic
					(cereals, fruit and nut orchards, and pasture) - dryland	Cumulic Ultic Haploxerolls	Coarse-silty, mixed, mesic
Deep and moderately deep, loamy and gravelly soils on nearly level to gently sloping Willamette Valley terraces.	2a	150-400	40-45	210-212	Cropland (forage crops, cereals and grass seed)	Aquultic Argixerolls	Fine-silty, mixed, mesic
						Argiaquic Xeric Argialbolls	Fine-silty, mixed, mesic
						Typic Albaqualfs	Fine, montmorillonitic, mesic
	2b	150-400	40-45	210-212	Cropland (cereals, vegetables, cane berries and forage crops)-dryland and irrigated	Ultic Argixerolls	Fine-loamy over sandy or sandy-skeletal, mixed, mesic
						Umbric Vitrandepts	Ashy over sandy-skeletal, mixed, mesic
						Typic Argiaquolls	Fine-loamy, mixed, noncalcareous, mesic
Deep and moderately deep, silty soils on gently to strongly sloping foothills and uplands.	3a	250-1,600	40-70	140-200	Cropland(cereals, fruit orchards, berries, and forage crops) - dryland	Typic Haplohumults	Clayey, mixed, mesic
					Rangeland	Ultic Haploxeralfs	Fine-loamy, mixed, mesic
					Forest land		
						Aquultic Haploxerolls	Very fine, mixed, mesic

1 & 2/ See footnotes at end of table.
**Soil series names not presently established.*

Representative contrasting soils of the associations

Series [1]	Percentage [2] of association	Position on landscape	Parent material	Soil characteristics: Texture surface soil	Texture subsoil	Aggregate: Kind	Aggregate: Percent	Profile depth	Permeabilit[y] subsoil
Chehalis	30	Flood plains (high positions)	Alluvium	Silty clay loam	Silty clay loam	None	--	60"+	Moderate
Cloquato*	25	Flood plains (low positions)	Alluvium	Silt loam	Silt loam	None	--	60"+	Moderate
Wapato	25	Flood plains (depressions)	Alluvium	Silty clay loam	Silty clay loam	None	--	60"+	Moderately slow
Newberg	10	Flood plains (low positions)	Alluvium	Sandy loam	Sandy loam	Gravel	0-15 in profile	60"+	Rapid
Sauvie	50	Flood plains (gently rolling and hummocky)	Alluvium	Silt loam	Silty clay loam	None	--	20-30" over seasonal water table	Moderately slow
Cloquato*	30	Flood plains and low terraces	Alluvium	Silt loam	Silt loam	None	--	60"+	Moderate
Woodburn*	70	Terraces (high positions)	Alluvium	Silt loam	Silt clay loam	None	--	60"+	Moderately slow
Amity	20	Terraces (low positions)	Alluvium	Silt loam	Silty clay loam	None	--	60"+	Moderately slow
Dayton	4	Terraces (depressions)	Alluvium	Silt loam	Clay	None	--	10-24" over clayey subsoil	Very slow
Salem	60	Terraces	Alluvium	Gravelly silt loam	Gravelly clay loam	Gravel and sand	20-50 above 15-30"; 85 below 15-30"	15-30" over gravel and sand	Moderate
Sifton	30	Terraces	Alluvium	Gravelly loam	Gravelly loam	Cobbles and gravel	20-50 above 16-24"; 50-90 below 16-24"	20-40" over gravel	Moderately rapid
Clackamas	3	Terraces	Alluvium	Gravelly loam	Gravelly clay loam	Cobbles and gravel	20-50 above 20-36"; 50-90 below 20-36"	20-40" over compact gravel	Moderately slow
Peavine*	50	Uplands (high foothills)	Colluvium and residuum from sedimentary rock	Silty clay loam	Silty clay	None	--	20-40" over fractured bedrock	Moderately slow
Willakenzie*	40	Uplands (low foothills)	Colluvium and residuum from sedimentary rock	Silty clay loam	Silty clay loam	None	--	20-40" over bedrock	Moderately slow
Hazelair*	5	Uplands (foot slopes on low foothills)	Alluvium and residuum from sedimentary rock	Silty clay loam or silt loam	Clay	None	--	20-40" over fractured bedrock	Slow

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Table II - 1

Profile depth	Permeability subsoil	Permeability substratum	Drainage class	Total available water-holding capacity	Major capability subclass Dryland	Irrigated	Major soil problems	Suitable land treatment and structures
				Soil qualities and interpretations				
60"+	Moderate	Moderately slow	Good	High	I, IIw	I, IIw	Fertility and organic matter maintenance. Occasional high water table.	Residue management; irrigation management
60"+	Moderate	Moderate	Good	High	IIw	IIw	Flooding	Flood protection; winter cover; residue mgmt; irrigation mgmt
60"+	Moderately slow	Moderately slow	Poor	High	IIIw	--	Flooding; seasonal high water table	Flood protection; drainage; residue management; cropping sequence; irrigation management
60"+	Rapid	Rapid	Somewhat excessive	Medium	IIw	IIw	Flooding	Flood protection; residue management; winter cover; irrigation management
20-30" over seasonal water table	Moderately slow	Slow	Somewhat poor	High	IIw, IIIw	IIw, IIIw	Flooding; high water table	Flood protection; drainage; residue management; cropping sequence; irrigation management; diking
60"+	Moderate	Moderate	Good	High	IIw	IIw	Flooding	Flood protection; residue management; winter cover; irrigation management
60"+	Moderately slow	Moderately slow	Moderately good	High	IIe, IIw, IIIe	IIe, IIw, IIIe	Erosion; wetness	Cross-slope operations; residue management; cropping sequence; subsurface tillage; drainage; irrigation mgmt.
60"+	Moderately slow	Moderately slow	Somewhat poor	High	IIw	IIw	High water table in winter and spring	Drainage; residue management; cropping sequence; irrigation management
10-24" over clayey subsoil	Very slow	Moderately slow to very slow	Poor	Medium	IIIw, IVw	IIIw, IVw	Perched water table over subsoil during rainy season	Drainage; residue management bedding; irrigation management
15-30" over gravel and sand	Moderate	Very rapid	Good	Low	IIs	IIs	Shallow and moderately deep over gravel and sand; gravelly profile	Residue management; irrigation management
20-40" over gravel	Moderately rapid	Rapid	Good	Low	IIs, IIIs	IIs, IIIs	Gravelly and cobbly profile	Residue management; irrigation management
20-40" over compact gravel	Moderately slow	Very slow to impervious	Somewhat poor	Low and medium	IIIw	IIIw	High water table during rainy season; gravelly and cobbly profile	Drainage; residue management irrigation management
20-40" over fractured bedrock	Moderately slow	Slow to impervious	Good	Medium	IIIe, IVe, VIe, VIIe	--	Erosion; moderately deep over bedrock; clayey subsoil	Cross-slope opers; residue mgmt; cropping sequence; pastureland mgmt; forest land mgmt;restrict logging oper during prolonged wet period
20-40" over bedrock	Moderately slow	Slow to impervious	Good	Medium and high	IIIe, IVe, VIe, VIIe	--	Erosion; moderately deep and deep over bedrock	Same as above
20-40" over fractured bedrock	Slow	Slow to impervious	Moderately good and somewhat poor	Medium and low	IIIe, IVe	--	Erosion; moderately deep over bedrock; clay subsoil	Cross-slope operations; residue management; cropping sequence; subsurface tillage pastureland management

Table II-1
Characteristics and Qualities of Soils

Soil groups	Soil Association: Map symbol	Elevation Feet	Precip. Inches	Freeze-free season Days	Major land use	Classification: Subgroup	Family	Series 1/	Percentage 2/ of association	Position on landscape
	3b	300-1,200	40-60	190-200	Cropland (forage crops, fruit orchards, cane berries, and grass seed)-dryland	Xeric Haplohumults	Clayey, mixed, mesic	Jory*	70	Uplands (rolling foothills)
					Forest land	Xeric Haplohumults	Clayey, mixed, mesic	Nekia*	20	Uplands (rolling to steep foothills)
						Lithic Ultic Haploxerolls	Loamy-skeletal, mixed, mesic	Witzel*	3	Upland (steep foothills)
	3c	450-1,200	45-80	180-200	Cropland (horticultural crops, forage crops, and cereals)-dryland	Ultic Haploxeralfs	Fine, mixed, mesic	Casadero*	50	Terraces (long and smooth)
						Ultic Haploxeralfs	Fine-silty, mixed, mesic	Bornstedt*	30	Terraces(slight depressions and footslopes)
	3d	100-1,500	40-70	190-212	Cropland (fruit orchards, berries, forage crops and cereals)-dryland	Typic Fragiocrept	Fine-silty, mixed, mesic	Kinton*	35	Uplands (slight depressions and footslopes)
					Forest land	Aquic Fragiumbrepts	Fine-silty, mixed, mesic	Cascade	30	Uplands (rolling foothills and ridges)
						Ultic Haploxeralfs	Fine-silty, mixed, mesic	Laurelwood*	20	Uplands (long convex slopes)
Moderately deep, loamy soils on strongly and steeply sloping lower mountainous uplands.	4a	500-2,000	60-70	170-190	Forest land	Typic Dystrochrepts	Fine, mixed, mesic	Melby*	50	Uplands (rolling and hilly)
						Typic Haplohumults	Fine-loamy, mixed, mesic	Olyic*	35	Uplands (rolling and hilly)
	4b	800-3,500	55-90	120-190	Forest land	Typic Haplumbrepts	Fine, mixed, mesic	McCully*	50	Uplands (moderately steep)
					Cropland (grass seed, cereals, and forage crops)-dryland	Andic Haplumbrepts	Fine-loamy, mixed, mesic	Kinney*	30	Uplands (moderately to steeply sloping)
	4c	750-1,200	60-80	180-200	Forest land	Typic Haplohumults	Clayey, mixed, mesic	Peavine*	40	Uplands (high footslopes)
						Typic Haplumbrepts	Loamy-skeletal, mixed, mesic	Klickitat*	30	Uplands (steep slopes)
						Typic Haplohumults	Clayey, mixed, mesic	Honeygrove*	15	Uplands (footslopes)
						Typic Haplumbrepts	Fine-loamy, mixed, mesic	Bohannon*	10	Uplands (ridgetops and steep slopes)

1 & 2/ See footnotes at end of table.

* *Soil series names not presently established.*

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Representative contrasting soils of the associations

Percentage[2/] of association	Position on landscape	Parent material	Texture surface soil	Texture subsoil	Aggregate Kind	Aggregate Percent	Profile depth	Permeability subsoil
70	Uplands (rolling foothills)	Colluvium from basic igneous rock	Silty clay loam	Clay	Gravel, cobbles and stones	0-20 in profile	40-60"+ over bedrock	Moderate
20	Uplands (rolling to steep foothills)	Basic igneous rock	Silty clay loam	Clay	Gravel, cobbles and stones	0-20 in profile	20-40" over bedrock	Moderate
3	Upland (steep foothills)	Basic igneous rock	Very stony silty clay loam	Very stony silty clay loam	Cobbles & stones	50-90 in profile	10-20" over bedrock	Moderate
50	Terraces (long and smooth)	Old alluvium	Silty loam	Silty clay loam to silty clay	Cobbles and gravel	20-50 below 36"	60"+	Moderate and moderately slow
30	Terraces (slight depressions and footslopes)	Old alluvium	Silt loam	Silty clay loam	None	--	40-60" over clayey material	Moderate
35	Uplands (slight depressions and footslopes)	Loess-like	Silt loam	Silty clay loam	None	--	20-40" to slightly compacted fragipan	Moderately slow
30	Uplands (rolling foothills and ridges)	Loess over old alluvium	Silt loam	Silty clay loam	None	--	20-40" to fragipan	Slow
20	Uplands (long convex slopes)	Loess	Silt loam	Silty clay loam	None	--	60"+	Moderate
50	Uplands (rolling and hilly)	Colluvium and residuum from sedimentary rock (siltstone and shale)	Silt loam	Silty clay	None	--	30-60" over sedimentary bedrock	Moderately slow
35	Uplands (rolling and hilly)	Colluvium and residuum from basic igneous rock	Silt loam	Silty clay loam	None	--	40-60" over basalt bedrock	Moderate
50	Uplands (moderately steep)	Basic igneous rock	Clay loam	Clay	Cobbles and gravel	0-15 in profile	60"+	Moderate
30	Uplands (moderately to steeply sloping)	Basic igneous rock	Cobbly loam	Cobbly clay loam	Cobbles and gravel	20-50 in profile	36-60" over breccia bedrock	Moderate
40	Uplands (high footslopes)	Colluvium and residuum from sedimentary rock (sandstone and shale)	Silty clay loam	Silty clay	None	--	20-40" over fractured bedrock	Slow
30	Uplands (steep slopes)	Basic igneous rock	Loam	Cobbly clay loam	Cobbles	20-50 below 10" in profile	20-40" over bedrock	Moderate
15	Uplands (footslopes)	Sedimentary rock (sandstone)	Silty clay loam	Silty clay	None	--	40-60"+ over bedrock	Moderately slow
10	Uplands (ridgetops and steep slopes)	Sedimentary rock (sandstone and shale)	Gravelly loam	Gravelly loam	Gravel	20-50 in profile	20-40" over bedrock	Moderate

Table II - 1

Soil qualities and interpretations

Permeability substratum	Drainage class	Total available water-holding capacity	Major capability subclass Dryland	Irrigated	Major soil problems	Suitable land treatment and structures
Moderately slow	Good	High	IIe, IIIe, IVe, VIe	--	Erosion on strong slopes	Cross-slope opers; residue mgmt; cropping sequence; irrig mgmt; forest land management
Impervious	Good	Medium and high	IIIe, IVe, VIe	--	Erosion on moderate and strong slopes	Cross-slope opers; residue mgmt; cropping sequence; irrig mgmt; forest land mgmt; pastureland mgmt
Impervious	Good	Low	VIs	--	Shallow over bedrock; stony profile	Forest land management; pastureland management
Moderately slow	Good	Medium	IIe, IIIe, IVe	--	Erosion	Cross-slope operations; residue management; cropping sequence; pastureland management
Slow	Moderately good	Medium to high	IIw, IIIe, IVe	--	Erosion; wetness	Cross-slope operations; residue mgmt; cropping sequence; drainage; pastureland mgmt
Moderate to moderately slow	Moderately good	High	IIIe, IVe, VIe	--	Erosion; wetness	Cross-slope opers; residue mgmt; cropping sequence; drainage; forest land mgmt; pastureland management
Very slow to impervious	Somewhat poor	High	IIIe, IVe, VIe, VIIe	--	Erosion; wetness	Cross-slope opers; residue mgmt; cropping sequence; drainage; forest land mgmt; pastureland mgmt
Moderate	Good	High	IIe, IIIe, IVe, VIe	--	Erosion	Cross-slope opers; residue mgmt; cropping sequence; forest land mgmt; pastureland management
Impervious	Good	Medium and high	VIe, VIIe	--	Erosion on steep slopes; acid soil; restricted trafficability	Forest land management; restrict logging operation during prolonged wet periods
Impervious	Good	Medium and high	VIe, VIIe	--	Erosion on steep slopes	Forest land management
Moderately slow	Good	High	IIe, IIIe, IVe, VIe, VIIe	--	Erosion; clayey profile; acid soil	Forest land management; cross-slope opers; residue mgmt; cropping sequence; soil amends; pastureland mgmt
Impervious	Good	Low and medium	VIs, VIIs	--	Erosion; cobbly profile; acid soil	Forest land management
Slow to impervious	Good	Medium	IVe, VIe	--	Erosion; moderately deep over bedrock; clayey subsoil	Forest land mgmt; restrict logging during prolonged wet periods
Impervious	Good	Low	VIe, VIIe	--	Erosion; moderately deep over bedrock; cobbly subsoil; acid soil	Forest land management
Impervious	Good	Medium and high	IVe, VIe	--	Erosion; acid soil	Forest land mgmt; restrict logging during prolonged wet periods
Impervious	Good	Low	VIe, VIIe	--	Erosion; moderately deep over bedrock; gravelly profile; acid soil	Forest land management; restrict logging during prolonged wet periods

Table II-1
Characteristics and Qualities of Soils

Soil groups	Soil Association: Map symbol	Elevation Feet	Precip. Inches	Freeze-free season Days	Major land use	Classification: Subgroup	Family
Moderately deep and shallow, stony loamy soils on moderately to very steeply sloping mountainous uplands.	5a	300-1,500	35-125	140-225	Forest land	Andic Haplumbrepts	Fine, mixed, mesic
						Typic Haplumbrepts	Fine-loamy, mixed, mesic
						Lithic Haplumbrepts	Loamy-skeletal, mixed, mesic
	5b	1,000-6,000	50-80	100-200	Forest land	Andic Dystrochrepts	Coarse-silty, mixed, mesic
						Typic Haplumbrepts	Loamy-skeletal, mixed, mesic
	5c	750-1,500	60-80	180-200	Forest land	Typic Haplohumults	Clayey, mixed, mesic
						Typic Haplumbrepts	Fine-loamy, mixed, mesic
Shallow and miscellaneous soils on steeply and very steeply sloping high mountainous uplands.	6a	2,500-6,000	70-90	80-120	Forest land	Typic Cryorthods	Coarse-loamy, mixed, ort
						Entic Cryumbrepts	Loamy-skeletal, mixed
						Typic Cryorthods	Loamy-skeletal, mixed
						Typic Cryorthods	Coarse-loamy, mixed
	6b	6,000-11,243	100-200	0-60	Other land	--	--
						Typic Cryorthods	Coarse-loamy, mixed

1/ *Differences of total percentage in each soil association from 100 per cent are inclusions of other soils and land types.*

2/ *Each soil series is a key soil that represents other soil series having similar characteristics and qualities. Blank spaces mean that a soil series has not been established in the given family and subgroup of an association.*

3/ *Miscellaneous land type.*

* *Soil series names not presently established are identified with an asterisk.*

			Representative contrasting soils of the associations						
				Soil characteristics					
Series [1/]	Percentage [2/] of association	Position on landscape	Parent material	Texture surface soil	Texture subsoil	Aggregate Kind	Aggregate Percent	Profile depth	Permeabil[illegible] subsoil
Astoria	70	Uplands (moderately steep slopes)	Sedimentary rock (siltstone or shale)	Silty clay loam or silt loam	Silty clay loam and silty clay	None	--	40-100" over bedrock	Moderate
Hembre*	20	Uplands (steep slopes and tabletop ridges)	Basic igneous rock	Gravelly loam and silt loam	Gravelly loam and silty clay loam	Gravel, cobbles & stones	20-50 in profile	36-60"+ over bedrock	Moderate
Kilchis	10	Uplands	Basic igneous rock	Stony loam	Very gravelly silt loam	Stones, cobbles, and gravel	20-90 in profile	12-20" over bedrock	Moderate
Bull Run*	50	Uplands (footslopes)	Loess, basic igneous rock	Silt loam	Silt loam	None	--	60"+	Moderate
Aschoff*	20	Uplands (footslopes)	Glacial till of basalt and andesite rocks	Stony silt loam	Stony clay loam	Stones	20-50 in profile	60"+	Moderate
Honeygrove*	45	Uplands (footslopes)	Sedimentary rock (sandstone)	Silty clay loam	Silty clay	None	--	40-60"+ over bedrock	Moderately slow
Bohannon*	35	Uplands (ridgetops and steep slopes)	Sedimentary rock (sandstone and shale)	Gravelly loam	Gravelly loam	Gravel	20-50 in profile	20-40" over bedrock	Moderate
Whetstone*	20	Uplands (moderate to steep slopes)	Colluvium and till over basic igneous rock	Stony sandy loam	Stony loam	Stones	20-50 in profile	40-60" over bedrock	Moderate
Henline*	20	Uplands (steep slopes)	Colluvium and till over basic igneous rock	Very stony sandy loam	Very stony sandy loam	Stones	50-90 in profile	30" over bedrock	Rapid
Sisi*	20	Uplands (steep slopes)	Glacial till of basic igneous origin	Gravelly loam	Very stony loam	Stones, cobbles, and gravel	50-90 in profile	40-100"+ over bedrock	Moderate
Lastance*	20	Uplands (steep slopes)	Glacial till of basic igneous origin	Gravelly fine sandy loam	Gravelly fine sandy loam	Stones, cobbles, and gravel	20-50 in profile	40-100"+ over bedrock	Moderately rapid
Rock land [3/]	70	Uplands (steep mountains)	Igneous rock	--	--	--	--	Less than 10" over bedrock	--
Timberline*	10	Uplands (mountain slopes)	Aeolian sands over till and basic igneous rock	Sandy loam	Fine sandy loam	None	--	20-40" over bedrock	Moderately rapid

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Table II - 1

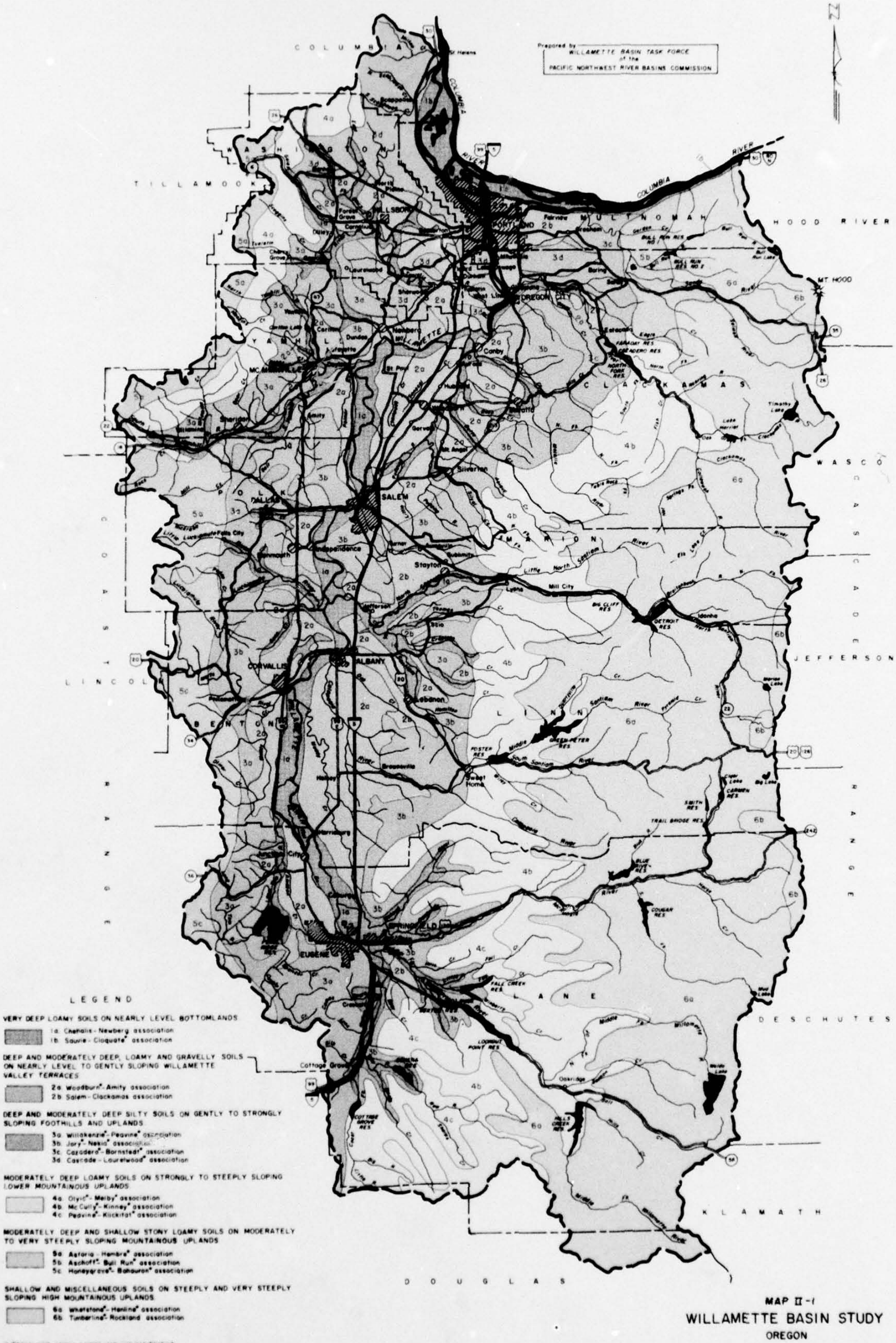
Soil qualities and interpretations

...ent	Profile depth	Permeability subsoil	Permeability substratum	Drainage class	Total available water-holding capacity	Major capability subclass Dryland	Irrigated	Major soil problems	Suitable land treatment and structures
	40-100" over bedrock	Moderate	Slow to impervious	Good	Medium and high	VIe	--	Erosion; acid soil	Forest land management; restrict logging during prolonged wet periods
n	36-60"+ over bedrock	Moderate	Impervious	Good	Low and medium	VIe, VIIe	--	Erosion; acid soil	Forest land management
n	12-20" over bedrock	Moderate	Impervious	Good	Low	VIIs	--	Shallow over bedrock; stony and gravelly profile; acid soil	Forest land management
	60"+	Moderate	Moderate	Good	High	IIIe, IVe VIe, VIIe	--	Erosion	Forest land management
n	60"+	Moderate	Moderate	Good	Medium	IIIe, IVe, VIe, VIIe	--	Erosion; stony profile	Forest land management
	40-60"+ over bedrock	Moderately slow	Impervious	Good	Medium and high	IVe, VIe	--	Erosion; acid soil	Forest land management; restrict logging during prolonged wet periods
n	20-40" over bedrock	Moderate	Impervious	Good	Low	VIe, VIIe	--	Erosion; moderately deep over bedrock; gravelly profile; acid soil	Forest land management; restrict logging during prolonged wet periods
n	40-60" over bedrock	Moderate	Impervious	Good	Medium	VIs, VIIs	--	Erosion; stony profile; acid soil	Forest land management
n	30" over bedrock	Rapid	Impervious	Good	Low	VIs, VIIs	--	Moderately deep over bedrock; stony profile	Forest land management
n	40-100"+ over bedrock	Moderate	Moderate	Good	Medium	VIs, VIIs	--	Erosion; stony profile; steep slopes	Forest land management
in	40-100"+ over bedrock	Moderately rapid	Moderately rapid	Good	Low	VIIs	--	Erosion; steep slopes	Forest land management
	Less than 10" over bedrock	--	Impervious	Good	Low	VIIIs	--	Shallow over bedrock; steep slopes	--
	20-40" over bedrock	Moderately rapid	Impervious	Good	Low	VIIs, VIIIs	--	Moderately deep over bedrock; acid soil; cold climate	--

Table II-1a

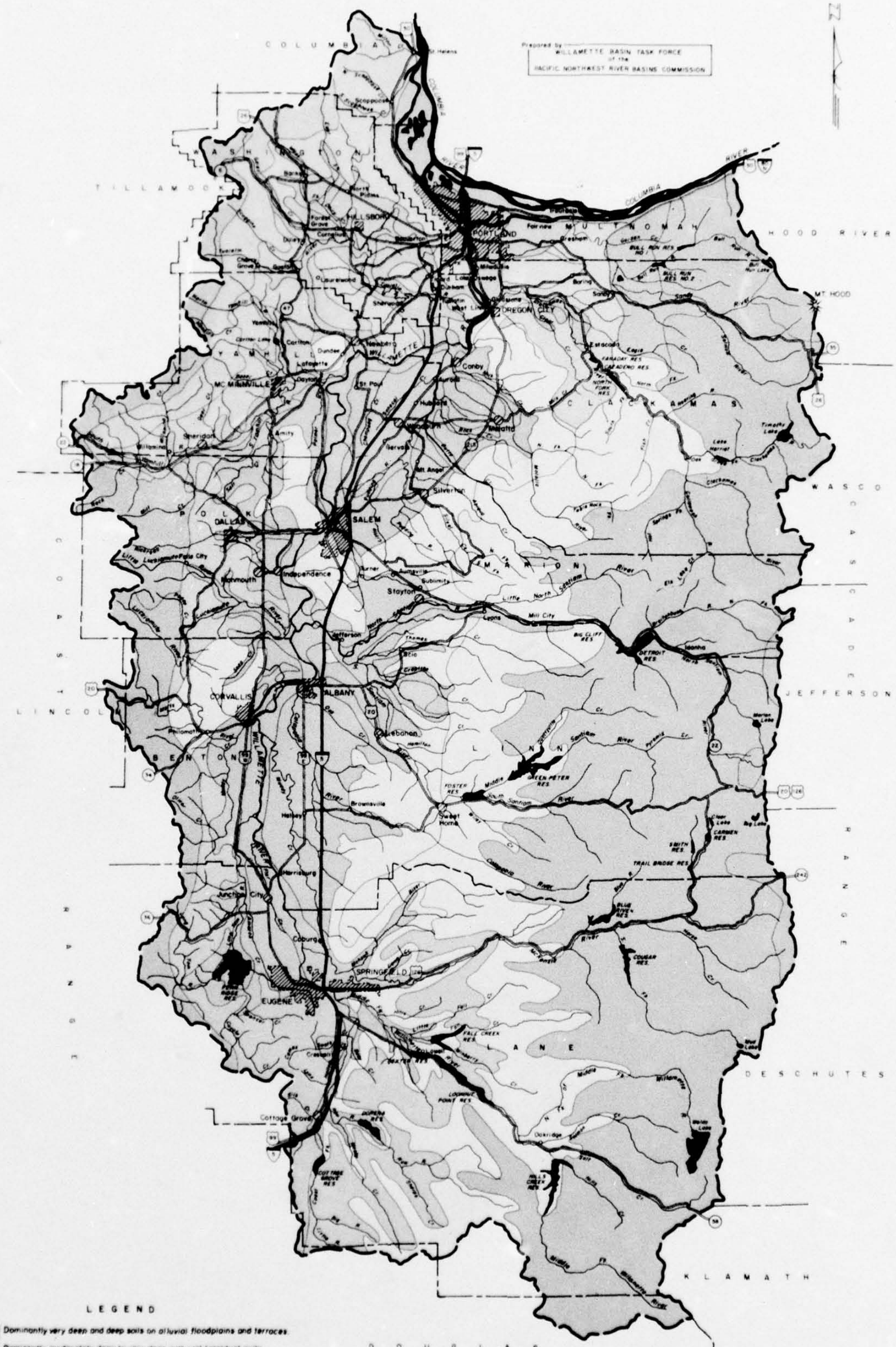
Estimated Acreage and Proportionate Extent of Land by Soil Associations in the Willamette Basin

Soil Association			
Map Symbol	Name	Basin Total 1,000 acres	Extent Percent
1a	Chehalis-Newberg	600.0	7.9
1b	Sauvie-Cloquato	90.0	1.2
2a	Woodburn-Amity	860.0	11.3
2b	Salem-Clackamas	125.0	1.7
3a	Willakenzie-Peavine	505.0	6.6
3b	Jory-Nekia	645.0	8.5
3c	Cazadero-Bornstedt	138.0	1.8
3d	Cascade-Laurelwood	285.0	3.8
4a	Olyic-Melby	200.0	2.6
4b	McCully-Kinney	945.0	12.4
4c	Peavine-Klickitat	275.0	3.6
5a	Astoria-Hembre	220.0	2.9
5b	Aschoff-Bull Run	90.0	1.2
5c	Honeygrove-Bohannon	200.0	2.6
6a	Whetstone-Henline	2,319.6	30.5
6b	Timberline-Rock Land	105.0	1.4
	Total Land Area	7,602.6	100.0
	Water Area	106.4	--
	Total Willamette Basin Area	7,709.0	100.0



MAP II-1
WILLAMETTE BASIN STUDY
OREGON
SOIL ASSOCIATIONS
1967

WBTF-O-1044-L



LEGEND

- Dominantly very deep and deep soils on alluvial floodplains and terraces.
- Dominantly moderately deep to very deep colluvial/residual soils associated with basic igneous bedrock.
- Dominantly moderately deep colluvial/residual soils associated with sedimentary bedrock.
- Dominantly moderately deep to deep soils formed in loess.
- Dominantly shallow to deep stony and cobbly, colluvial/residual soils associated with various kinds of parent materials.

(This is a general map; there may be up to 20 percent inclusions of intermingled areas that differ from the dominant condition described.)

MAP II - 2

WILLAMETTE BASIN STUDY

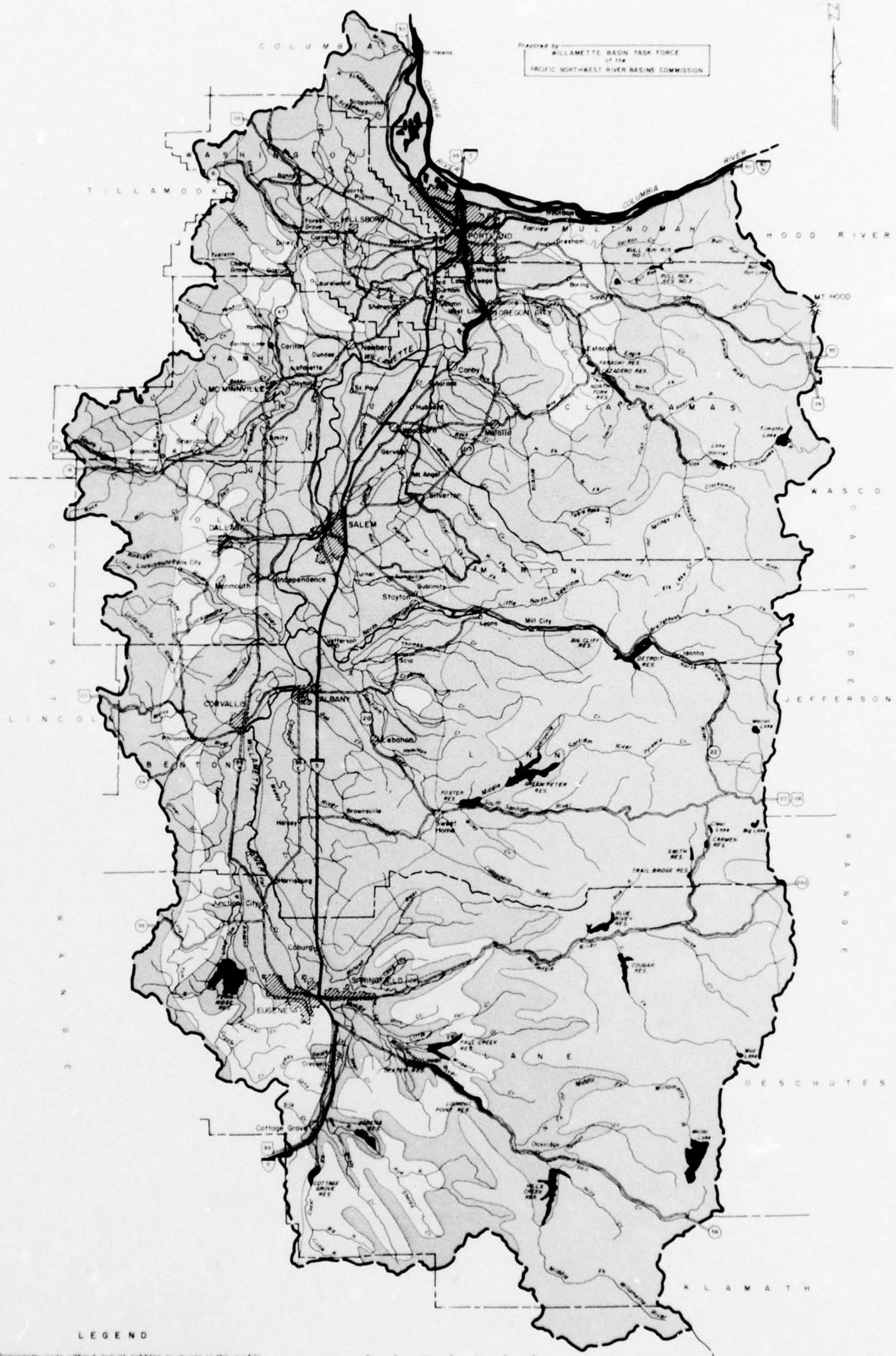
OREGON

SOIL PARENT MATERIALS

1967

SCALE IN MILES

WBTF-O-1045-L



LEGEND

- Dominantly soils without gravel, cobbles or stones in the profile.
- Dominantly soils with less than 20 percent aggregate in the profile.
- Dominantly soils with 20 to 50 percent aggregate in the profile.
- Dominantly soils with 50 to 90 percent aggregate in the profile.

(There may be up to 15 percent inclusion of intermingled areas that differ from the dominant condition described.)

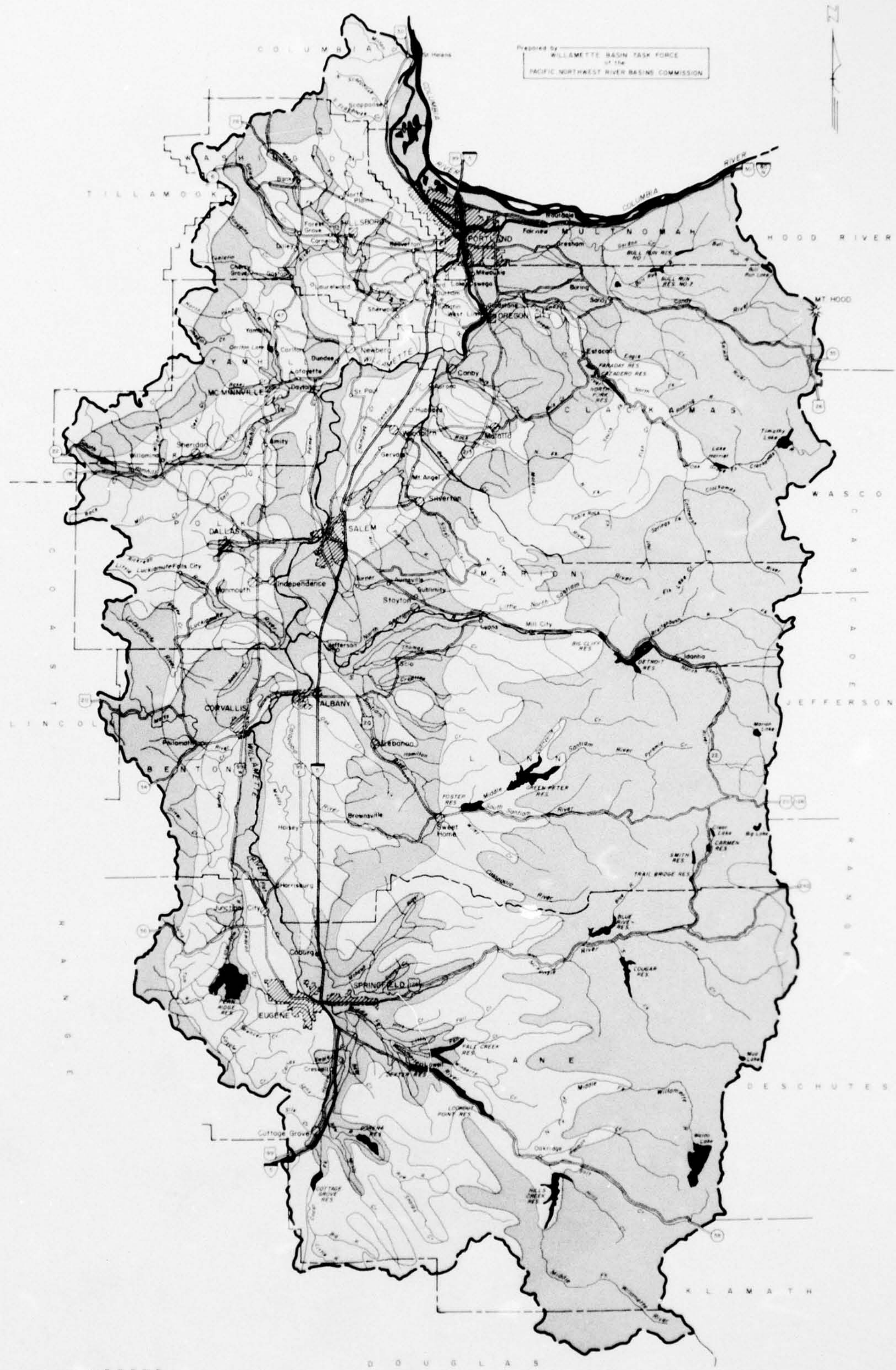
MAP II-3
WILLAMETTE BASIN STUDY
OREGON

SOIL AGGREGATE

1967

6 0 6 12
SCALE IN MILES

WBTF-O-1046-L



LEGEND

Dominantly moderately permeable soils over moderately permeable substrata.

Dominantly moderately permeable soils over slowly permeable substrata.

Dominantly moderately to somewhat rapidly permeable soil over very slowly permeable to impervious subsoil.

(Each segregation may include up to 20 percent that differ from dominant condition described.)

MAP II - 4

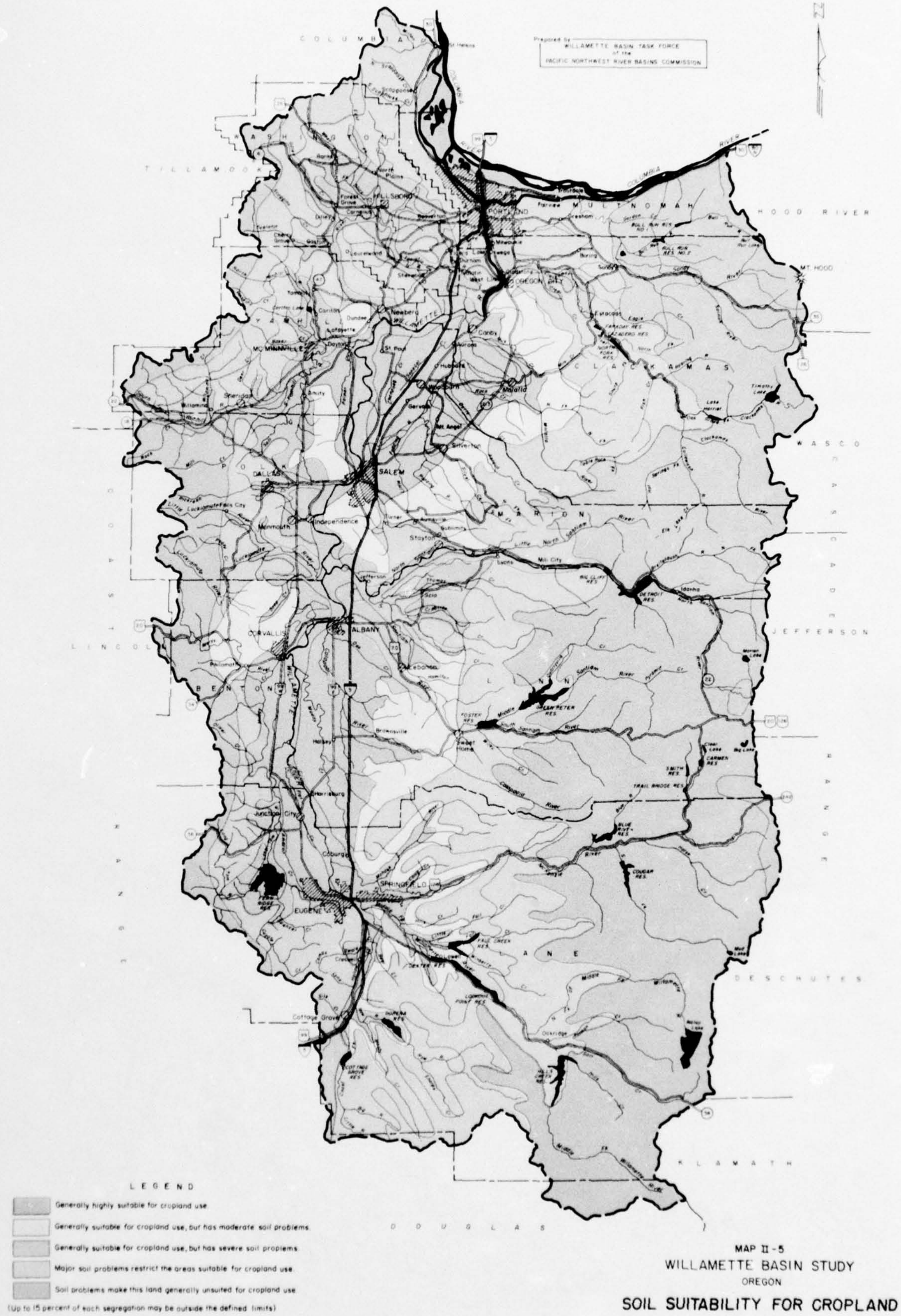
WILLAMETTE BASIN STUDY

OREGON

PERMEABILITY OF SOILS AND SUBSTRATA

1967

WBTF-O-1047-L



MAP II - 5
WILLAMETTE BASIN STUDY
OREGON

SOIL SUITABILITY FOR CROPLAND

1967

THE LAND-CAPABILITY CLASSIFICATION

Standard soil survey maps show the different kinds of soils that are significant and their location in relation to other features of the landscape. These maps are intended to meet the needs of users with widely different problems and, therefore, contain considerable detail to show important basic soil differences.

The soil map includes additional information in the form of interpretations. The capability classification is one of a number of interpretive groupings made primarily for agricultural purposes. The capability classification begins with the individual soil mapping units, which are building stones of the system. In this classification the arable soils are grouped according to their potentialities and limitations for sustained production of the commonly cultivated crops that do not require specialized site conditioning or site treatment. Non-arable soils (soils unsuitable for longtime sustained use for cultivated crops) are grouped according to their potentialities and limitations for the production of permanent vegetation and according to their risks of soil damage if mismanaged.

The individual mapping units on soil maps show the location and extent of the different kinds of soil. Mapping units permit making the greatest number of precise statements about the individual soils and predictions about their use and management. The capability grouping of soils is designed to (1) help landowners and others use and interpret the soil maps, (2) introduce users to the detail of the soil map itself, and (3) make possible broad generalizations based on soil potentialities, limitations in use and management problems.

The capability classification provides three categories: (1) Capability class, (2) Capability subclass, and (3) Capability unit. The first and broadest category in the capability classification places all the soils in eight capability classes. The risks of soil damage or limitations in use become progressively greater from class I to class VIII. Soils in the first four classes are capable under good management of producing adapted plants, such as cultivated field crops and pasture plants. Soils in classes V, VI and VII are suited to the use of adapted native plants. Some soils in classes V and VI are also capable of producing specialized crops, such as certain fruits and ornamentals and even field and vegetable crops under highly intensive management involving elaborate practices for soil and water conservation. Soils in class VIII do not return onsite benefits for inputs of management for crops, grasses or trees.

The second category in the classification is the subclass. This is a grouping of capability units having similar kinds of limitations and hazards. In the Willamette Basin three kinds of limitations or hazards are recognized: (1) erosion hazard, (2) wetness, and (3) root zone limitations. Climate is also a factor that is limiting, but is not important in the Willamette.

The third category is the capability unit, which is a grouping of soils that have about the same influence on production and response to systems of management of commonly cultivated crops and pasture plants. Soils in any one capability unit are adapted to the same kinds of common cultivated and pasture plants and require similar alternative systems of management for these crops. Long time estimated yields of adapted crops for individual soils within the unit under comparable management do not vary more than about 25 percent.

CAPABILITY CLASSES

The grouping of soils into capability classes, subclasses, and units, is done primarily on the basis of their capability to produce common, cultivated crop and pasture plants without deterioration over a long period. To show suitability of the soils for range and woodland use the soil mapping units are grouped into range sites and woodland sites.

Class I.--Soils in class I have few limitations that restrict their use. They are suited to a wide range of plants and may be used safely for cultivated crops, pasture, range, woodland and wildlife. The soils are nearly level, and erosion hazard (wind or water) is low. They are deep, generally well drained and easily worked. They hold water well and are either fairly well supplied with plant nutrients or highly responsive to inputs of fertilizer.

The soils are not subject to damaging overflow. They are productive and suited for intensive cropping. The local climate must be favorable for growing many of the common field crops.

Soils that are used for crops need ordinary management practices to maintain productivity--both soil fertility and soil structure. Such practices may include the use of one or more of the following: fertilizers and lime, cover and green-manure crops, conservation of crop residues and animal manures and sequences of adapted crops.

Class II.--Soils in class II have some limitations that reduce the choice of plants or require moderate conservation practices. They require careful soil management, including conservation practices, to prevent deterioration or to improve air and water relations when the soils are cultivated. The limitations are few and the practices are easy to apply. The soils may be used for cultivated crops, pasture, range, woodland or for wildlife food and cover.

The soils in this class provide the farm operators less latitude in the choice of either crops or management practices than soils in class I. They may also require special soil-conserving cropping systems, soil conservation practices, water-control, devices or tillage methods when used for cultivated crops. For example, deep soils of this class with gentle slopes that are subject to moderate erosion when cultivated may need one of the following practices or some combination of two or more: terracing, strip cropping, contour tillage, crop rotations that include grasses and legumes, vegetated water-disposal areas, cover or green-manure crops, stubble mulching, fertilizers, manure and lime. The exact combinations of practices vary from place to place depending on the characteristics of the soil, the local climate and the farming system.

Class III.--Soils in class III have severe limitations that reduce the choice of plants or require special conservation practices, or both. They have more restrictions than those in class II, and when used for cultivated crops, the conservation practices are usually more difficult to apply and maintain. They may be used for cultivated crops, pasture, woodland, range or for wildlife food and cover.

When cultivated, many of the wet, slowly permeable but nearly level soils require a drainage system and a cropping system that maintains or improves the structure and tilth of the soil. To prevent puddling and to improve permeability it is commonly necessary to supply organic material to such soils and to avoid working them when they are wet. In some irrigated areas, part of the soils have limited use because of high water table or slow permeability. Each distinctive kind of soil has one or more alternative combinations of use and practices required for safe use, but the number of practical alternatives for average farmers is less than for soils in class II.

Class IV.--Soils in class IV have very severe limitations that restrict the choice of plants, require very careful management or both. The restrictions in use for these soils are greater than those in class III, and the choice of plants is more limited. When these soils are cultivated, more careful management is required and conservation practices are more difficult to apply and maintain. They may be used for crops, pasture, woodland, range or for wildlife food and cover.

These soils may be well suited to only two or three of the common crops or the amount of harvest produced may be low in relation to inputs over a long period. Use for cultivated crops is limited as a result of the effects of one or more permanent physical features.

Many sloping soils in this class are suited for occasional but not regular cultivation. Some of the poorly drained, nearly level soils are not subject to erosion but are poorly suited to intertilled crops because of the time required for the soil to dry out in the spring and because of low productivity for cultivated crops. Some soils in class IV are well suited to one or more of the special crops, such as fruits and ornamental trees and shrubs, but this suitability itself is not sufficient to place a soil in class IV.

Class V.-- Soils in class V have little or no erosion hazard but have other limitations that are impractical to remove that limit their use largely to pasture, range, woodland or wildlife food and cover. The basin has only 1,800 acres in this class.

Soils in this class have limitations that restrict the kind of plant that can be grown and that prevent normal tillage of cultivated crops. They are nearly level but some are wet, are frequently overflowed by streams, are stony, have climatic limitations, or have some combination of these limitations.

Class VI.--Soils in class VI have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland or wildlife food and cover.

Physical conditions of soils are such that it is practical to apply range or pasture improvements, if needed, such as seeding, liming, fertilizing and water control with contour furrows, drainage, ditches, diversions or water spreaders. These soils have continuing physical limitations that cannot be corrected. Due to one or more of these limitations these soils are not generally suited for cultivated crops; but they may be used for pasture, range, woodland or wildlife cover or some combination of these.

Some soils can be safely used for the common crops provided unusually intensive management is used. Some of the soils in this class are also adapted to special crops such as sodded orchards, blueberries, etc., requiring soil conditions unlike those demanded by the common crops. Depending upon soil features and local climate the soils may be well or poorly suited to woodlands.

Class VII.--Soils in class VII have very severe limitations that make them unsuited for cultivation and that restrict their use largely to grazing, woodland or wildlife.

Physical conditions of soils are such that it is impractical to apply such pasture or range improvements as seeding, liming, fertilizing and water-control measures such as contour furrows, ditches, diversions or water spreaders. Soil restrictions are more severe than those in class VI because of one or more continuing limitations that cannot be corrected, such as very steep slopes, erosion, shallow soil, stones, wet soil, unfavorable climate or other limitations that make them unsuited for common cultivated crops. They can be used safely for grazing or woodland or wildlife food and cover, or some combination of these under proper management.

Depending upon the soil characteristics and local climate, soils in this class may be well or poorly suited to woodland. They are not suited to any of the common cultivated crops; in unusual instances, some soils in this class may be used for special crops under unusual management practices. Some areas may need seeding or planting to protect the soil and to prevent damage to adjoining areas.

Class VIII.--Soils and landforms in class VIII have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply or aesthetic purposes. Rock outcrop, sandy beaches, river wash, mine tailings, and other nearly barren lands are included in this class. It may be necessary to give protection and management for plant growth in order to protect other more valuable soils, to control water, or for wildlife or aesthetic reasons. These areas cannot be expected to return significant onsite benefits from management for crops, grasses, or trees, although benefits from wildlife use, watershed protection or recreation may be possible.

Capability Subclasses

Subclasses are groups of capability units within classes that have the same kinds of dominant limitations for agricultural use as a result of soil and climate. Some soils are subject to erosion if they are not protected, while others are naturally wet and must be drained if crops are to be grown. Some soils are shallow or droughty, or have other soil deficiencies. The three kinds of limitations recognized at the subclass level are: risks of erosion, designated by the symbol (e); wetness, drainage, overflow (w); and root-zone limitations (s). The class and subclass provide the map user information about both the degree and kind of limitation. Subclasses are not recognized in capability class I.

Subclass (e) erosion is made up of soils where the susceptibility to erosion is the dominant problem or hazard in their use. Erosion susceptibility and past erosion damage are the major soil factors for placing soils in this subclass.

Subclass (w) excess water is made up of soils where excess water is the dominant hazard or limitation in their use. Poor soil drainage, wetness, high water table and overflow are the criteria for determining which soils belong in this subclass.

Subclass (s) soil limitations in the root zone is made up of soils where root zone limitations are the dominant hazard or limitation in their use. These limitations are the results of such factors as shallow soils, stoniness, low moisture-holding capacity, low fertility difficult to correct and acidity.

Limitations imposed by erosion, excess water, shallow soils, stones, low moisture-holding capacity, or acidity can be modified or partially overcome and take precedence over climate in determining subclasses. The dominant limitation or hazard to the use of the land determines the assignment of capability units to the (e), (w) and (s) subclasses.

Where two kinds of limitation which can be modified or corrected are essentially equal, the subclasses have the following priority: (e), (w), and (s). For example, to group a few soils that have both an erosion hazard and an excess water hazard; with them the (e) takes precedence over the (w); with soils having both an excess water limitation and a root-zone limitation the (w) takes precedence over the (s).

Capability Units

Though the land-capability subclasses provide general information on the broad kinds of conservation problems, they do not indicate the specific kinds of management required. This information is provided by the more detailed category of the classification, the capability unit, and is shown for the eleven subbasins in Table II-2.

The degree of magnitude of the conservation problem is shown by the class designation that accompanies the problem designation. For example, a soil classified as class IVw has a greater limitation in use than one classified as IIw and the task of overcoming the wetness would be correspondingly more difficult. Differences in initial costs of the protective or development systems do not influence the land classification.

The fact that certain wet soils are in classes II, III and IV does not imply that they should be drained; but the class does indicate the degree of their continuing limitation in use or risk of soil damage, or both, if they were drained. Where it is not feasible to improve soils by drainage, irrigation, removal of stones or excess acidity, or to protect them from overflow, they are classified according to present limitations in use.

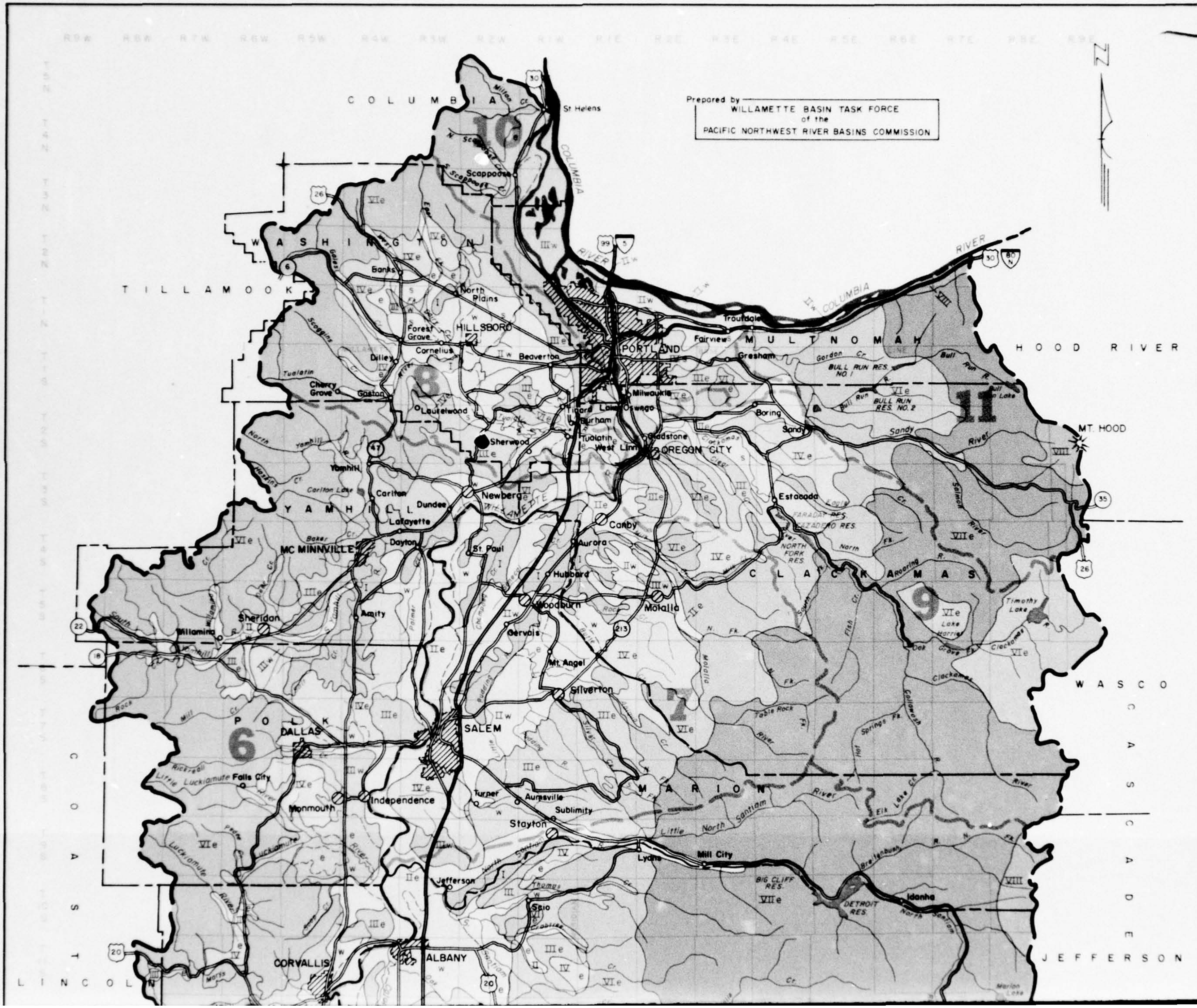
Soils already drained or irrigated are grouped according to the continuing soil and climatic limitations and risks that affect their use under the present systems or with feasible improvements.

Land capability classes and subclasses are broad general summaries of soil characteristics from which general conclusions can be drawn. This information can be very helpful for broad planning. Map II-6 shows the land capability classes generalized.

Table II-2

Estimated Acreage of Land by Capability Class and Subclass

Capability class	Total Willamette Basin	Upper Willamette: 1 Coast Fork	Upper Willamette: 2 Middle Fork	Upper Willamette: 3 McKenzie	Upper Willamette: 4 Long Tom	Upper Willamette: Total	Middle Willamette: 5 Santiam	Middle Willamette: 6 Coast Range	Middle Willamette: 7 Pudding	Middle Willamette: Total	Lower Willamette: 8 Tualatin	Lower Willamette: 9 Clackamas	Lower Willamette: 10 Columbia	Lower Willamette: 11 Sandy	Lower Willamette: Total
		1,000 acres					1,000 acres				1,000 acres				
I	171.5	12.3	8.1	11.1	39.3	70.8	31.0	32.1	27.4	90.5	4.0	--	5.6	0.6	10.2
IIe	279.9	4.7	2.4	3.7	9.9	20.7	96.4	35.5	50.0	181.9	12.5	38.0	21.6	5.2	77.3
IIw	305.4	3.1	1.6	2.4	9.7	16.8	88.6	55.9	58.2	202.7	50.2	9.4	24.7	1.6	85.9
IIs	320.9	3.1	2.1	2.6	10.0	17.8	48.3	111.3	65.2	224.8	48.4	6.9	21.5	1.5	78.3
Total II	906.2	10.9	6.1	8.7	29.6	55.3	233.3	202.7	173.4	609.4	111.1	54.3	67.8	8.3	241.5
IIIe	530.7	26.9	26.5	28.6	58.6	140.6	69.3	112.8	66.6	248.7	61.7	37.6	31.1	11.0	141.4
IIIw	256.3	4.4	2.0	3.9	14.8	25.1	46.2	74.6	30.1	150.9	26.8	7.6	32.8	13.1	80.3
IIIs	64.9	4.7	2.5	4.2	14.9	26.3	9.2	6.5	11.9	27.6	--	5.6	3.3	2.1	11.0
Total III	851.9	36.0	31.0	36.7	88.3	192.0	124.7	193.9	108.6	427.2	88.5	50.8	67.2	26.2	232.7
IVe	575.2	31.5	56.5	56.6	53.4	198.0	138.3	98.2	29.9	266.4	59.6	32.7	11.4	7.1	110.8
IVw	245.7	6.5	4.0	5.8	19.3	35.6	152.8	26.6	24.1	203.5	3.6	1.7	1.3	--	6.6
IVs	51.3	1.1	0.6	1.0	2.7	5.4	3.9	10.8	2.1	16.8	0.1	2.8	19.1	7.1	29.1
Total IV	872.2	39.1	61.1	63.4	75.4	239.0	295.0	135.6	56.1	486.7	63.3	37.2	31.8	14.2	146.5
Total I-IV	2,801.8	98.3	106.3	119.9	232.6	557.1	684.0	564.3	365.5	1,613.8	266.9	142.3	172.4	49.3	630.9
Vw	1.8	--	--	--	--	--	--	--	--	--	1.8	--	--	--	1.8
VIe	1,937.9	116.8	250.1	252.7	31.4	651.0	264.5	418.0	125.4	807.9	167.9	153.8	74.0	83.3	479.0
VIs	161.0	3.0	13.4	12.3	0.7	29.4	--	119.7	9.7	129.4	--	0.6	--	1.6	2.2
Total VI	2,098.9	119.8	263.5	265.0	32.1	680.4	264.5	537.7	135.1	937.3	167.9	154.4	74.0	84.9	481.2
VIIe	2,543.1	201.1	467.1	405.2	56.9	1,130.3	573.0	19.7	245.3	838.0	17.7	343.1	2.9	211.1	574.8
VIIs	28.6	2.0	8.8	8.0	0.2	19.0	--	9.6	--	9.6	--	--	--	--	--
Total VII	2,571.7	203.1	475.9	413.2	57.1	1,149.3	573.0	29.3	245.3	847.6	17.7	343.1	2.9	211.1	574.8
VIII	128.4	1.3	2.4	55.2	1.1	60.0	24.2	10.1	8.7	43.0	0.4	6.3	4.3	14.4	25.4
Total V-VIII	4,800.8	324.2	741.8	733.4	90.3	1,889.7	861.7	577.1	389.1	1,827.9	187.8	503.8	81.2	310.4	1,083.2
Total land area	7,602.6	422.5	848.1	853.3	322.9	2,446.8	1,545.7	1,141.4	754.6	3,441.7	454.7	646.1	253.6	359.7	1,714.1
Water area	106.4	2.9	18.3	5.8	13.9	40.9	15.9	6.8	4.5	27.2	0.4	2.9	22.2	12.8	38.3
Total Willamette Basin area	7,709.0	425.4	866.4	859.1	336.8	2,487.7	1,561.6	1,148.2	759.1	3,468.9	455.1	649.0	275.8	372.5	1,752.4


Prepared by
WILLAMETTE BASIN TASK FORCE
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PACIFIC NORTHWEST RIVER BASINS COMMISSION
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CASCADE
JEFFERSON
COAST
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St Helens
Scappoose
Banks
North Plains
Forest Grove
HILLSBORO
Cornelius
Dilley
Beaverton
Cherry Grove
Gaston
Laurelwood
Sherwood
PORTLAND
Troutdale
Fairview
Gresham
Milwaukie
Lake Oswego
Tigard
Durham
Tualatin
West Linn
Gladstone
OREGON CITY
Boring
Sandy
Estacada
BULL RUN RES. NO. 1
BULL RUN RES. NO. 2
MT. HOOD
Yamhill
Carlton
Dundee
Newberg
Lafayette
Dayton
MC MINNVILLE
Canby
Aurora
St. Paul
Hubbard
Woodburn
Molalla
Gervais
Mt. Angel
Silverton
Sheridan
Willamina
Amity
SALEM
DALLAS
Falls City
Monmouth
Independence
Turner
Aumsville
Sublimity
Stayton
Lyons
Mill City
Jefferson
Scio
ALBANY
CORVALLIS
Idanha
BIG CLIFF RES.
DETROIT RES.
NORTH FORK RES.
FARADAY RES.
Timothy Lake
Lake Harriet
COLUMBIA RIVER
WILLAMETTE
Sandy River
Salmon River
Clackamas
Molalla
Santiam
North Santiam
Little North Santiam
Luckiamute
Tualatin
Yamhill
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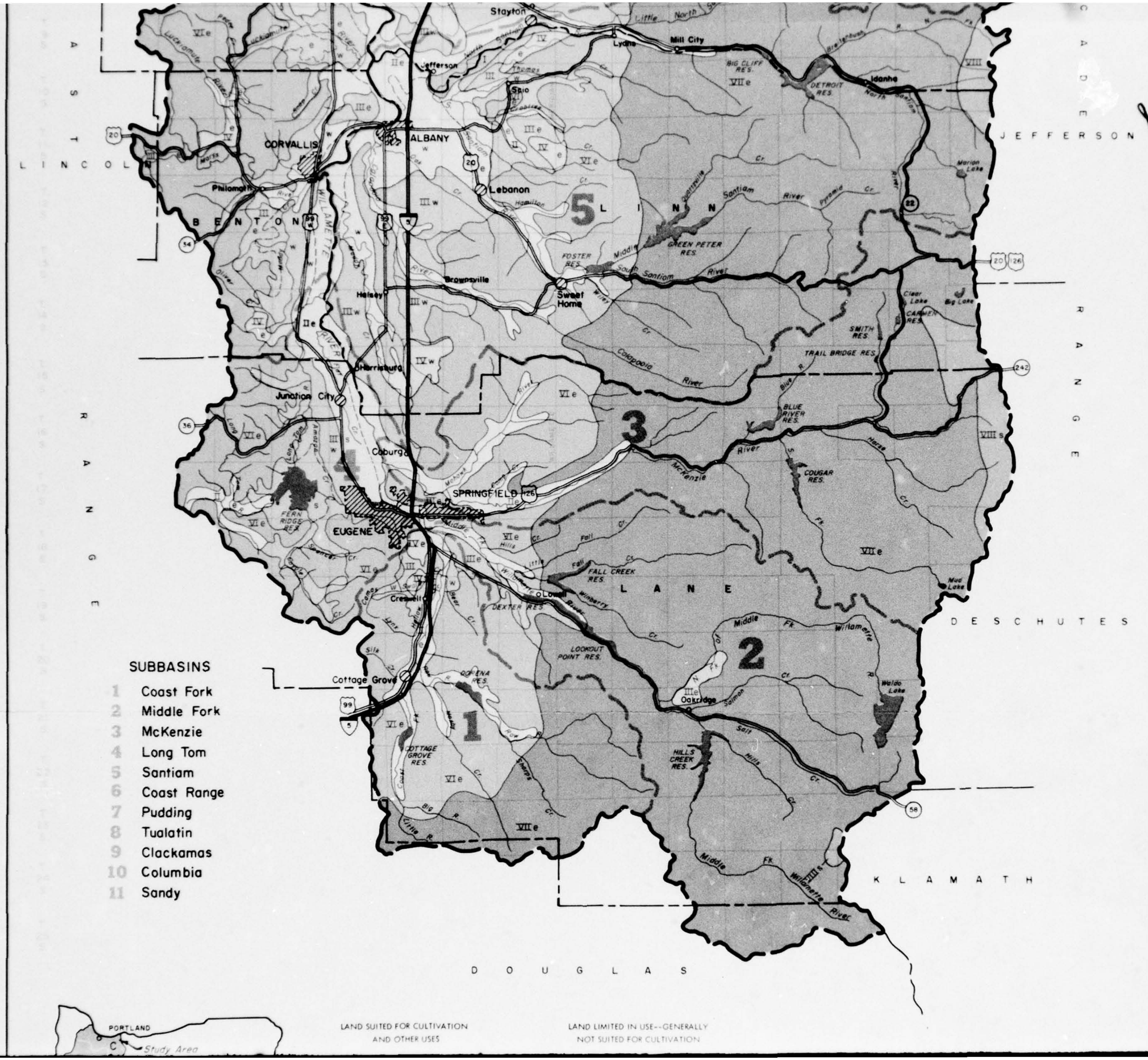
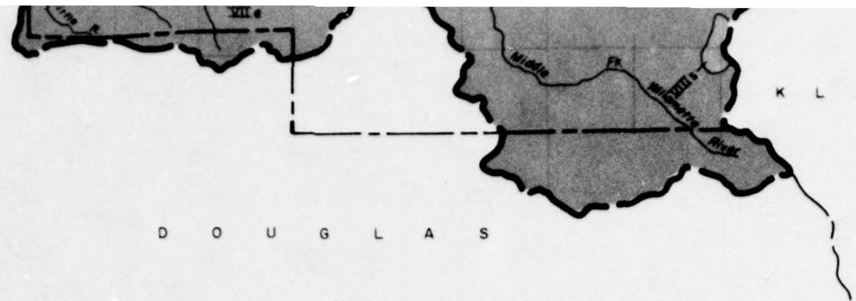
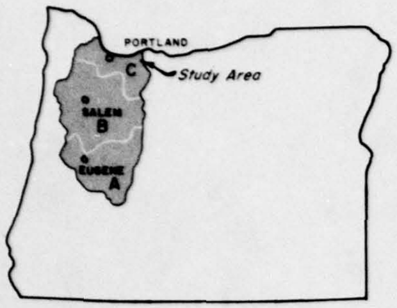


SUBBASINS
1 Coast Fork
2 Middle Fork
3 McKenzie
4 Long Tom
5 Santiam
6 Coast Range
7 Pudding
8 Tualatin
9 Clackamas
10 Columbia
11 Sandy
LAND SUITED FOR CULTIVATION AND OTHER USES
LAND LIMITED IN USE--GENERALLY NOT SUITED FOR CULTIVATION
LINCOLN
BENTON
LINN
LANE
DOUGLAS
DESCHUTES
KLAMATH
JEFFERSON
CORVALLIS
ALBANY
EUGENE
SPRINGFIELD
Lebanon
Sweet Home
Stayton
Mill City
Lyons
Idanha
Jefferson
Scio
Philomath
Brownsville
Halsey
Harrisburg
Junction City
Coburg
Creswell
Cottage Grove
Lowell
Oakridge
DETROIT RES.
BIG CLIFF RES.
GREEN PETER RES.
FOSTER RES.
SMITH RES.
TRAIL BRIDGE RES.
BLUE RIVER RES.
COUGAR RES.
FALL CREEK RES.
DEXTER RES.
LOOKOUT POINT RES.
HILLS CREEK RES.
DORENA RES.
COTTAGE GROVE RES.
FERN RIDGE RES.
Waldo Lake
Marion Lake
Clear Lake
Big Lake
Mud Lake
WILLAMETTE
Calapooia River
McKenzie River
Santiam River
South Santiam River
Middle Fk. Willamette River
Salmon Cr.
Salt Creek
Portland
Study Area

8 Tualatin
9 Clackamas
10 Columbia
11 Sandy





SUBAREAS

A Upper
B Middle
C Lower

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

LAND LIMITED IN USE--GENERALLY 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 susceptibility and past erosion damage are major factors for placement in this sub class.

w- Wetness, high water table, poor soil drainage and overflow are major factors in this subclass.

s- Soils which have limitations such as shallowness, stoniness, low moisture-holding capacity, low fertility difficult to correct, salinity or alkalinity.

MAP II-6
WILLAMETTE BASIN STUDY
OREGON

GENERALIZED LAND CAPABILITY

1967

6 0 6 12
SCALE IN MILES

3

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EXTENT OF CONSERVATION PROBLEMS

Table II-3 shows the extent of the various conservation problems in the Willamette Basin. All but 5 percent of the total basin area is characterized by the dominance of one or another of the three major problems that limit the land capability. Two percent, or 171,500 acres, is classified as class I land. About 3 percent of the total is either class VIII land or in water bodies.

Table II-3
Land Capabilities by Type of Problem

	Cropland (I-IV)		All Basin Lands	
	Acres	%	Acres	%
No problem	171,500	6	171,500	2
Excess water	807,400	29	809,200	11
Unfavorable soil	437,100	16	626,700	8
Erosion	1,385,800	49	5,866,800	76
Class VIII	-		128,400	2
Water bodies	-		106,400	1
Total	2,801,800		7,709,000	

Erosion susceptibility and past erosion damage occur on 5.9 million acres. This is the major capability limitation and is found on 76 percent of the basin land area. Approximately two-thirds of the erosion problem area is currently devoted to forest uses and much of it is located in the National Forest. Due to the severity of the problem, it is not likely that much of this land will be cultivated in the foreseeable future. Forestry problems are discussed in detail in the forestry section of this apppendix.

Basin lands in capability classes I through IV (36%) total over 2.8 million acres. Erosion is the dominant problem on 49 percent of this land, or nearly 1.4 million acres. Erosion is the most limiting problem in the Upper Subarea; 359,000 acres are affected. The Middle Subarea lands with erosion problems total 697,000 acres. The Lower Subarea has 330,000 acres with an erosion problem.

Poor internal soil drainage, wetness, high water table and overflow plague 29 percent of these lands. Nearly all of the 809,000 acres are located in areas currently being cultivated. The problem is most extensive in the Middle Subarea, moderately extensive in the Lower Subarea, and fairly limited in the Upper Subarea. This acreage represents 36 percent, 28 percent and 16 percent of the problem soils in the respective areas.

The 809,000 acres is comprised of land, each acre of which has a wetness problem as a primary limitation. Later, in the drainage section a larger figure (1,310,000 acres) is shown as needing improvement. This latter figure is developed by using soil associations which include acreage that does not have a wetness problem but is located physically in such a way that it must be considered in problem solution.

Characteristics of the root zone that place soils in a limiting category include shallow soils, stoniness, low moisture holding capacity, low fertility and soil acidity. Sixteen percent of the basin's agricultural lands, or 437,000 acres, have these problems. The Middle Subarea has 269,000 acres (18 percent); the Lower Subarea has 118,000 acres (19 percent); and the Upper Subarea 50,000 acres (10 percent) in this category. These soils may also have secondary problems of erosion or excess water.

L A N D U S E

The soils, topography and water relationships of land influence its potential both as a resource and as a problem source. How the land is used now and in the future determines the extent of this two-way potential. Land, as it is used or abused, has a direct bearing on rates of runoff and production of sediment. After a hard rain, rill erosion and gullying can be seen on much of the basin's fall cultivated lands, and the streams flow with a dirty brown water. Any proposed program or project for flood control, irrigation, or drainage usually depends on an increased intensity of land use for its economic feasibility. Changed land use will accelerate the need for associated land measures to maintain the status quo or reduce runoff, erosion and sediment deposition.

MAJOR LAND USES

General and specific land uses in the basin have been inventoried as a requisite part of moving from land through its uses to its problems and potentials as they affect the quantity, quality and use of water. The inventory was made during 1961-1963 and adjustments made for additional data received for 1965 from the Bureau of Reclamation.

The Willamette Basin includes 7.7 million acres of land; slightly over 5 million are devoted to forest and woodland use, and 1.5 million to the production of cultivated crops (Figure II-1). The remaining area is devoted to native pasture, urban and "other" uses. This latter category includes roads, highways, airports, cemeteries, gravel pits, water areas, farmsteads, rurban homes, estates, etc.

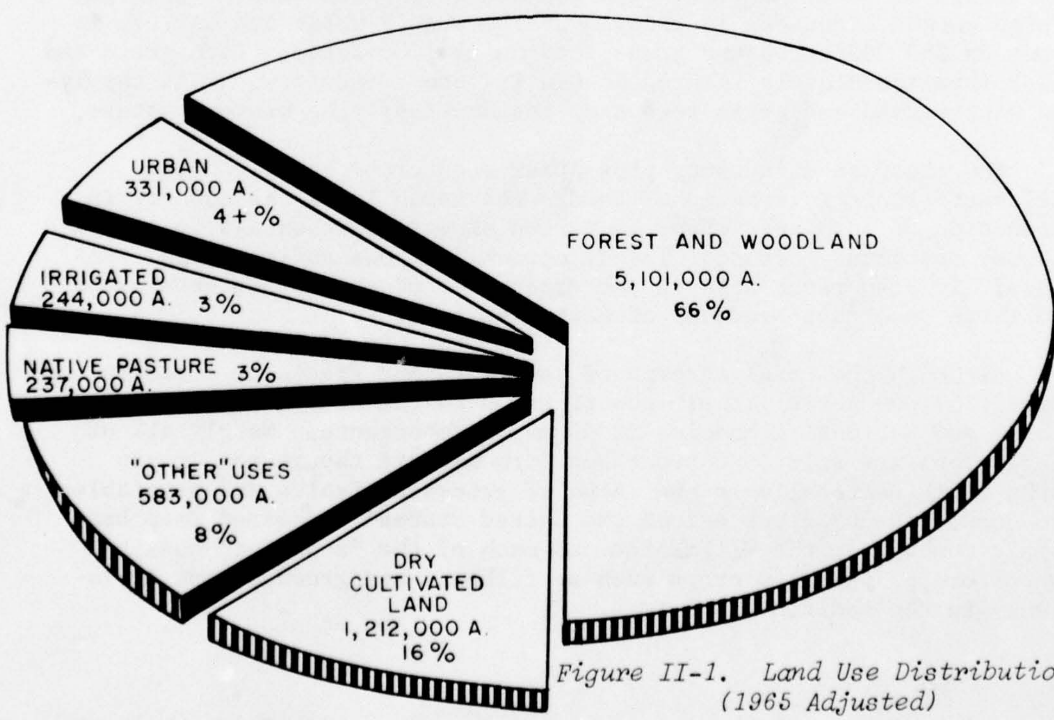


Figure II-1. Land Use Distributions (1965 Adjusted)

Map II-7 shows the various types of land use. The bulk of the timber lands are found on the strip of higher elevation slopes that ring the basin. The agricultural area is located in the valley bottoms at elevations of 1,000 feet or less. Much of the "other" land use is located around the urban population areas scattered throughout the valley floor.

AGRICULTURAL LAND USE

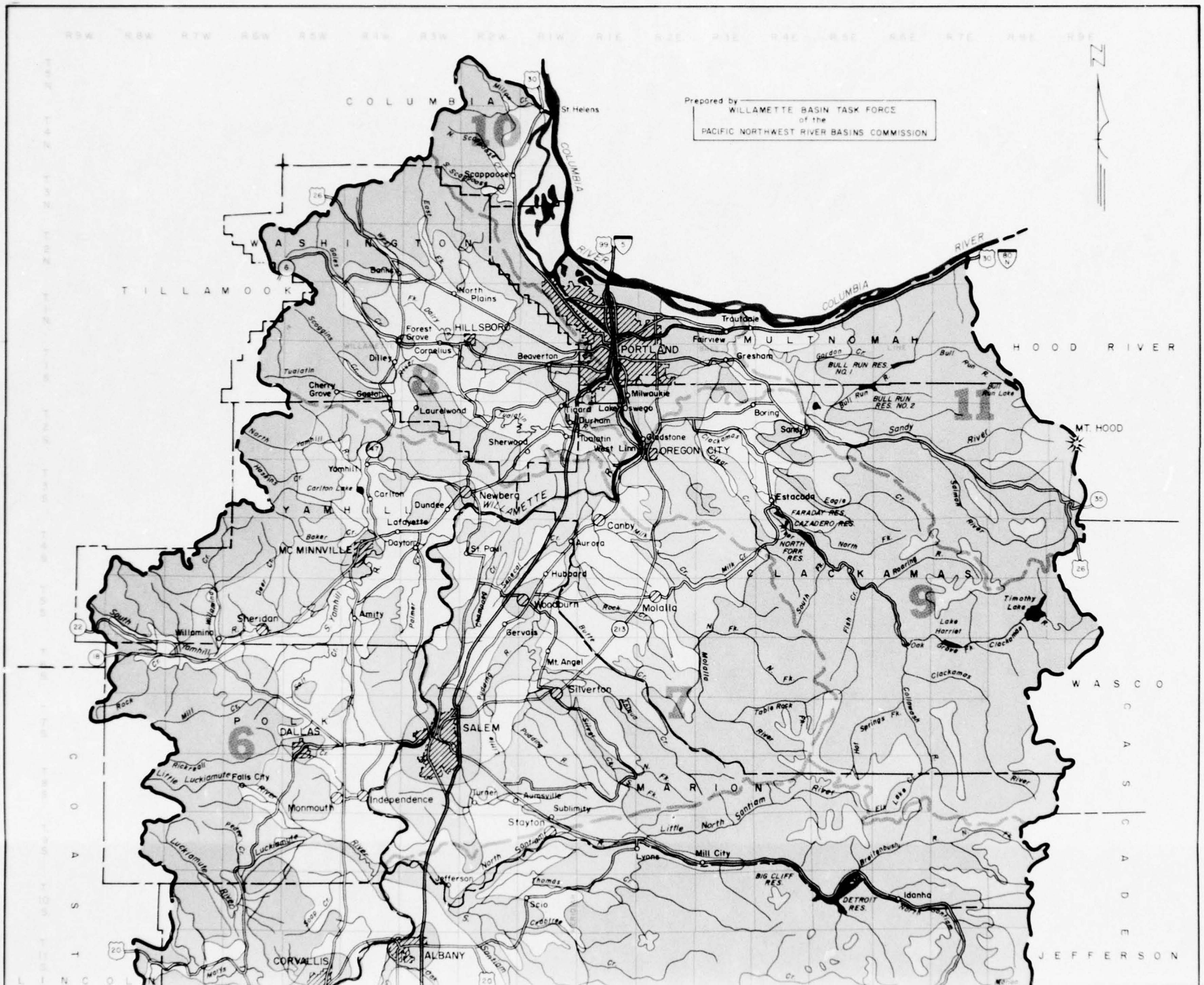
An estimate of the acreage of crops grown on the agricultural lands is presented in Table II-4. The figures shown were field-collected in three different years (1961-1963) for the Upper, Middle, and Lower Subareas, but are considered to be representative of the ever-changing cropping pattern. Also shown is the privately owned forest and native pasture lands used in conjunction with the cropland areas.

Nearly 700,000 acres are grazed. Much of this area is in a forested-crop transition zone and is located at the slightly higher elevations and on the steeper slopes of the zone. Often it is used as fall or early spring pasture, in conjunction with other improved land. Historically, forage yields are quite low; yet these areas have potential to double in yield of native vegetation through proper management and to quadruple yield if they can be seeded to permanent improved species.

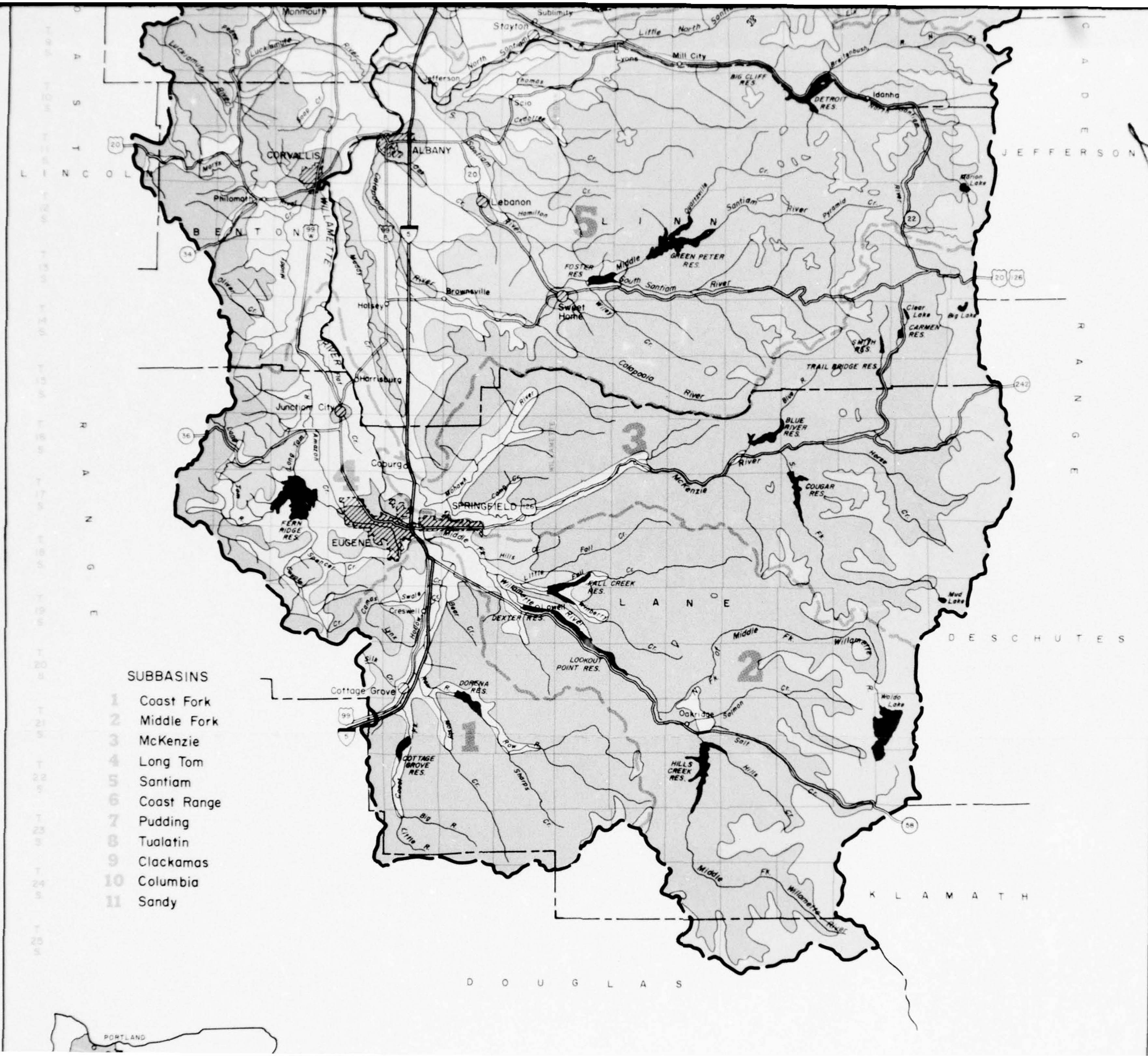
Land that is cultivated or idle cropland is estimated to be 1,456,000 acres. A total of 429,000 acres or 30 percent of the land is devoted to improved pastures, hay or forage. This includes both dry and irrigated land, portions of which are very productive, supporting a significant livestock industry. Grain, mostly wheat and barley, is grown on 383,000 acres and grass seed on 240,000 acres. Both grain and grass seed are closely related to the livestock industry, grain supplying winter feed and grass seed crop residue supplying winter pasture.

The grass seed industry plus other seed crops has given the Willamette Basin international fame. The basin leads the country in production of such seed crops as Merion bluegrass, chewings fescue, red fescue, bentgrass, crimson clover, common ryegrass and perennial ryegrass. It also ranks high in the production of many other seed crops and is an important producer of certified seed.

Although the total acreage of row crops and specialty crops is not large (153,000 acres), their contribution to the Willamette Basin, regional and national economics is of major importance. Nearly all of these crops are sold in a processed form and are the reason Oregon ranks fifth nationally in the value of processed fruits and vegetables produced. About 22 percent of the United States' processed snap bean supply comes from the Willamette and much of the "superior" quality sweet corn. Specialty crops such as filberts are grown almost exclusively in the basin.



Prepared by
WILLAMETTE BASIN TASK FORCE
of the
PACIFIC NORTHWEST RIVER BASINS COMMISSION
COLUMBIA
WASHINGTON
TILLAMOOK
YAMHILL
POLK
MULTNOMAH
CLACKAMAS
MARION
HOOD RIVER
WASCO
CASCADE
JEFFERSON
COAST
10
11
9
8
7
6
St. Helens
Scappoose
Banks
North Plains
Forest Grove
HILLSBORO
Cornelius
Dilley
Cherry Grove
Gaston
Laurelwood
Beaverton
PORTLAND
Troutdale
Fairview
Gresham
Milwaukie
Tigard
Lake Oswego
Durham
Tualatin
West Linn
Gladstone
OREGON CITY
Boring
Sandy
Estacada
Sherwood
Yamhill
Carlton
Carlton Lake
Newberg
Dundee
Lafayette
Dayton
MC MINNVILLE
St. Paul
Canby
Aurora
Hubbard
Woodburn
Molalla
Gervais
Mt. Angel
Silverton
Sheridan
Willamina
Amity
DALLAS
SALEM
Falls City
Monmouth
Independence
Turner
Aumsville
Sublimity
Stayton
Lyons
Mill City
Jefferson
Scio
Idanha
CORVALLIS
ALBANY
MT. HOOD
Timothy Lake
Lake Harriet
BULL RUN RES. NO. 1
BULL RUN RES. NO. 2
Bull Run Lake
FARADAY RES.
CAZADERO RES.
NORTH FORK RES.
BIG CLIFF RES.
DETROIT RES.
COLUMBIA RIVER
WILLAMETTE



SUBBASINS
1 Coast Fork
2 Middle Fork
3 McKenzie
4 Long Tom
5 Santiam
6 Coast Range
7 Pudding
8 Tualatin
9 Clackamas
10 Columbia
11 Sandy
LINN
LANE
BENTON
LINCOLN
DOUGLAS
KLAMATH
DESCHUTES
JEFFERSON
EUGENE
SPRINGFIELD
CORVALLIS
ALBANY
Lebanon
Sweet Home
Cottage Grove
Oakridge
Junction City
Harrisburg
Coburg
Brownsville
Creswell
Stayton
Mill City
Idanha
Monmouth
Philomath
Halsey
Lowell
PORTLAND
GREEN PETER RES.
FOSTER RES.
DETROIT RES.
BIG CLIFF RES.
BLUE RIVER RES.
COUGAR RES.
TRAIL BRIDGE RES.
CARMEN RES.
SMITH RES.
FERN RIDGE RES.
FALL CREEK RES.
DEXTER RES.
LOOKOUT POINT RES.
DORENA RES.
COTTAGE GROVE RES.
HILLS CREEK RES.
WILLAMETTE RIVER
Waldo Lake
Marion Lake
Clear Lake
Big Lake
Mud Lake

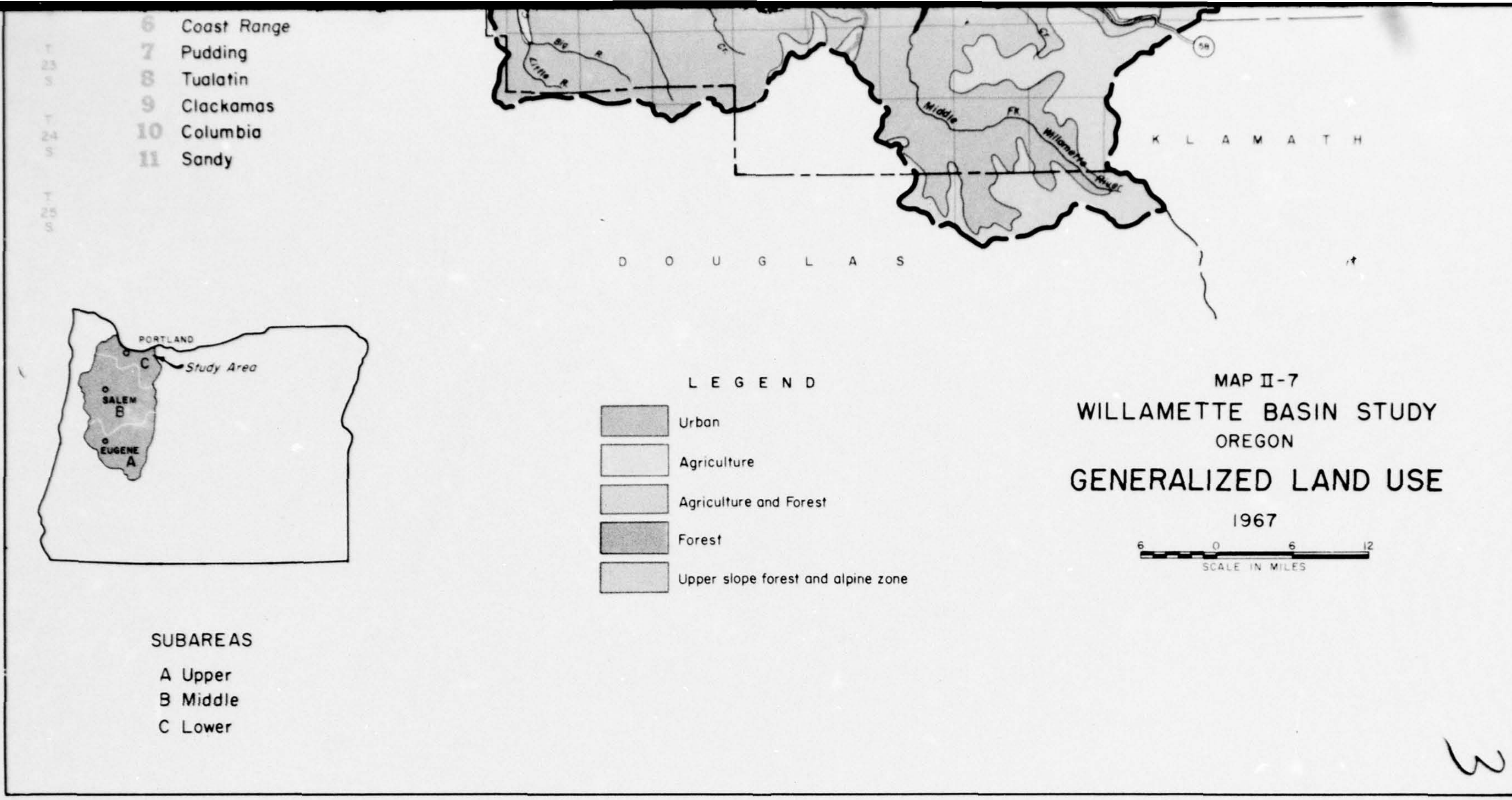


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Table II-4

Agricultural Land Use by Subbasin

Land use	1 Coast Fork	2 Middle Fork	3 McKenzie	4 Long Tom	5 Santiam	6 Coast Range
Agricultural land use						
Grazing land						
Forest land 1/	29,050	15,230	13,940	58,210	90,500	124,800
Unimproved pasture	13,590	1,550	6,080	28,500	52,500	54,800
Total grazing land	42,640	16,780	20,020	86,710	143,000	179,100
Cropland						
Small grain	900	610	1,380	17,830	52,960	137,350
Grass seed	1,750	100	200	17,900	130,930	37,040
Pasture	10,530	2,900	5,270	35,050	40,540	54,380
Hay and forage	4,520	1,160	2,470	18,940	26,620	37,480
Fruits and nuts	1,330	530	1,680	5,050	6,910	26,530
Vegetables	580	1,070	1,910	5,700	11,550	8,570
Field corn	--	--	90	2,010	4,970	3,210
Other seed crops	110	--	150	2,240	2,080	10,480
Specialty and other	--	60	940	2,230	10,610	29,840
Idle	320	200	--	7,090	33,940	37,040
Total cropland	20,040	6,630	14,090	114,040	321,110	381,920
Total agricultural land	62,680	23,410	34,110	200,750	464,110	561,020

Land use	7 Pudding	8 Tualatin	9 Clackamas	10 Columbia	11 Sandy	Total Willamette Basin
Agricultural land use						
Grazing land						
Forest land 1/	70,100	22,050	12,500	7,300	11,000	454,680
Unimproved pasture	27,200	17,440	20,350	11,250	6,260	239,020
Total grazing land	97,300	39,490	32,850	18,550	17,260	693,700
Cropland						
Small grain	89,330	65,890	11,930	3,980	800	382,960
Grass seed	44,800	3,530	3,030	240	300	239,820
Pasture	50,460	16,930	11,990	15,400	4,260	247,710
Hay and forage	38,960	23,730	10,370	13,680	3,450	181,380
Fruits and nuts	20,560	17,950	5,480	3,690	1,830	91,540
Vegetables	12,690	2,790	1,660	4,470	1,000	51,990
Field corn	12,620	2,680	1,540	240	50	27,410
Other seed crops	7,980	4,890	1,210	170	100	29,410
Specialty and other	11,840	1,930	910	1,730	750	60,840
Idle	41,080	11,260	7,000	4,120	1,040	143,090
Total cropland	330,320	151,580	55,120	47,720	13,580	1,456,150
Total agricultural land	427,620	191,070	87,970	66,270	30,840	2,149,850

1/ *There is an additional 270,000 acres of forest land which is not grazed or used for agricultural purposes but is managed by farmers and small woodland owners.*

Photo II-3. Forest cropland transition. Upper slopes being used for pasture as well as forestry. (SCS Photo 0-731-1)

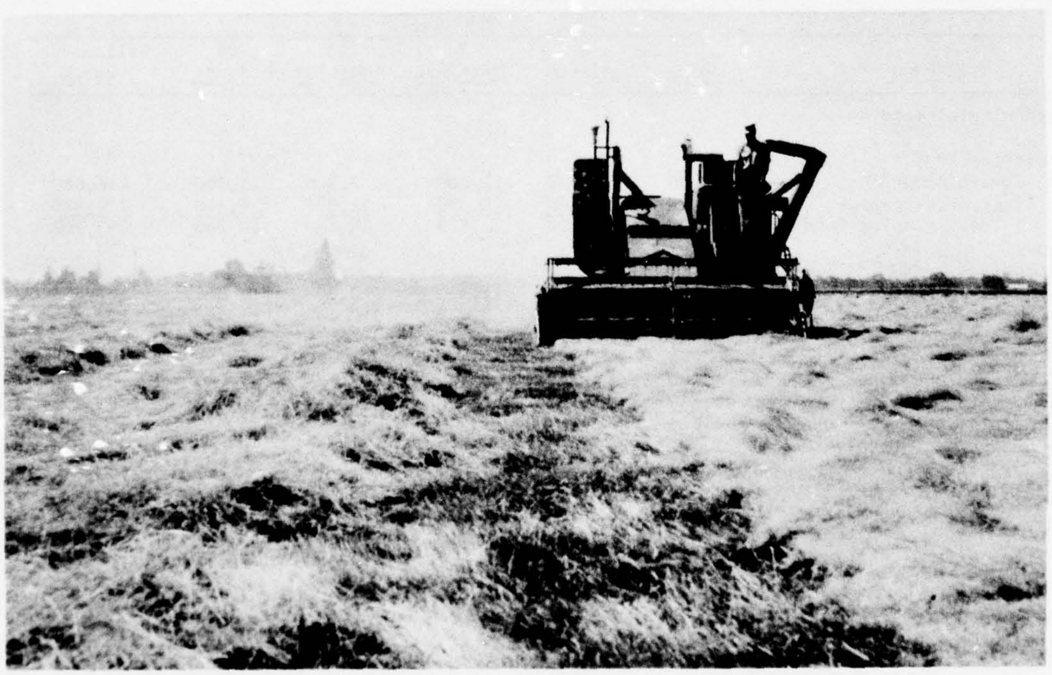


Photo II-4. Grass seed is a major field crop and important source of farm income in the basin. (SCS Photo 7-852-9)

LAND- AND WATER-RELATED PROBLEMS

The Willamette Basin economy is dependent on water and land resources. Water is necessary for the existence and growth of urban, industrial and agricultural development in the area. The total water supply is excellent and should be sufficient to meet future basin requirements. Even though plentiful, water is still a scarce resource in terms of availability at the proper time and place.

As the basin develops, competition between water uses will increase. Many uses are interrelated, and what affects one use could affect others--either beneficially or detrimentally. In solving water use problems of one type, effects of the solution on other water uses must be evaluated. Competition for water use is reflected in decisions involving water rights, statutory limitations, institutional pressures, and economics. These decisions vary with time and place and will dictate the direction of future water development on a local basis.

Major water problems result from the "feast or famine" rainfall, runoff, and streamflow in the basin. During the wet winter months the soils reach and maintain a saturation point from the abundant rainfall. Any high-intensity rainfall, or even prolonged moderate rain, causes annual flooding along smaller tributaries. Periodically, major floods occur along the entire river system, causing great damage.

Crops and agricultural property repeatedly are damaged by overflow waters. Damage, for instance, may vary from actual crop loss to a management decision to "live with" the problem and grow less productive crops which can stand "wet feet". Restricted land use, both in choice of crop and yield level, causes a much greater loss than any single flood event. Livestock, equipment, buildings and supplies are damaged by the more infrequent events. Urban areas and public property have suffered substantial losses in the past; with rapid urban expansion on the valley floor lands, this problem will intensify.

An important point to emphasize is that elimination of flooding, either prolonged or frequently recurring, is often the prerequisite to successful irrigation and drainage.

Overland flow and lack of outlets have compounded the drainage problem. Thousands of acres on the valley floor are "wet" most of the year. As a result, in some years, certain soils cannot be worked at all. In addition, the crop alternatives are limited by wet conditions.

Conversely, after the rainy season in the late spring, little measurable precipitation falls during the summer months. As the season progresses, the readily available soil moisture is used up, and the crops may go into stress. Irrigation is needed to maintain high quality and yields from perennial and vegetable crops.

Erosion and bank cutting occur in both the forested areas and the cultivated lands. It is not uncommon for farmers to lose acres of excellent land as a result of the streams slowly eating back into their fields. Not only is the soil depleted or lost in one place, but sediment and debris are deposited to cause problems in another. The excessive sediment loads adversely affect water quality for human consumption as well as the fish and aquatic life.

RESTRAINTS ON LAND USE

Each of the major types of land use--woodlands, pasture and cultivated crops--have distinct problems. Land measures are necessary to maintain soil productivity and minimize excessive runoff, erosion and scour. Many individual measures or groups of measures are necessary for the different land uses, soils and topographic conditions. These three classes are discussed generally as to the type of problems occurring and some of the land measures that must be considered.

Woodlands

This discussion is limited to problems of the small woodland owners in the transitional area of the basin. Forest problems are discussed in detail in the Forestry sections. The basin agricultural land has a total of 725,000 acres of woodlands. This is about 10 percent of the basin land area. Approximately 455,000 acres of the total are grazed and 270,000 acres used strictly as woodlands.

Poorly planned management of woodland resources can result in flooding, erosion and sedimentation. Woodlands generally exist on steeper ground where the slopes can accelerate water erosion. The rapid runoff of precipitation may be very damaging if the protective vegetative cover is carelessly removed.

Many areas are susceptible to slumps and slides. Lack of detailed soil surveys and interpretive information handicaps the efforts of farm forest land managers in planning adequate soil and watershed protection in connection with road development, timber harvesting and other forest practices. Some managers are reluctant to adopt soil and watershed protection measures because protective measures are costly and may not provide a direct short term economic benefit.

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

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 sediment sources. Special measures such as adequate drainage and installation of a protective plant and mulch cover helps in such cases.

Photo II-5. Marion County cutover land being used for pasture. Areas such as this should be re-forested. (SCS Photo 0-720-5)

Much of the forest land in the foothill area of the basin is in individual ownerships of less than 500 acres each. Many of these ownerships are too small for efficient, profitable timber management on an individual basis. The owners often lack forestry training and experience and cannot afford to hire consultants. Many owners are unaware of the profitability of sound forest management. For these reasons, many small private forest holdings are rather poorly managed. Data, as pointed out in a Forest Service report entitled Timber Resources for America's Future, indicate that many small private holdings are cutover at too young an age for maximum profits, and there is often inadequate provision for reforestation. Small forest holdings owned by farmers tend to be better managed than those owned by nonfarmers. Forest values for water, recreation, and wildlife are often neglected on small holdings because of lack of management abilities or economic feasibility.

Since woodlands have problems similar to those experienced in the forested area, the solutions are also similar. The primary concern is to minimize soil disturbance when harvesting the various woodland products or when using woodlands for grazing and wildlife. Major practices involve woodland cutting, intermediate cutting, pruning, thinning and weeding. These practices have a direct effect on sediment and water production and are highly important in a fire-control program. Tree planting for reforestation, for stabilization of critical areas and for diversion of cropland to woodland also are very important.

Grazing of woodlands must be well managed to avoid overuse and damage to reproduction. Conservation measures such as wildlife habitat development and preservation may be needed land measures.

Non-improved and Improved Pasture Lands

Slightly less than half a million acres fall in the non-improved and improved pasture category. About 243,000 acres are classified strictly as grazing land. Another 248,000 acres of pasture are on cropland which in many cases is quite marginal. This discussion is limited to the marginal cropland areas and grazing land. Portions of improved and irrigated pastures have conservation problems similar to cropland.

The pasture lands normally occur in small parcels occupying a narrow belt in the foothill areas of the basin. This is a transitional area where cropland and forest lands are intermingled. In general, grazing does not conflict with other uses but rather complements them. It is often used in conjunction with the woodland pasture areas.

Originally a large portion of the present grazing land was forest. As this land was logged off, it was used for grazing. Slash burning stimulated herbaceous growth, and repeated burning became a common practice. However, burning has been found to stimulate growth of noxious and unpalatable weeds and brush as well as grass and forage and to endanger adjacent timber lands. At the present time very little range burning is practiced in the basin.

Photo II-6. Logging slash caused a log jam and blocked fish passage on the Calapooia River. The resulting flood left logs, brush and silt piled on the adjacent farmlands.
(SCS Photo 0-1096-6)

Photo II-7. Farm logging roads properly built minimize road disturbance. Columbia County. (SCS Photo F-424-1)

The erosion problem on certain areas is fairly serious from a local standpoint. At worst, it results in patches of rilled and gullied land scattered over the grazed slopes. Local losses have been incurred through continuation of gullies through cultivated lands below and from sediment deposition on these lands and lower improvements. The heavy grazing use that removes the grass and weed cover and permits erosion generally leads to invasion by brush and trees. When the livestock are removed, natural regeneration usually stabilizes the soil fairly rapidly. This regrowth, however, does not necessarily improve forage production.

Ground squirrels and other rodents are present but are not particularly significant pests. Deer invade the range and adjacent cultivated land used by domestic stock and cause overuse in localized areas. Special hunting seasons have been used to reduce game numbers and so ease the problem.

The principal problem of pasture use is how to improve the vegetative cover in order to increase its productive value and better stabilize the soils. Rotational grazing, deferred grazing, proper stocking, spring development, fertilization, pasture renovation, brush or land clearing and pasture planting are examples of land treatment practices applied on pasture lands.

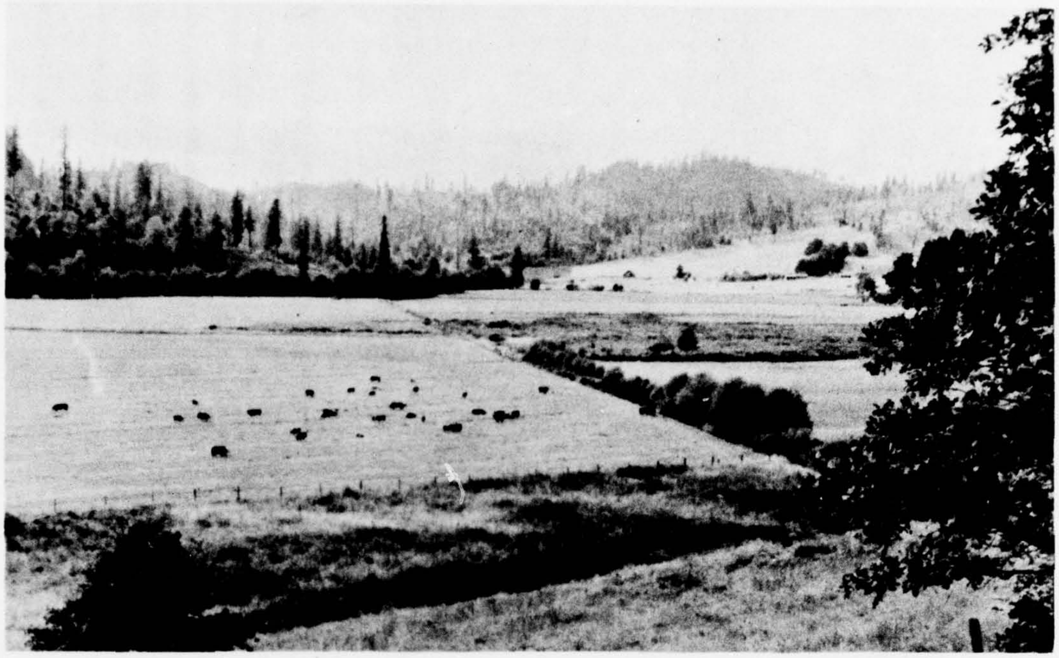


Photo II-8. *Improved pastures, native pastures and cutover woodlands should be used during the proper season to maintain vegetative cover.* (SCS Photo F-61-13)

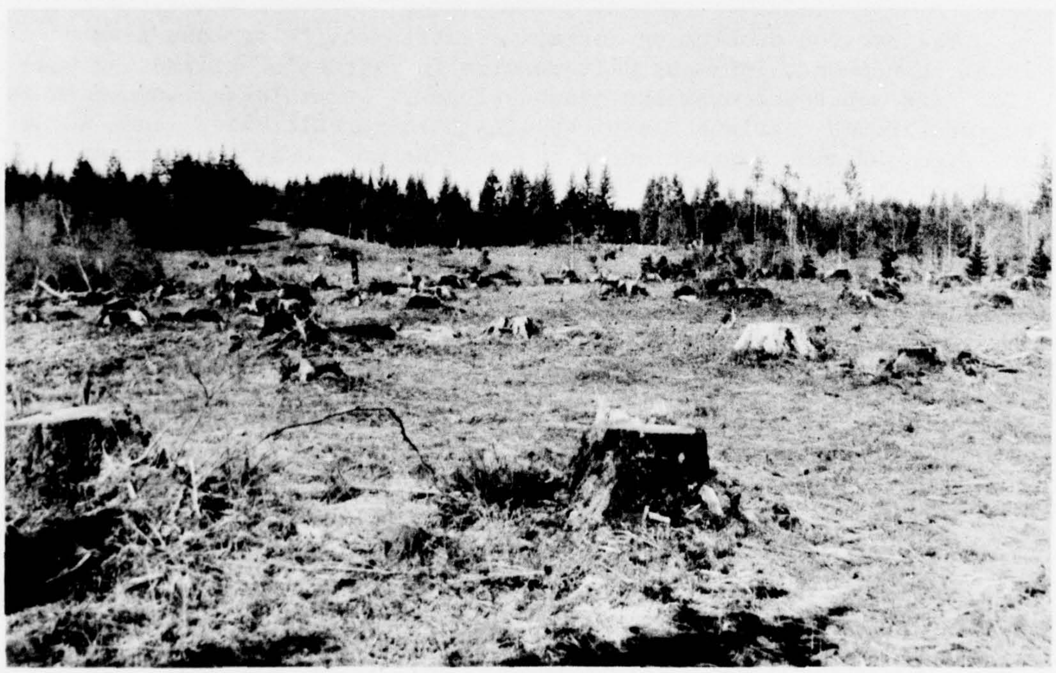


Photo II-9. *Clearings in cutover land contribute to the native pasture production. Marion County.* (SCS Photo 0-1792-3)

Cultivated Lands

The cropland in the Willamette Basin is located primarily along the valley floor, along the major tributary streams, on the bench lands which extend back from the major streams, through the rolling hills which predominate in the area near the foothills of the mountains, and in the stringer valleys leading to the major tributaries of the Willamette River. Nearly 1 and 1/2 million acres are used as cropland (Table II-4). Closely planted crops such as grain, grass seed, pasture, hay and forage, make up two-thirds of this total. The other third is devoted to orchards, berries, row crops, specialty crops and idle land.

Agricultural crop and property losses usually comprise nearly half of the total evaluated flood and sediment damage. Land damage from erosion, leaching, scour and deposition is very significant; but this type of damage is difficult to evaluate and usually is inadequately appraised. An estimated 60 percent of the agricultural flood damage caused by the major flood of 1964 consisted of land damage loss. Some 20 million tons of farm soil were washed into the streams by this flood to the permanent detriment of the valley's productive capacity.

The erosion season on cropland starts in the late fall and extends over the winter and into the spring. Usually in the late fall heavy rains do much damage to areas that are not protected. The winter and spring rains continue the erosion process if vegetative cover does not become established. In general, the rainy season is of long duration and the soil becomes fully saturated. Whenever a heavy storm occurs, it contributes to the erosion hazard and causes considerable damage to newly seeded lands, clean-tilled orchards and berry fields. Occasionally, soil freezing contributes to erosion.

Sheet, gully and rill erosion are serious local problems, but are not serious from a basin standpoint. Occurrence of this type of erosion affects most farmlands in varying degrees. Sheet and rill erosion with the accompanying soil loss and depletion, occurs on sloping fields during the wet winter period. In addition, gullies develop principally in steeply sloping swales and drainage ways, unless protected by grassed waterways. Flood-plain scour is caused by overbank flows and occurs most frequently along the uncontrolled smaller tributary streams. The hazard of flood-plain scour makes it necessary to plant winter cover crops.

There is some severe erosion, generally temporary, associated with nonagricultural land use. Such erosion occurs principally in connection with building site development and road construction. Unprotected earth embankments, cut slopes and drainage ways, are often seriously eroded by excess water. This can be reduced by careful construction operations and the early planting of vegetative cover.

Streambank erosion, the major source of sediment in the basin, occurs at scattered locations along larger rivers and tributary streams. Most of the streambank losses coincide with the high water flows during the wet winter period. The principal onsite damages are: loss of agricultural land, gradual development of acute changes in channel locations, interference with land use operations, and failure of adjacent construction such as roads and buildings.

Sediment and its deposition effects are not a large problem on basin lands during most years. However, there are problems of a serious localized nature. Farm ponds and reservoirs located below large cultivated areas are subject to sedimentation rates considerably above the basin average. Accordingly, these small structures are subject to a high rate of storage volume loss. Conservation measures are very important in these critical sediment source areas.

Cultivated lands require a wide variety of land treatment measures depending on the crop and the land capability. Much of the grass, grain and forages are grown on the steeper hillsides, or, as in the case of several grasses, on the flat benches of heavy, poorly drained soils. On the steeper lands contour farming, chiseling, conservation cropping systems, crop residue use, grassed waterways, and diversions may be required. The flat lands will require drainage measures.

As cultivation intensity increases in row crops, specialty crops, orchards and berries, the problem potential increases and greater combination of land measures may be in order. Contour planting and cover crops become critically important. Greater drainage needs are usually experienced.

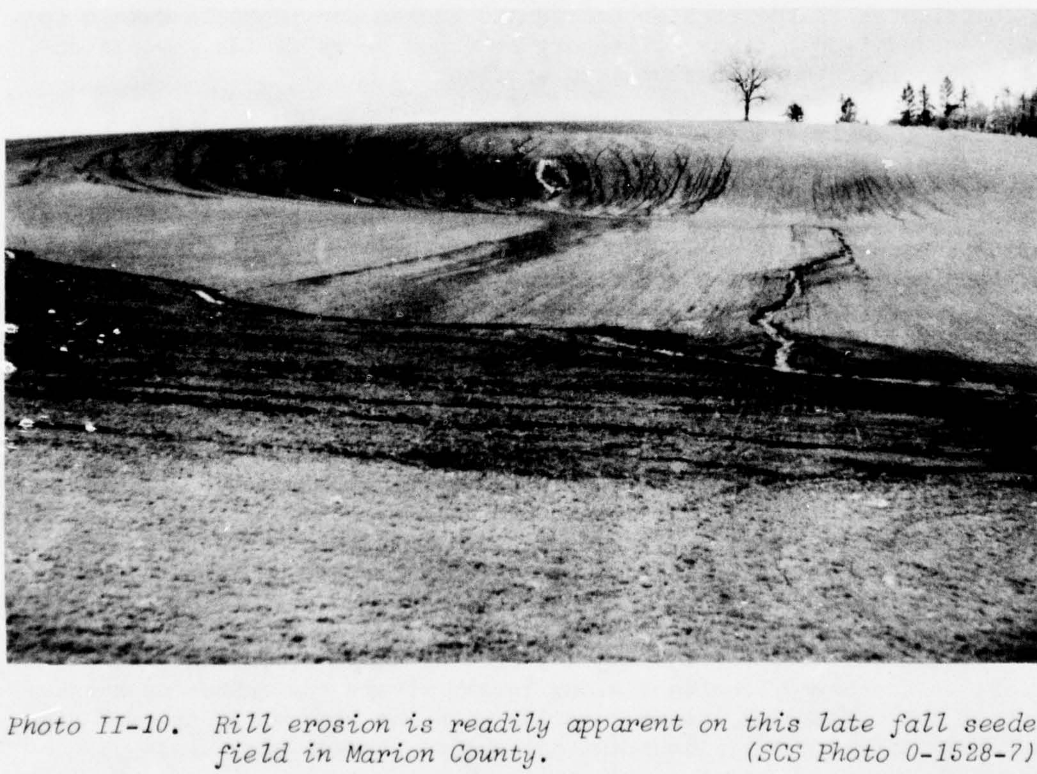


Photo II-10. Rill erosion is readily apparent on this late fall seeded field in Marion County. (SCS Photo 0-1528-7)

Photo II-11. Rill erosion and sheet erosion of severe proportions is occurring on this field left bare over winter.
(SCS Photo 0-7525-8)

Photo II-12. This gully started with water running down the farm field road--two days later it was like this.
(SCS Photo 0-1731-11)

Photo II-13. Flood-plain scour has stripped 1-2 feet of soil from an orchard located along the Willamette.
(SCS Photo F-116-6)

Photo II-14. A natural waterway is protected by a permanent grass cover, Subbasin 11, Clackamas County. (SCS Photo F-64-9)

Photo II-15. *Strawberries can be planted on the contour to help prevent erosion, Subbasin 10.* (SCS Photo B-847-2)

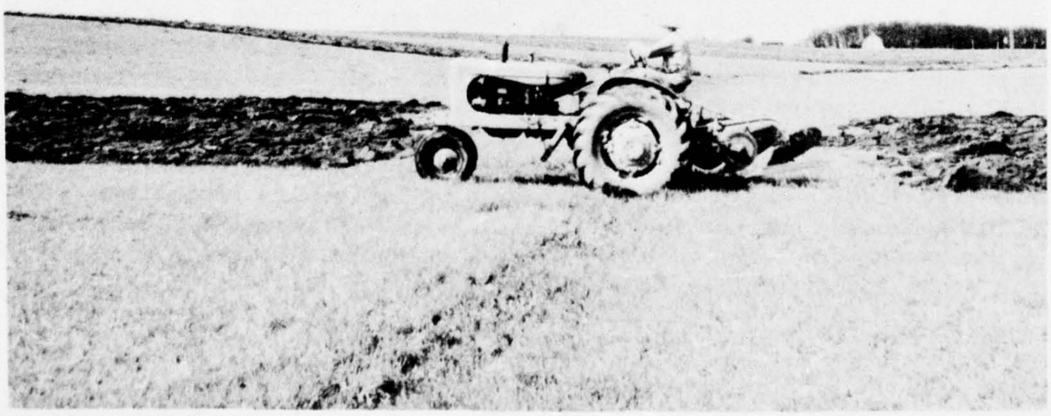


Photo II-16. *This field is being plowed around the hill, but the permanent grassed waterway is undisturbed.* (SCS Photo 7-495-10)

Photo II-17. The soil in this filbert orchard is protected by a winter cover crop, Subbasin 8. (SCS Photo 7-550-9)

EROSION AND SEDIMENTATION

The history of erosion and sediment control is recounted briefly in Part I. Before the white man, the land was in permanent cover and erosion was at a minimum with exception of the periods after a catastrophic event such as a major forest fire. Even then the land healed quickly. The white man came and began clearing land and farming both the hills and the bottom lands. Areas were abused, erosion increased rapidly as did flooding and flood-plain scour. In many areas the abuse was so bad that the land was abandoned. By the turn of the century, most unclaimed land was gone--farmers found they could not move on to better areas every few years. Gradually farmers began to use crop rotations to help maintain their production. New crops that improved forage potentials were introduced. Then in the 1930's the grass seed industry developed and many of the eroding hills were seeded down to permanent cover and the vast wet lands seeded to annual and perennial rye grasses. Thus the pendulum swung back again. However, portions of the problem and certainly the problem potential still remain.

Foothills

The foot slopes of the basin foothills made up an important part of the farmland first developed by the older settlers. Wheat and other small grains were the major crops up until the 1920's. The method of farming was such that for about one-half the time fields were fallow over the winter months. There is evidence to indicate that certain soils were altered during a 70-year period of continuous, though not necessarily severe, erosion.

Substantial areas of soils formed on foot slopes, including Chehalem, Jory, Nekia, Salkum, Steiwer, and Willakenzie, as well as associated series, are included in the area that may have been influenced by early erosion. The degree and intensity of alteration varies with slope and historical use.

Beginning in the 1920's, methods of management began to evolve that led to the development of a system of farming that in general provides winter cover on these soils formerly subjected to recurrent erosion. Over most of the area, management systems include planting of crops that provide good winter cover. Predominant cropping systems include perennial grasses for seed, perennial grass and legume forage crops, winter annual and biannual legumes for seed and forage, and winter grain. This type of farming has extended to the majority of foothill soils devoted to agriculture.

The deeper soils on the foothills, particularly in the north half of the basin, support a major portion of the basins' tree fruit and nut industry. In the early stages of the development of the orchard industry, clean cultivation was generally practiced and winter erosion was often intense. Erosion probably was a major factor leading to the abandonment of substantial areas of orchard land, partciularly in the southern half of the valley. Existing older orchards occasionally provide evidence of past serious erosion. Beginning in the 1930's, the practice of using winter cover crop began to be quite generally adopted in the orchard areas. However, most of the orchard lands are still not adequately protected during the winter.

At the present time, excessive rainfall creates a major problem, particularly with the foothill soils and associated terraces in the northern part of the basin. The most erosive soils are those covered with a silt mantle. These soils are quite erosive because of the lack of a well developed structure as compared to those soils weathered over bedrock. However, they are deep and have natural high fertility. Large areas have been devoted to the production of intensive row crops, berries, vegetables, potatoes and nursery stock. Cover cropping is not always practical. Intensive use and subsequent heavy foot and machine traffic result in varying degrees of soil compaction. Erosion remains a serious problem in this intensively utilized area.

To the southward on the less erosive soils formed over native rock, erosion is generally not serious. However, there are localized areas intensively used for production of strawberries and other row crops where erosion is a continuing and sometimes critical problem. Also, throughout the basin there are many isolated areas where adequate cover is not provided, with resulting erosion losses.

On occasions there are seasons when erosion is extensive on much of the foothill farmland because annual winter cover has not become established. This condition occurs when lack of rainfall retards fall establishment or freezing weather destroys the stand.

From the standpoint of erosion, it is fortunate that most of the steeper slopes, 20 percent and steeper, were never cleared and remain as forest land. Further, and more important, most areas of steep land once cultivated are now covered with permanent grass or forest.

Older Terraces

The Willamette soils and other soils formed on terraces have only limited erosion problems. In the generally flat or gently sloping topography, runoff seldom achieves erosive velocities. The terraces lie at an elevation above the reach of floods. Erosion from rainfall, however, can be a serious problem locally, particularly adjacent to streams. Here surface slopes increase and erosion can be serious on unprotected land. Woodburn, Salem, Hillsboro and Aloha are typical soil series in these problem areas.

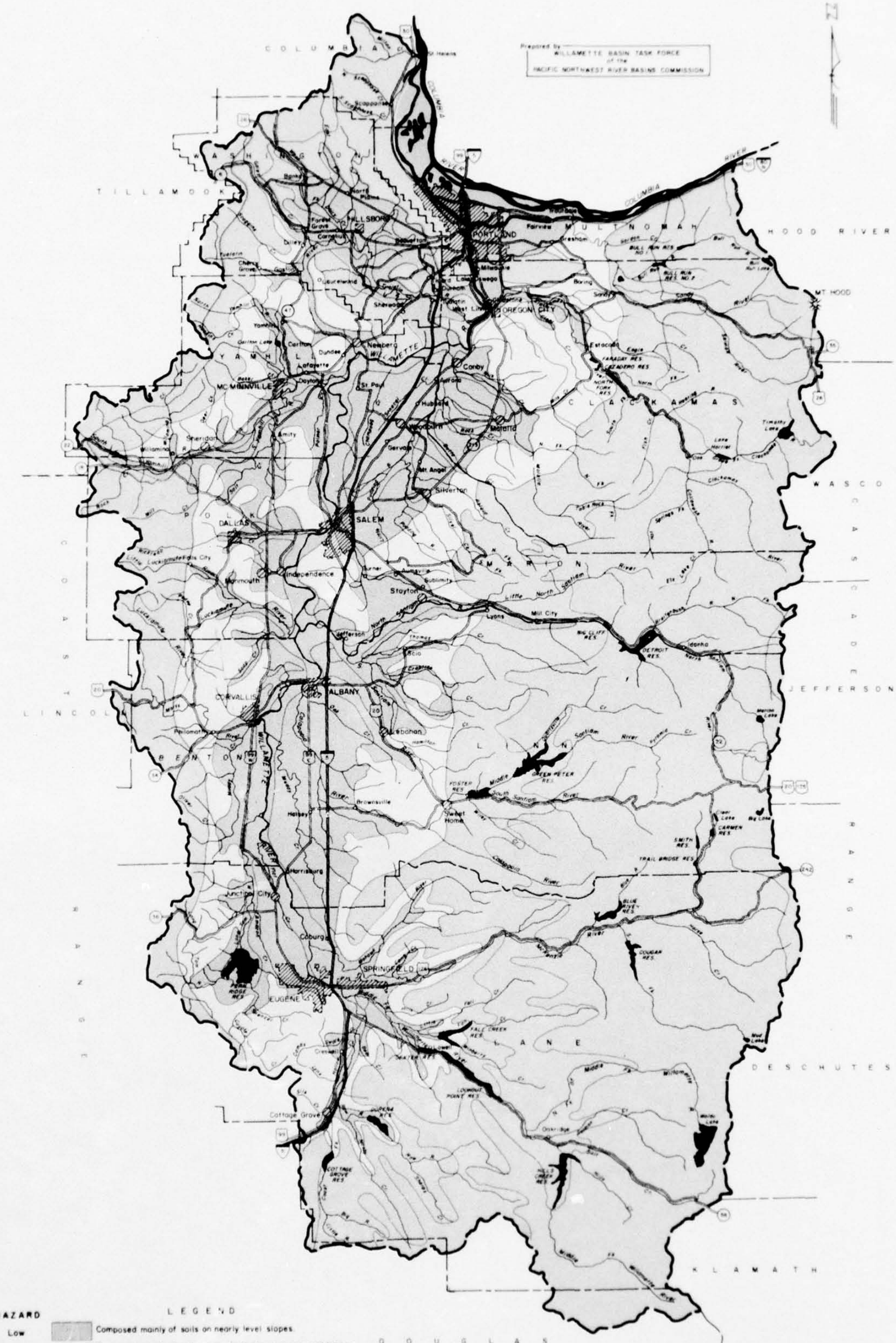
The major terrace area in Multnomah County has steeper slopes than the Willamette terrace. The major soil series is Sauvie, highly erosive because of a high silt content and weak structure. The erosion problem is aggravated by intensive agricultural land use. Much of the area is devoted to production of berries and other row crops.

Recent Alluvials

The soils formed in recent alluvium of the flood plains and low terraces along the Willamette River and major tributaries were developed agriculturally much later than the terrace and foothill areas, probably because of the recognized threat of floods. However, recent development has been rapid and intensive. At the present time substantial acreages are cleared and brought into cultivation each year. The area includes some of the most productive soils in the basin. The better drained soils--Chehalis, Cloquato and Newberg--are largely devoted to the intensive production of row crops. A high percentage of the area is irrigated. Periodic erosion has been serious in the past even on those soils with excellent natural drainage. The extent and nature of the damage varies with location and nature of the overflow, as well as local land use. Damage was particularly severe during the 1964-65 floods.

Because of excellent drainage characteristics, sizable areas of Newberg and Chehalis are devoted to crops such as carrots intended for harvest during the winter months. These fields are especially subject to erosion. The heavier soils of the recent alluvials, such as the Bashaw, Waldo and Wapato series, were deposited by backwater and are less susceptible to erosion.

Map II-8 illustrates the erosive potential of Willamette Basin soils which may aid in guiding future land use changes.



LEGEND

HAZARD		
Low		Composed mainly of soils on nearly level slopes.
Medium		Composed mainly of soils on gentle to strong slopes and having favorable combinations of infiltration and permeability
High		Composed mainly of soils on strong to steep slopes and having somewhat restricted permeability
Very High		Composed mainly of soils on steep to very steep slopes and having restrictions in profile depth and/or permeability

(Up to 15 percent of each segregation may be inclusions of soils with slope classes, infiltration, and permeability outside the defined limits)

MAP II-8

WILLAMETTE BASIN STUDY

OREGON

POTENTIAL ERODIBILITY

1967

SCALE IN MILES

WBTF-O-1049-L

Erosion Factors

Upland Erosion

Average climatic conditions in the Willamette Basin tend to provide a limited stress on the stability of upland agricultural soils. Studies of factors which contribute to high rates of erosion have shown that high intensity rainfall is characteristically one of these. In the Willamette Basin rainfall is normally of low intensity. The gentle rains of long duration contribute toward a healing of disturbed locations unless the disturbance is continued or scars such as gullies become deeply ingrained. A departure from average climatic conditions which greatly accelerates erosion occurs when saturated soils are frozen followed by a sudden warming trend accompanied by rain, melting snow, or both.

Soils most susceptible to erosion are those of silty texture. Soils which fit closest to this description in Willamette Basin are those on sloping lands near Gresham and locally on the west side of the valley. Of the topographic factors generally considered to be significant in causing erosion, steepness and length of slope are the most important.

Of the four major factors affecting rates of erosion--climate, soils, topography and cover--the last has the most dominating influence. If vegetative density is high enough, it doesn't matter greatly whether or not the other elements are conducive to high soil loss--the protection afforded by good cover will keep erosion to a minimum. In the upland agricultural lands, row crops provide the least protection while grass grown for seed or orchards with cover crops provides the best.

Flood-Plain Scour

Flood-plain scour erosion results from flood flows which exceed channel capacities and spread over flood plains. The erosive force is intensified if swales or depressions enable concentration of flow. Soil damage from scour occurs mostly on fallow land, row crops and fall-seeded grain fields. In addition to the loss of land, scour generally requires releveling of fields for continued crop production. During the December 1964 flood, heaviest damage from flood-plain scour occurred in the central portion of the basin, particularly along North and South Santiam Rivers and Crabtree and Thomas Creeks.

Channel Erosion

An analysis of suspended sediment discharge (Henry W. Anderson; Trans. Amer. Geophysical Union, Vol. 35, No. 2, April 1954; pp. 268-281) has indicated that the main channel of the river has been contributing about 54 percent of the total sediment volume produced, forest land 24 percent and agricultural land 22 percent. A partial reason for the high proportion of sediment yield from banks is that most fine soil erosion drop out at the base of slopes or on flood plains enroute to the principal channels. If it were possible to measure the amount deposited upstream, the yield from slope erosion would prove to be a much larger proportion of the total.

In addition to erosion along the main stem of the Willamette River, many of the tributaries show evidence of intermittent bank cutting. During the December 1964 flood, those streams which showed the strongest evidence of erosion were North and South Yamhill Rivers and some of their tributaries, Little Muddy Creek and Thomas Creek.

Measurements of Erosion

During the middle of February 1949, hard rains falling on partly frozen and snow-covered soils resulted in one of the most severe periods of soil erosion in the history of the basin. The Soil Conservation Service made a survey to determine the extent of land damage to cropland, and the effect of different soil conditions and land use on erosion. The survey revealed that approximately 97,000 acres of agricultural land lost approximately 1,000,000 tons of soil.

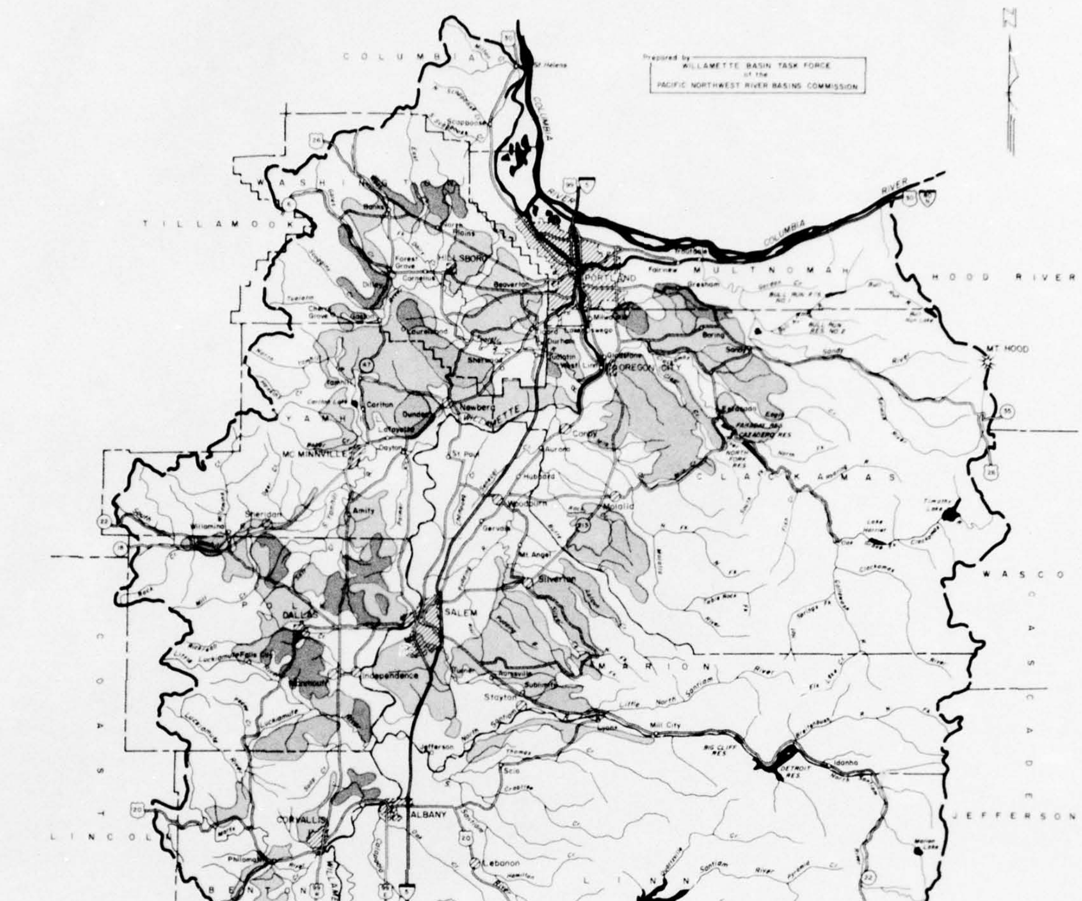
Map II-9 divides the Willamette Basin erosion areas into three soil loss categories. Almost all areas with erosion problems will have approximately the following loss:

Erosion Grouping	Soil Loss tons/acre/year	Soil Loss inches/year
None to slight	0- 5	0-.03
Moderate	5-20	.03-.12
Severe	20-50	.12-.30

Climatic conditions somewhat similar to those of February 1949 again occurred in December 1964. Soil losses from sloping land were nearly as widespread but not so severe as during the 1949 storm (Map II-9). On the other hand, it was evident that soil losses from floodplain scour were more severe during the 1964 flood, exceeding by far the approximately 150,000 tons eroded in 1949. Channel bed and bank cutting were also much more severe in December 1964.

Deposition of Sediment

Sediment deposition tends to occur initially at a break in the slope gradient. This usually occurs near the toe of the hill from which the sediment was derived, causing accumulating of colluvial deposits. In 1949, about 20 percent of the eroded material deposited as colluvium, covered an aggregate of about 400 acres of fall-seeded crops with 3 or more inches of sediment. Because of the much greater volume of water produced by storms such as that of December 1964, overbank flooding and associated sediment deposition were of considerably greater magnitude. Most of the sediment consists of silt sizes which do not cause any permanent damage but either require removal when deposited in or around structures or regrading of cropland. Gravel splays are deposited from larger streams when channel capacity is exceeded and overland flow begins.



MAP II-9
WILLAMETTE BASIN STUDY
OREGON

UPLAND EROSION AREAS ON CULTIVATED LANDS
1949 AND 1964 STORMS

1967

WBTF-O-1050-L

Sediment is also deposited in some of the low-gradient tributary channels and in the Willamette River channel. Data is available from the Corps of Engineers on the amount of material removed by maintenance dredging from the river, averaged over a five-year period. The average annual amount is shown in Table II-5.

Table II-5
Average Annual Sediment Removal from Willamette River Channel

Reach	River Mile	Quantity (cu. yds.)
Mouth to Broadway Bridge	0-11.6	1,548,000
Broadway Bridge to Ross Island Bridge	11.6-14.0	29,300
Upstream of Ross Island Bridge	14.0-144.0	655,000
Total	0-144.0	2,232,300

Damages caused by sedimentation include cost of dredging the river and Portland harbor, increased cost of treating municipal and industrial water supplies, cost of cleanup and land releveling. Damage occurs to the fisheries resource by erosion and deposition in spawning and feeding areas, but is difficult to assess. It is known that bank cutting undermines trees and the resulting tree loss reduces shading of the water; silt deposited with gravels reduces permeability and oxygen supply to redds or nests; and turbid water filters light needed for adequate food supply.

Table II-6 summarizes reported sediment and erosion effects of the 1964 storm event. Land and channel restoration costs were estimated at $2.4 million from this single storm. In addition, road damages totaled over $2.5 million. This tabulation shows only the immediate estimates of restoration activities. Many thousands of additional acres experienced scour and gullying and had reduced crop yields for one or more years.

Table II-6

Summary of Sedimentation and Land Damage in the Willamette Basin
December 1964 Storm 1/

County	Land Damage	Unit	No. Units	Cost of Restoration($)
Benton	Debris removal	acres	3200	32,000
	Grading & shaping Land	acres	9000	90,000
	Restoring Stream Channels	acres	10	10,000
Total				$132,000
Clackamas	Debris removal	acres	1500	90,000
	Brading & Shaping Land	acres	2000	200,000
	Restoring stream Channels	li.ft.	12000	240,000
	Permanent cover restoration	acres	250	7,500
Total				$537,500
Lane	Debris removal	farms	204	59,860
	Grading & shaping land	farms	447	186,399
	Restoring stream channels	jobs	172	86,000
	Permanent cover restoration	acres	756	26,250
Total				$358,509
Linn	Debris removal	acres	2850	142,500
	Grading & shaping Land	acres	2500	75,000
	Grading & shaping land	li.ft.	10000	10,000
	Restoring stream channels	li.ft.	70000	210,000
Total				$437,500
Marion	Debris removal	acres	12000	120,000
	Grading & shaping land	acres	5550	111,000
	Permanent cover restoration	acres	2000	30,000
	Permanent cover restoration	cu.yd.	20000	10,000
	Restoring stream channels	li.ft.	130000	130,000
Total				$401,000

Table II-6 (continued)

County	Land Damage	Unit	No. Units	Cost of Restoration ($)
Multnomah	Debris removal	acres	150	7,500
	Grading & shaping land	acres	400	24,000
Total				$31,500
Polk	Grading & shaping land	acres	4000	350,000
	Restoring stream channels	jobs	10	5,000
Total				$355,000
Washington	Debris removal	acres	1000	20,000
	Grading & shaping land	acres	600	18,000
	Grading & shaping land	feet	1260	500
	Permanent cover restoration	acres	720	18,000
	Permanent cover restoration	feet	2500	500
	Restoring stream channels	feet	15000	30,000
Total				$87,000
Yamhill	Grading & shaping land	cu.yd.	50000	12,500
	Debris removal	acres	1300	6,500
	Permanent cover restoration	acres	483.3	7,250
	Restoring stream channels	feet	26000	6,500
Total				$32,750
Basin Total				$2,372,759

1/ *Report of meeting on erosion and sedimentation - 1964-1965 flood season. Columbia County missing. Water Supply and Water Pollution Control, Sub-committee Columbia River Basin Interagency Committee - April 29, 1965.*

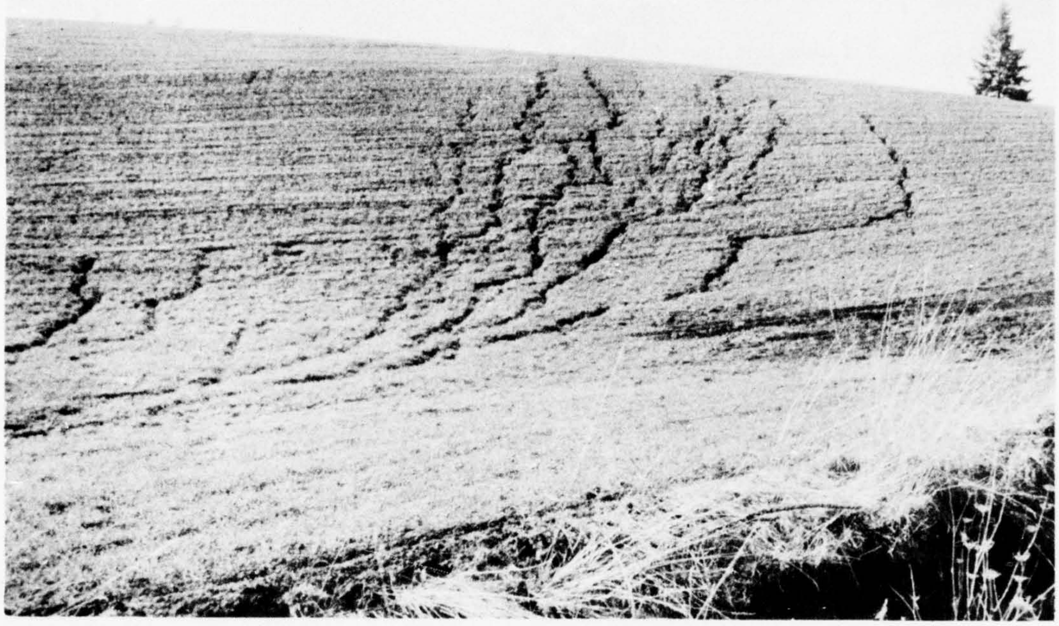


Photo II-18. Upland erosion loss at 40 tons per acre. On shallow soils this soon restricts crop yields. (SCS Photo 0-1390-4)

Photo II-19. Unprotected row cropland in Multnomah County after the 1964 storm. (SCS Photo 0-1760-9)

AD-A036 759 PACIFIC NORTHWEST RIVER BASINS COMMISSION VANCOUVER WASH F/G 8/6
THE WILLAMETTE BASIN COMPREHENSIVE STUDY OF WATER AND RELATED L--ETC(U)
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Photo II-20. Sheet erosion on the upper part of the field creates deposition problems below. (SCS Photo 0-595-4)

Photo II-21. Prior to the 1964 flood, this was a young orchard near Salem; major flood prevention improvements are needed here. (SCS Photo 0-1743-11)

FLOODING

Soil properties influence the rate of runoff from rainfall and snow melt. They must be considered, even if only indirectly, in methods of flood control. When runoff from individual storms is the major concern the properties can be represented by a hydrological parameter--the minimum rate of infiltration obtained for a bare soil after prolonged wetting.

Vegetative cover is important in the rainfall-runoff relationship because it is a major influence in determining the amount of water that will run off and that which will infiltrate and be available for plant use and the recharging of ground water. The infiltration rate is the rate at which water enters the soil at the surface and is controlled by surface conditions.

The rate of runoff varies from place to place. Some areas have high runoff while others produce much less runoff with the same rainfall amounts. The hydrologic soils groups (see Map II-10) are:

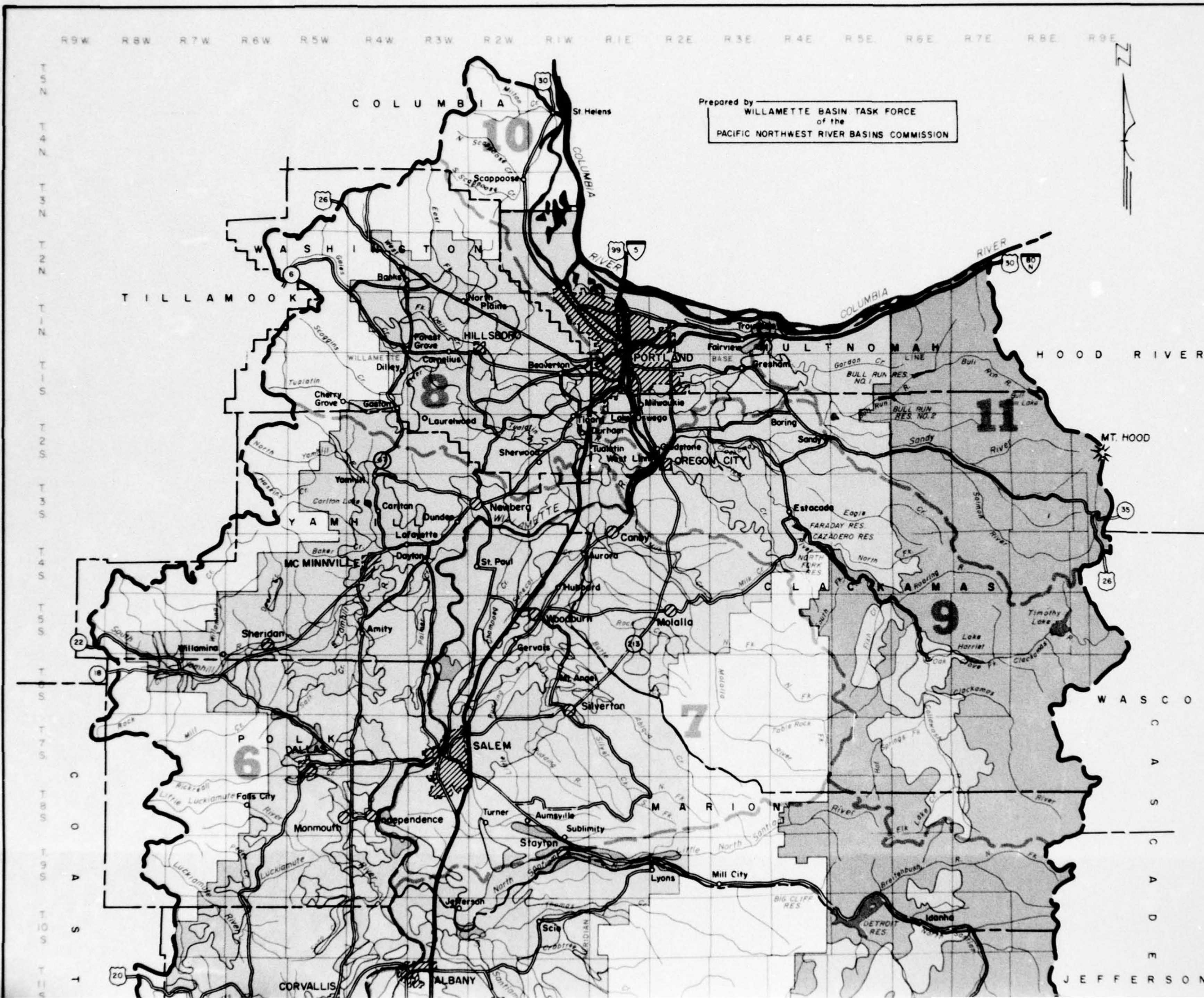
A. (Low runoff potential). Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission.

B. Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

C. Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

D. (High runoff potential). Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

In most portions of the Willamette Basin, a change in land use will reflect very little difference in flooding conditions. An estimated 66 percent of the basin is in forest cover--located primarily at the higher elevations. Only 34 percent of the land is devoted to agriculture and other uses and is on the valley terraces and floor. A reduction in flooding by a change in land use and treatment would, therefore, be of a localized nature.



Prepared by
WILLAMETTE BASIN TASK FORCE
of the
PACIFIC NORTHWEST RIVER BASINS COMMISSION
COLUMBIA
WASHINGTON
TILLAMOOK
YAMHILL
POLK
MARION
CLACKAMAS
MULTNOMAH
HOOD RIVER
WASCO
JEFFERSON
CASCADE
COAST
PORTLAND
SALEM
OREGON CITY
HILLSBORO
MC MINNVILLE
CORVALLIS
ALBANY
St. Helens
Scappoose
Gresham
Estacada
Sandy
Molalla
Silverton
Woodburn
Newberg
Dallas
Independence
Monmouth
Stayton
Lyons
Mill City
Idanha
MT. HOOD
COLUMBIA RIVER
10
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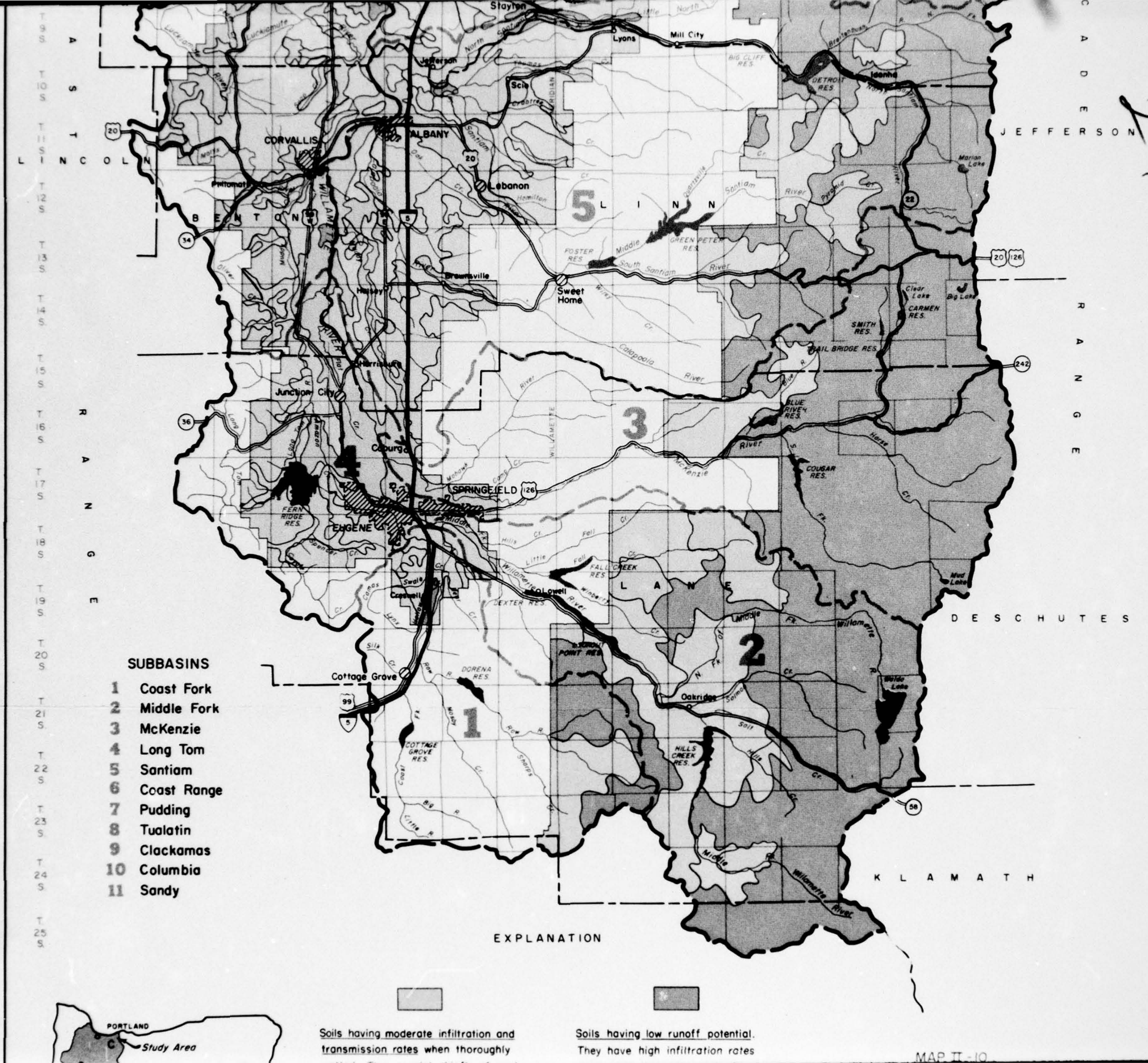
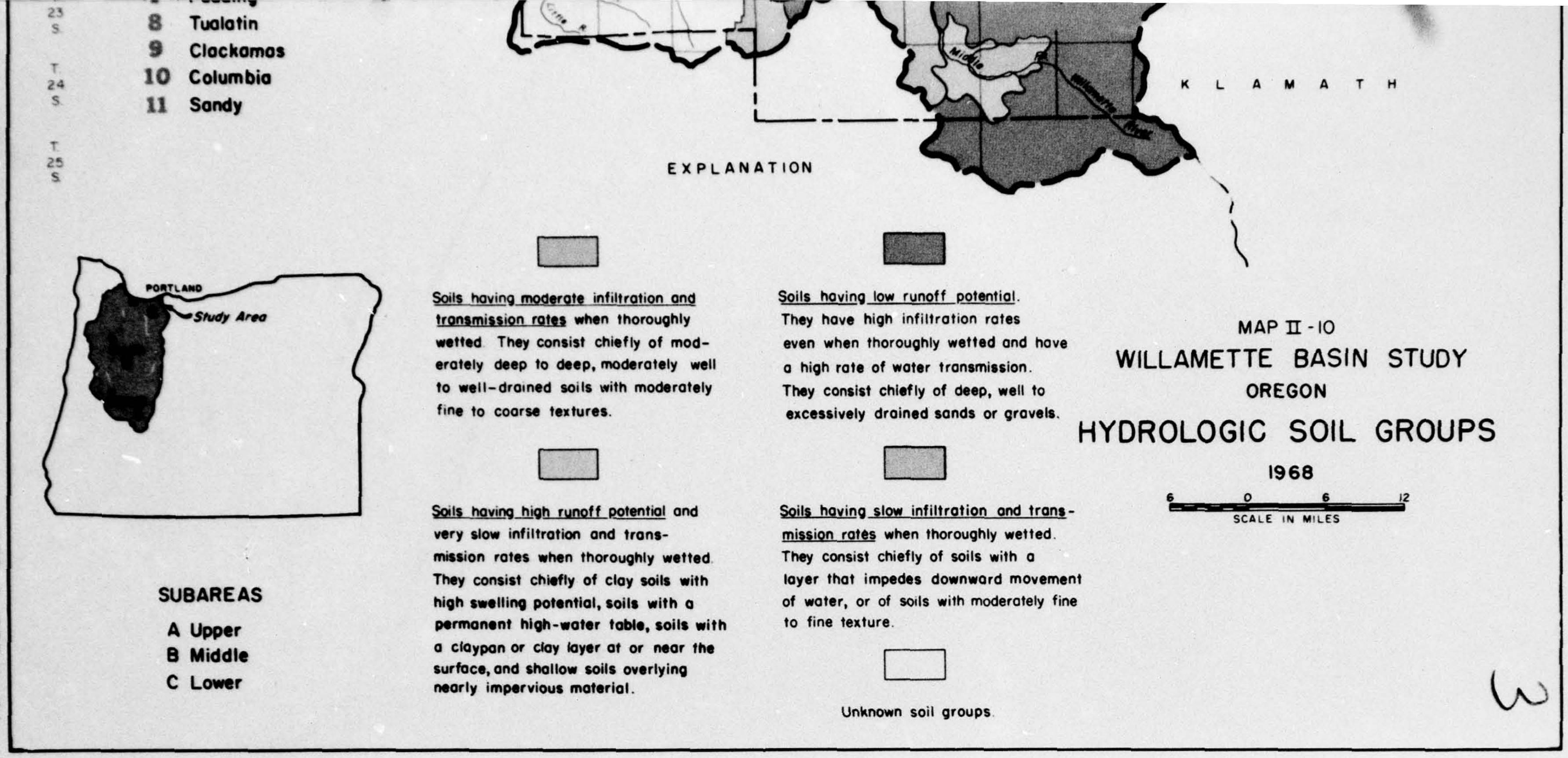

SUBBASINS
1 Coast Fork
2 Middle Fork
3 McKenzie
4 Long Tom
5 Santiam
6 Coast Range
7 Pudding
8 Tualatin
9 Clackamas
10 Columbia
11 Sandy
EXPLANATION
Soils having moderate infiltration and transmission rates when thoroughly
Soils having low runoff potential. They have high infiltration rates
PORTLAND
Study Area
CORVALLIS
ALBANY
Lebanon
Sweet Home
Lyons
Mill City
Stayton
Jefferson
Scio
Brownsville
Halsey
Harrisburg
Junction City
Coburg
SPRINGFIELD
EUGENE
Cottage Grove
Oakridge
Lowell
Philomath
Idanha
DETROIT RES.
BIG CLIFF RES.
GREEN PETER RES.
FOSTER RES.
SMITH RES.
CARMEN RES.
TRAIL BRIDGE RES.
BLUE RIVER RES.
COUGAR RES.
FALL CREEK RES.
DEXTER RES.
DORENA RES.
COTTAGE GROVE RES.
HILLS CREEK RES.
FERN RIDGE RES.
LINN
BENTON
LANE
LINCOLN
JEFFERSON
DESCHUTES
KLAMATH
MAP II-10



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Generally basin flooding is the result of heavy rainfall following low-intensity storms occurring over several days. The gentle rainfall saturates the ground in two or three days so continuing rainfall becomes all runoff. Usually this type of storm will cover the basin fairly uniformly so flooding is widespread.

General flood-plain areas are shown on Map II-11 and specific data for a number of upstream tributary watersheds has been tabluated in Table II-7. In the upstream areas over 63,000 acres floods each year and over 110,000 will be inundated on a maximum event. The relationship of yearly flooding to the maximum flood plain is significant.

Most basin floods occur during the winter months of December, January and February. Usually sufficient rainfall has fallen prior to this season to provide a good vegetative cover except for fall seeded grass or grain and some row crop and orchard lands. Quite often floods will occur when a warming condition in the higher elevations creates heavy rainfall on the heels of a heavy snow. The ground may be frozen. This was the condition prior to the Christmas flood of 1964.

Because of the extended light rainfall patterns prior to the main rainy season, much of the basin is in a nearly saturated condition during the floods. Changed land use or various land measures will have very little effect on the quantity of water or peak rates of runoff.

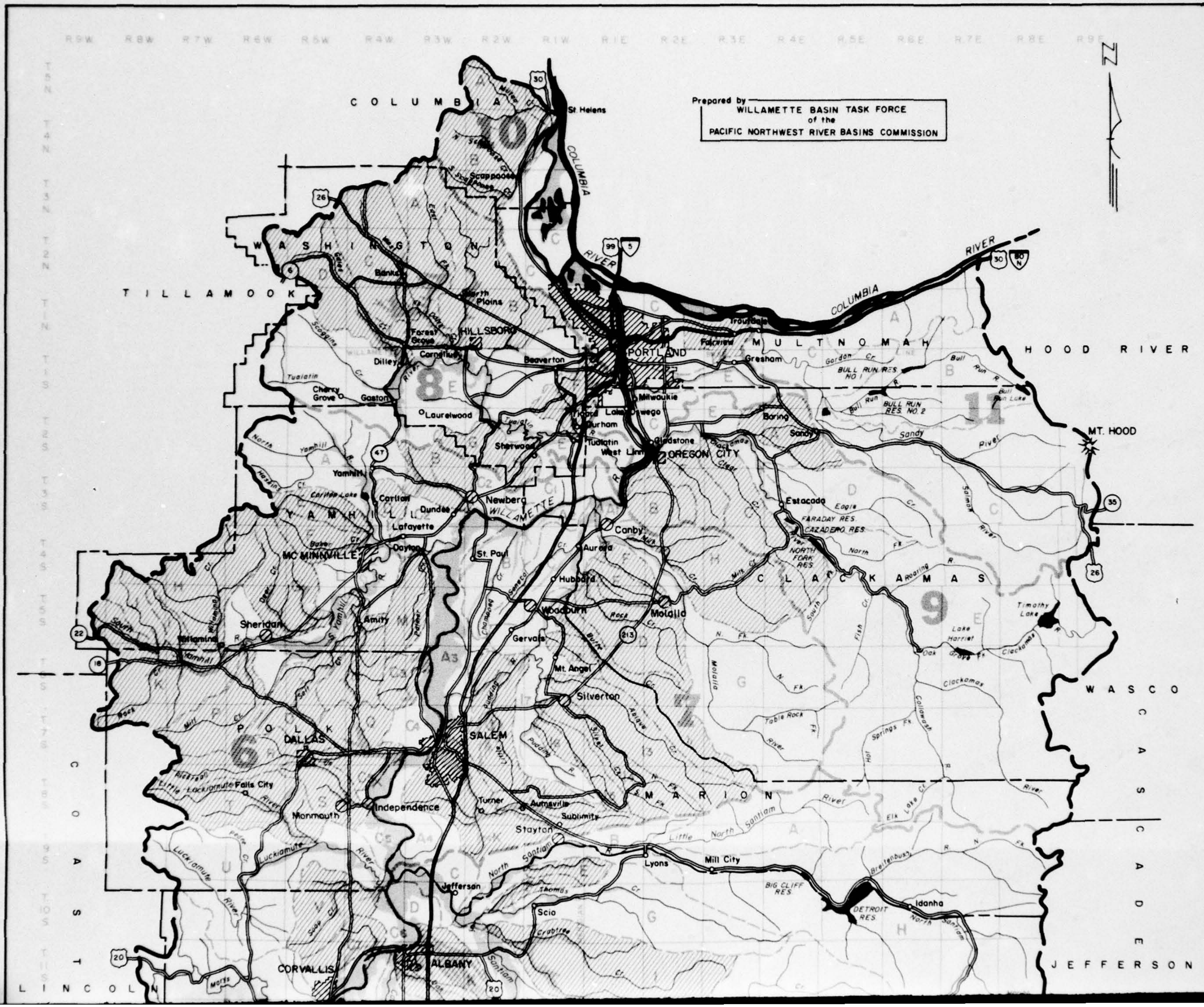
Photo II-22. Typical flood scene in Willamette Basin. Thousands of acres are inundated each year. (SCS Photo 0-75182)

Table II-7

Upstream Tributary Flooding on the Lesser Basin Streams

Subbasin and Tributary	Number 1/	Acres Flooded Maximum	Yearly	Average Annual
1--COAST FORK				
Camas Swale	1-B	2,700	1,560	1,600
Cloverdale	1-D	1,880	1,090	1,200
Gettings Creek	1-E	260	151	164
Silk Creek	1-F	174	101	110
Martin Creek	1-G	114	66	72
		5,128	2,968	3,146
2--MIDDLE FORK				
Hills Creek	2-B	50	29	32
Rattlesnake	2-C	550	50	240
Lost Creek	2-D	140	81	88
		740	160	360
3--MCKENZIE				
Camp Creek	3-C	124	72	78
4--LONG TOM				
Amazon-Flat Creek	4-C	17,200	10,000	11,000
Ferguson Creek	4-D	1,050	610	660
Bear Creek	4-E	1,800	1,040	1,130
Coyote-Spencer Creek	4-F	4,350	2,520	2,740
		24,400	14,170	15,510
5--SANTIAM				
Sucker Slough	5-F	810	470	500
Crabtree Creek	5-I	5,856	3,397	3,689
Grand Prairie	5-K	9,060	5,250	5,710
Oak Creek	5-L	1,959	1,136	1,234
East Muddy Creek	5-O	6,400	3,700	4,000
Walton Slough	5-P	2,300	1,340	1,450
Lake Creek	5-Q	740	0	233
Hamilton Creek	5-R	439	0	139
McDowell Creek	5-S	498	0	157
		28,062	15,293	17,112
6--COAST RANGE				
Chehalem Creek	6-B	1,110	640	700
Spring Valley	6-C_3	450	400	420
Bowers Slough	6-C_7	1,653	959	1,041
Hawn Creek	6-D	250	220	230
Panther Creek	6-E	1,006	869	755
Baker Creek	6-F	749	516	504
Deer Creek	6-G	1,600	800	810
Willamina Creek	6-H	540	61	125
Cosper Creek	6-I	50	40	45
Agency Creek	6-J	73	46	50
Upper South Yamhill River	6-K	1,793	345	604
Palmer Creek	6-M	830	780	800
Ash Swale	6-N	900	808	820
6--COAST RANGE (cont'd)				
Salt Creek	6-O	3,100	1,800	1,950
Mill Creek	6-P	1,129	732	742
Basket Slough	6-Q	1,310	826	842
Rickreall Creek	6-R	1,660	871	799
Ash Creek	6-S	1,500	640	760
Little Luckiamute River	6-T	2,900	1,600	1,700
Soap Creek	6-V	1,550	900	950
Muddy Creek	6-X	7,250	4,200	4,570
		31,403	18,053	19,217
7--PUDDING				
Rock Creek	7-D	1,154	669	727
Bear Creek	7-E	214	0	70
Gribble Creek	7-F	401	233	253
Milk Creek	7-H	938	544	591
Butte Creek	7-I_1	1,451	842	914
Zollner Creek	7-I_2	250	220	230
Abiqua Creek	7-I_3	770	447	485
Silver Creek	7-I_4	224	130	141
Drift Creek	7-I_5	318	318	318
Beaver Creek	7-I_6	172	100	108
Mill Creek	7-K	3,000	1,740	1,810
		9,092	5,243	5,647
8--TUALATIN				
East Fork Dairy Creek	8-A	1,900	1,100	1,200
McKay Creek	8-B	3,500	2,030	2,205
West Fork Dairy Creek	8-C	3,400	1,960	2,100
Gales Creek	8-D	3,268	1,896	2,059
Fanno Creek	8-F	300	272	280
Baker Creek	8-G	170	155	160
Chicken Creek	8-H	130	115	120
		12,668	7,528	8,124
9--CLACKAMAS				
Clear Creek	9-C	130	116	120
Abernethy Creek	9-F	209	121	132
		339	237	252
10--COLUMBIA				
Milton Creek	10-A	112	65	71
Scappoose Creek	10-B	158	92	99
Fairview Creek	10-D	200	110	120
		470	267	290
TOTAL		112,426	63,991	69,736

1/ Number refers to the tributary area shown on Map II-11.
Source: Soil Conservation Service, Willamette Basin Flood-Plain Study.


Prepared by
WILLAMETTE BASIN TASK FORCE
of the
PACIFIC NORTHWEST RIVER BASINS COMMISSION
COLUMBIA
TILLAMOOK
WASHINGTON
YAMHILL
POLK
LINCOLN
COAST
MULTNOMAH
HOOD RIVER
CLACKAMAS
MARION
WASCO
CASCADE
JEFFERSON
COLUMBIA RIVER
WILLAMETTE
MT. HOOD
St. Helens
Scappoose
Banks
North Plains
Forest Grove
HILLSBORO
Cornelius
Beaverton
Dilley
Gaston
Cherry Grove
Laurelwood
PORTLAND
Troutdale
Fairview
Gresham
Milwaukie
Lake Oswego
Tigard
Durham
Tualatin
West Linn
Gladstone
OREGON CITY
Sherwood
Boring
Sandy
Estacada
Yamhill
Carlton
Newberg
Dundee
Lafayette
Dayton
MCMINNVILLE
St. Paul
Aurora
Canby
Hubbard
Woodburn
Molalla
Gervais
Mt. Angel
Silverton
Sheridan
Willamina
Amity
DALLAS
SALEM
Falls City
Monmouth
Independence
Turner
Aumsville
Sublimity
Stayton
Lyons
Mill City
Idanha
Jefferson
Scio
CORVALLIS
ALBANY
BULL RUN RES NO 1
BULL RUN RES. NO. 2
FARADAY RES.
CAZADERO RES.
NORTH FORK RES
Timothy Lake
Lake Harriet
BIG CLIFF RES
DETROIT RES
Sandy River
Salmon River
Clackamas
Molalla
Santiam
Luckiamute River
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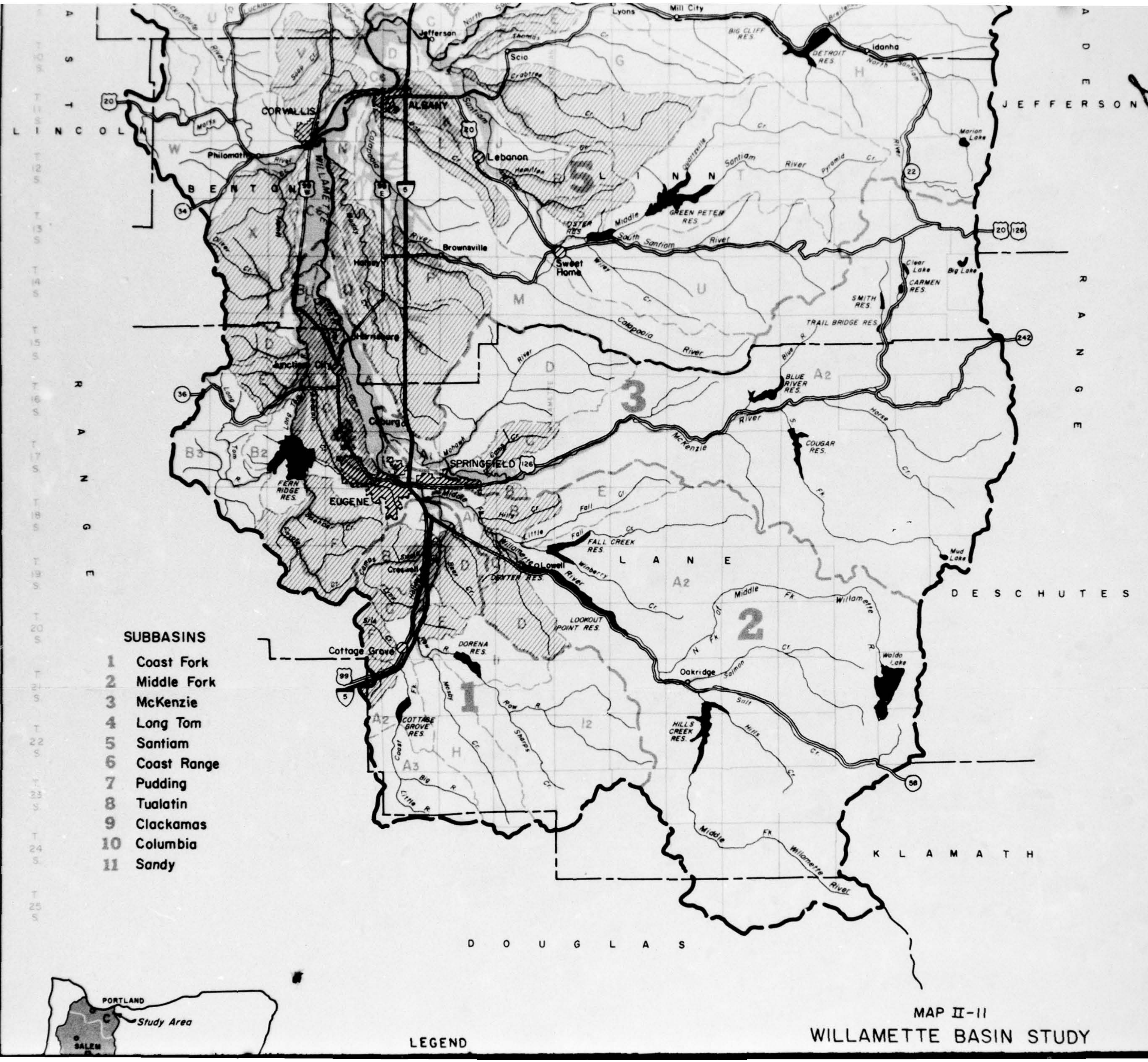
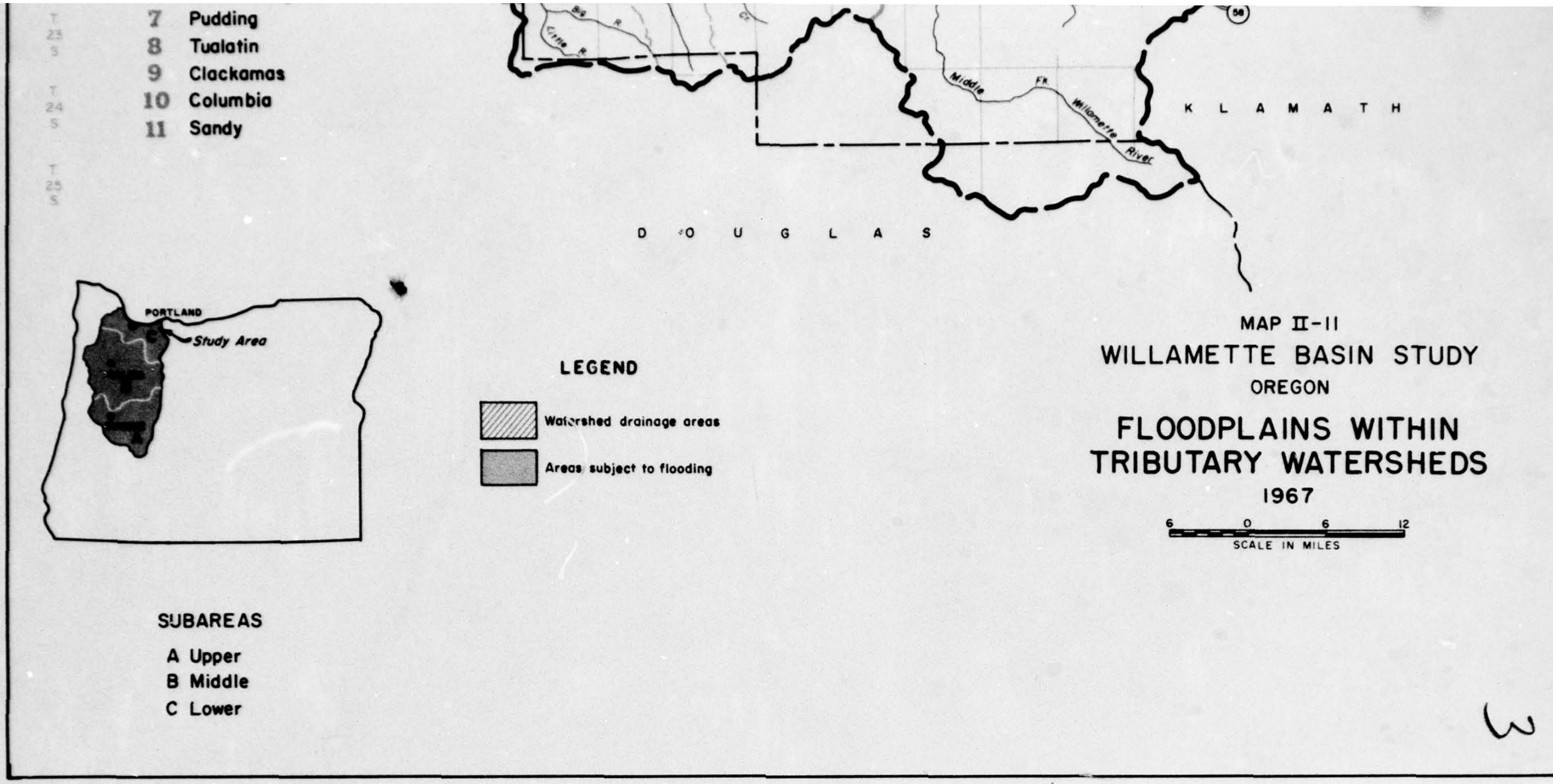


MAP II-11
WILLAMETTE BASIN STUDY



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The elimination of prolonged flooding is often a prerequisite to a successful drainage and/or irrigation system. Physical damage occurs to crops from actual flood flows and in addition, losses also result from floodwaters and excessive precipitation that is retained on the land. In the Willamette Basin, frequently recurring floods and ponding have retarded development of extensive areas of low lands to a point where individual landowners suffer extensive economic losses from the retained waters. Removal of these waters is one of the major needs to prevent this loss and permit more intensive land use.

WATER CONSERVATION

Land Measures in Applying Irrigation Water

Conservation of irrigation water involves applications when the plant needs it for best growth but only in such amounts as to uniformly refill the soil reservoir so the plant roots can get moisture. Wasted water often results in soil erosion, leached fertilizers and drainage troubles.

Soil directly affects the type of crop that can be grown. Additionally, it influences production costs and crop yields. The soil influences or properties that are of particular concern to an irrigator are soil texture, soil structure and soil depth and layering. These factors in their various combinations determine when, how much and how often to apply irrigation water.

Proper on-farm application of irrigation water is necessary to conserve water, land and soil nutrients. In order to accomplish proper irrigation, the farmer must consider each of the factors just discussed--namely crops and texture, structure and depth of the soil. Based on these physical factors he must plan his distribution system needs.

A proper distribution system is designed to apply the proper amount of water during peak crop use. This peak requirement may last only two weeks or a month during the hottest part of summer. During the early and late seasons either the time between irrigations may be lengthened or the amount of water applied per irrigation reduced.

Crops under irrigation may suffer from lack of water due to any of the following reasons:

1. Starting too late at the beginning of the irrigation season.

2. Too many days between irrigations.

3. Applying less water than the crop requires.

4. Failing to irrigate the soil profile completely at any irrigation.

5. Poor distribution of water from the sprinkler.

Irrigation must be timed so that the entire field may be covered before the soil at the first set gets too dry. Failure to start early enough may result in the irrigation program being "behind" all season.

Enough water should be applied at each irrigation to bring the soil to field capacity the full depth of the ultimate rooting zone of the crop. Once the soil has been wetted to field capacity, the ideal amount of water to apply at each irrigation is that amount used by the crop plus evaporation loss since the last irrigation plus that lost through distribution during irrigation. Applying more water leaches plant nutrients and raises power bills. Applying less will leave dry areas below the plant roots resulting in shallow root systems. Plant roots will not grow into dry soil even to reach moist areas below.

Light, frequent irrigations are ordinarily necessary on shallow or sandy soils. On heavy soils longer intervals between irrigations and slower water application rates are the rule.

The Irrigation Appendix more specifically details information on present irrigation as well as the potential for future development. Much of the presently irrigated 244,000 acres is on the better soils near the rivers and streams. These soils are deep and well drained but subject to extensive scour if cover crops are not planted. Further, from the streams the tighter, shallower and steeper soils have more severe limitations for irrigated use. Of the approximately 1,732,000 acres suitable for irrigation development as defined in the Irrigation Appendix, the dominant hazard or limitation is erosion on approximately 40 percent of the acreage, wetness on 30 percent and soil limitations on 20 percent. The remaining 10 percent have no serious limitations or hazards.

Land Management Practices for Irrigation

Land management is closely related to water management. Through proper land management, it is possible to irrigate areas which have definite limitations because of soils, erosion or wetness.

For irrigated lands, several land measures are necessary for sustained crop production and reduction of damage to the land itself. Most of these practices are so interrelated with erosion, flood control and drainage that they cannot be separated as necessary for a single soil or land capability use. Agronomic practices which improve soil structure are:

1. Conservation Cropping Systems: Growing crops in combination with needed cultural and management measures. Cropping systems include the use of rotation that contain grasses and legumes, as well as sequences in which the desired benefits are achieved without the use of such crops.

2. Cover and Green Manure Crops: A crop of close growing grasses, legumes or small grain used primarly for winter protection and for soil improvement.

3. Crop Residue Use: Utilizing plant residues left in cultivated field by incorporating them into the soil.

The most significant single practice is cover cropping. Much of the irrigated land is subject to flooding in the winter and may scour badly if not protected. This may also occur with improper irrigation applications prior to establishment of a cover crop. Many of the land measures recommended for erosion control should be applied to irrigated lands. Contour farming and subsoiling becomes more important when land is to be irrigated.

Irrigated soils with wetness problems require a number of additional land management practices. If the water problem is flooding, then floodwater diversion channels, dikes, floodways or floodwater retarding structures may be necessary. If drainage is the main problem a number of practices or combinations of practices may help, such as:

Chiseling and subsoiling
Drainage field ditches
Diversions
Drainage land grading
Drainage mains and laterals
Grassed waterways and outlets
Tile drains.

Under natural conditions the water table in most Willamette Valley soils rises following the winter rains, recedes during the spring and summer, and reaches its lowest point in the fall. Under irrigation with the most careful practices in which there are no percolation losses, the natural water table regimen should not be affected. In actual practice, however, irrigation is frequently accompanied by some percolation losses which contribute to the ground water table. If these losses are substantial and if drainage is not provided, the water table may remain high during the entire irrigation season, and plant root development, crop growth and farm production will be reduced. Only crops with shallow root systems which will tolerate wet field conditions will do well. Desirable water table depths can be maintained by the installation of subsurface drainage systems.

Future development will see a trend in cropping patterns to a higher percentage of intensive crops and a lower percentage of field crops. As this change in crop pattern takes place, good drainage will become more important.

Throughout the basin, poorly drained soils are intermingled with better-drained soils. Unless drainage is provided for the poorly drained soils, the development of farm and community irrigation projects is handicapped. Improved drainage can make large contiguous areas available for less costly irrigation project development.

Photo II-23. Checking the soil profile to determine potential problems. Clackamas County. (SCS Photo 0-1303-4)

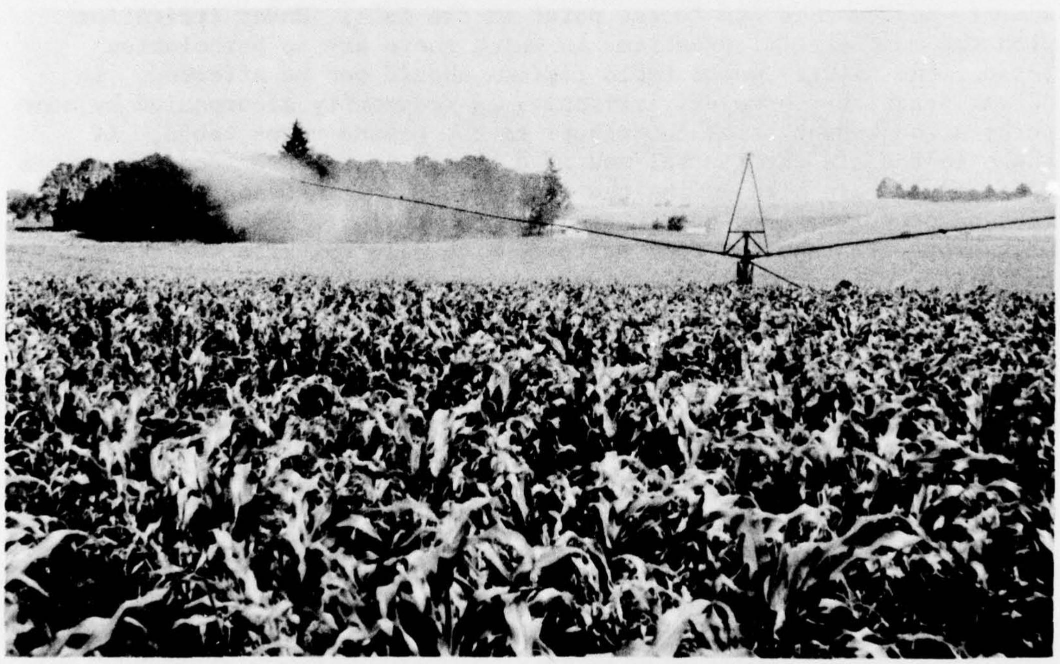


Photo II-24. Regulating pressure of end nozzles to avoid crop damage and soil loss is a problem. (SCS Photo 0-1439-4)

Photo II-25. On-farm irrigation canals must be maintained to avoid water losses and weed problems. (SCS Photo 0-739-11)

DRAINAGE

Lands suitable for agriculture in the basin total approximately 2.8 million acres. The 1965 Willamette Basin General Soil Association Map and Report classified about 1.3 million acres or almost one-half of the total as having an excessive wetness problem created by either a high water table, internal soil restrictions, or flooding and overflow conditions. As previously indicated, the installation of drainage has long been considered one of the more important land treatment measures by farmers.

According to ASCS and SCS records landowners invested over $16,000,000 in drainage between 1937 and 1964. These drainage improvements benefited approximately 432,000 acres. Records prior to that time are fragmentary, incomplete, or conflicting because of definition, but it is estimated that permanent drainage improvement valued at approximately $23,000,000 has been installed to date, benefiting approximately 500,000 acres of land in the basin. A comparison of the record for drainage improvements for the 22-year period from 1937 to 1959 with the 5-year period from 1959 to 1964 is shown in Table II-8.

Landowners are currently installing about 2,700,000 feet of drain tile and 230,000 feet of open drains annually, which benefit about 11,000 acres. Annual investment in drainage improvements is estimated at $600,000. About 95 percent of this investment is on individual farms with 5 percent being accomplished as a result of groups of two or more farmers pooling their efforts.

The unit values shown in Table II-8 are summarized from records of the ten counties that make up the basin. The counties experiencing the low and high investment per acre for open drainage are Lane and Marion, respectively; for closed drainage investment per acre the counties are Lane and Multnomah, respectively.

Table II-8

Investment in Drainage Improvements, With ACP and SCS Assistance

	1937-1959	1959-1964
Total acres drained	376,000	56,000
Total investment	$13,053,400	$3,030,600
Cost per acre	$34.70	$54.10
Annual accomplishment (acres)	71,100	11,200
Open Drains:		
Total acres drained	233,100	21,900
Total excavation	9,434,700	1,047,300
Total investment	$3,821,500	327,500
Annual accomplishment (acres)	10,500	4,400
Unit Values:		
Average cost per acre	$16.40	$15.00
Average cost per c.y.	$.41	$.31
Average c.y. per acre	40	48
Closed Drains:		
Total acres drained	142,000	34,100
Total investment	$9,231,900	$2,703,100
Annual accomplishment (acres)	6,500	6,800
Unit Values:		
Average cost per acre	$64.60	$79.30
Average cost per linear foot	$.23	$.20
Average linear feet per acre	277	400

Although the acreage annually improved in the most recent 5-year period is less, farmers are investing more per acre than in the earlier 22-year period. The investment was up because landowners are installing more efficient drainage with more tile per acre and more capacity in outlet ditches. This indicates that drainage requirements can change with time and cropping patterns. A drainage system adequate for small grains or forage crops at the time it was installed likely would be inadequate for growing strawberries, vegetables or other more specialized crops.

It is also significant that about 90 percent of the drainage investment for the recent 5-year period is in tile drainage compared to about 70 percent in the earlier period. Tile systems are preferred by farmers because they allow efficient farming, there are minor maintenance costs and no land is lost to production.

Nearly all of the tile drainage improvements have been installed by individuals. Many of the groups organized to undertake drainage work constructed open ditches to serve as outlets for individual drainage improvements. These outlets aid in removing floodwaters that otherwise inundate cropland for periods of two or more days to two weeks during the winter storms. In fact, it is difficult if not impossible, to distinguish flood protection from drainage benefits on most of the excessively wet lands in the basin. Channels properly designed to evacuate storm flows are of more than adequate capacity to provide good drainage outlets.

Drainage Problems

The lack of adequate outlets for much of the wet land has been and continues to be a major obstacle to improved development of these lands. Current accomplishments by individuals attest to the value farmers place on drainage practices as an economic and worthwhile improvement to their lands; but many are unable to make these improvements for lack of a suitable outlet. Repeated testimony from landowners during the 1963 and 1964 public hearings of the Willamette Basin Task Force listed the lack of community drains and tributary channel improvement as the major problems limiting future agricultural development of their lands.

The Oregon State University soil association report and drainage interpretive groupings were utilized to develop Map II-12. The map denotes only those soils and groups of soils of the basin where lack of community outlets is a problem. It portrays those areas of the valley floor where land slopes and natural channel gradients are flat. Under these conditions, frequent flooding occurs and high water tables persist. The map does not indicate the location or extent of all the soils in the basin with a drainage problem. Omitted from the map are those areas of the fans, footslopes, hill slopes and isolated valley floor areas where drainage improvements can usually continue to be accomplished on an individual basis.

The following soil groups and their characteristics were used as a basis for defining major outlet problem areas.

Group A

Approximately 75 percent of the soils in this group have difficult problems caused by excess surface water and lack of adequate outlets. The principal soils of this group are:

Dayton	Bashaw
Wapato	Concord
Holcomb	Courtney
Waldo	

The remaining 25 percent of the soils are intermingled and are not considered to have significant drainage problems.

Group B

The soils of this group are composed of Group A and Group C soils. They differ from the Group C soils in that the remaining 25 percent of the group are intermingled or isolated and have difficult problems caused by excess surface water or lack of outlets.

Woodburn	Quatama
Amity	Maytown
Aloha	Clackamas

Approximately 25 percent of this group are:

Dayton	Bashaw
Wapato	Concord
Holcomb	Courtney
Waldo	

Group C

Approximately 75 percent of the soils in this group require drainage for intensive use and are considered easily drained where suitable outlets are available. High water tables persist over extensive areas of soils in this group. The principal soils of this group are:

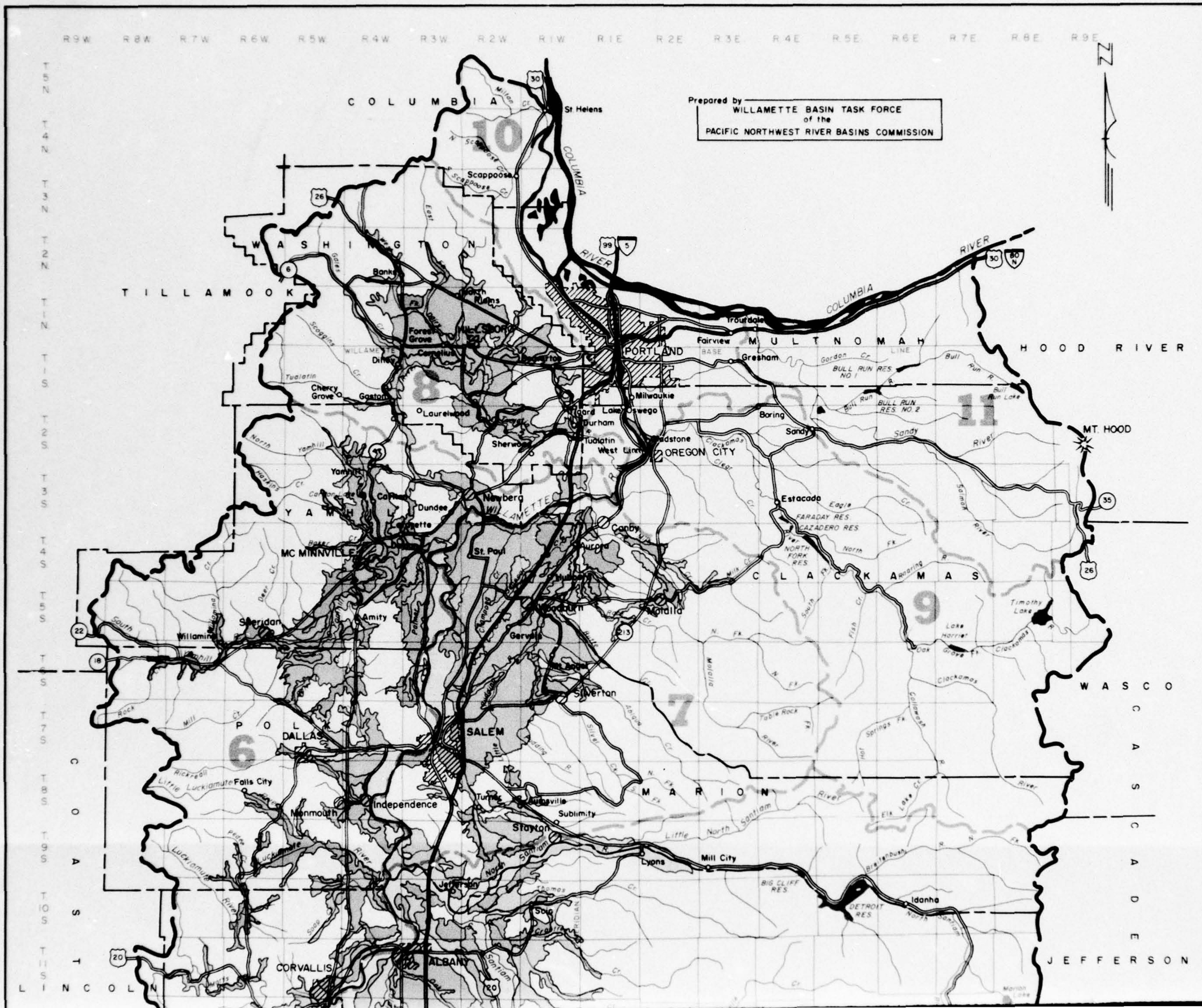
Woodburn	Aloha
Amity	Quatama
Maytown	Clackamas

The remaining 25 percent of the soils in this group are intermingled and are not considered to have significant drainage problems.

Group D

Over 75 percent of the soils of this group have no serious drainage limitations and are considered to have excellent irrigation suitability. The principal soils of the group are:

Chehalis
Cloquato
Willamette
Hillsboro



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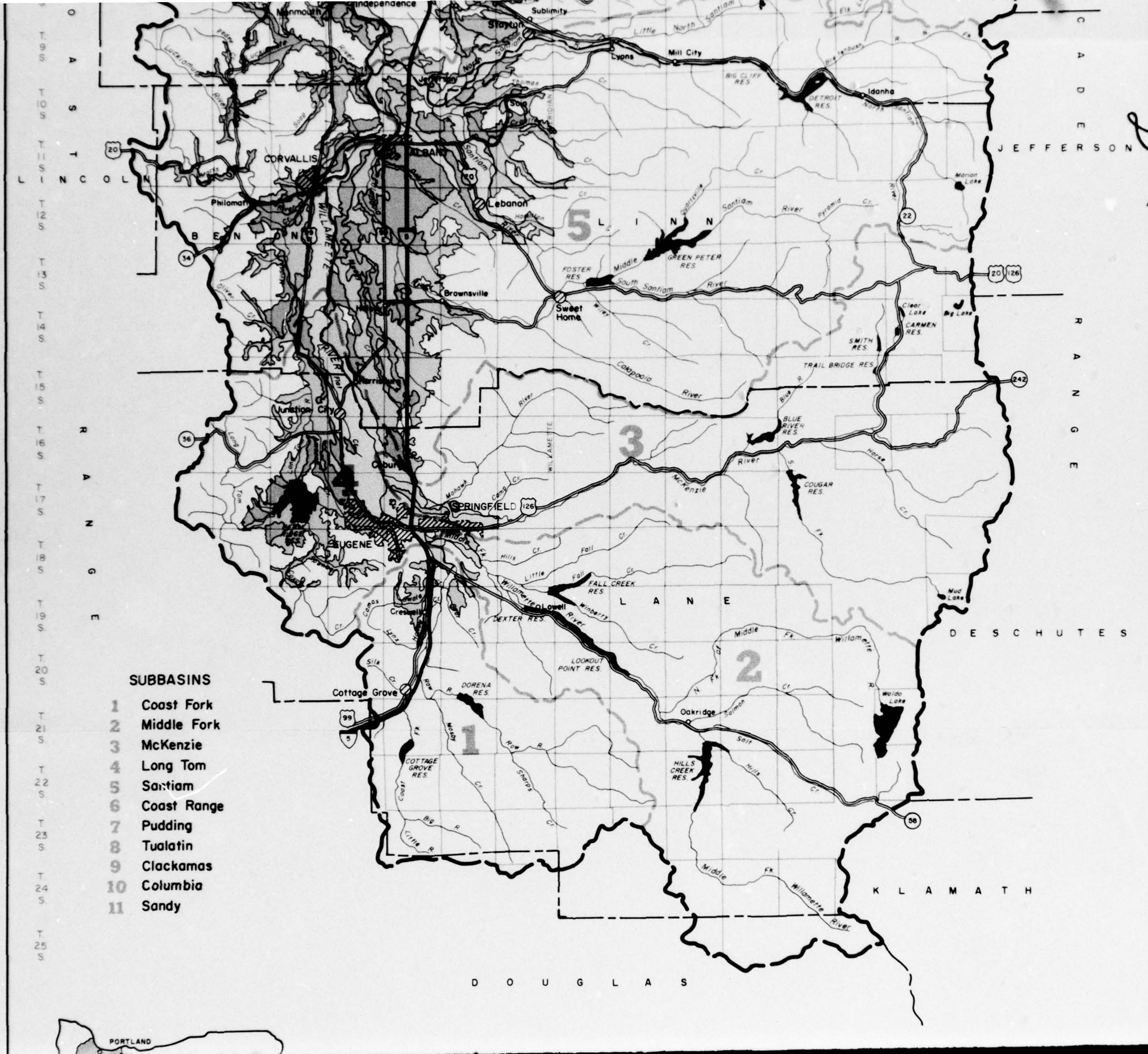
T5N T4N T3N T2N T1N T1S T2S T3S T4S T5S T6S T7S T8S T9S T10S T11S
COLUMBIA
WASHINGTON
TILLAMOOK
MULTNOMAH
HOOD RIVER
CLACKAMAS
YAMHILL
POLK
MARION
WASCO
CASCADE
COAST
LINCOLN
JEFFERSON
COLUMBIA RIVER
St Helens
Scappoose
Banks
Forest Grove
Cornelius
Dilley
Cherry Grove
Gaston
Laurelwood
Sherwood
Tualatin
Durham
Lake Oswego
Milwaukie
West Linn
OREGON CITY
PORTLAND
Troutdale
Fairview
Gresham
Boring
Sandy
Estacada
Canby
Aurora
St. Paul
Newberg
Dundee
Yamhill
MC MINNVILLE
Amity
Sheridan
Willamina
Dallas
Falls City
Monmouth
Independence
SALEM
Gervais
Silverton
Molalla
Turner
Sublimity
Stayton
Lyons
Mill City
Idanha
Jefferson
CORVALLIS
ALBANY
MT. HOOD
BULL RUN RES NO 1
BULL RUN RES. NO. 2
FARADAY RES
CAZADERO RES
NORTH FORK RES.
BIG CLIFF RES
DETROIT RES
Timothy Lake
Lake Harriet
BASE LINE


SUBBASINS
1 Coast Fork
2 Middle Fork
3 McKenzie
4 Long Tom
5 Santiam
6 Coast Range
7 Pudding
8 Tualatin
9 Clackamas
10 Columbia
11 Sandy
LINCOLN
BENTON
LINN
LANE
DOUGLAS
JEFFERSON
DESCHUTES
KLAMATH
COAST RANGE
CASCADE RANGE
CORVALLIS
EUGENE
SPRINGFIELD
Lebanon
Sweet Home
Brownsville
Junction City
Cottage Grove
Oakridge
Mill City
Lyons
Idanha
Stayton
Sublimity
Independence
Monmouth
Philomath
Creswell
Coburg
PORTLAND
DETROIT RES.
BIG CLIFF RES.
GREEN PETER RES.
FOSTER RES.
BLUE RIVER RES.
COUGAR RES.
TRAIL BRIDGE RES.
SMITH RES.
CARMEN RES.
FALL CREEK RES.
DEXTER RES.
LOOKOUT POINT RES.
HILLS CREEK RES.
DORENA RES.
COTTAGE GROVE RES.
Waldo Lake
Marion Lake
Clear Lake
Big Lake
Mud Lake
WILLAMETTE RIVER
McKenzie River
Calapooia River
South Santiam River
North Santiam
Middle Fk Willamette River
T. 9 S.
T. 10 S.
T. 11 S.
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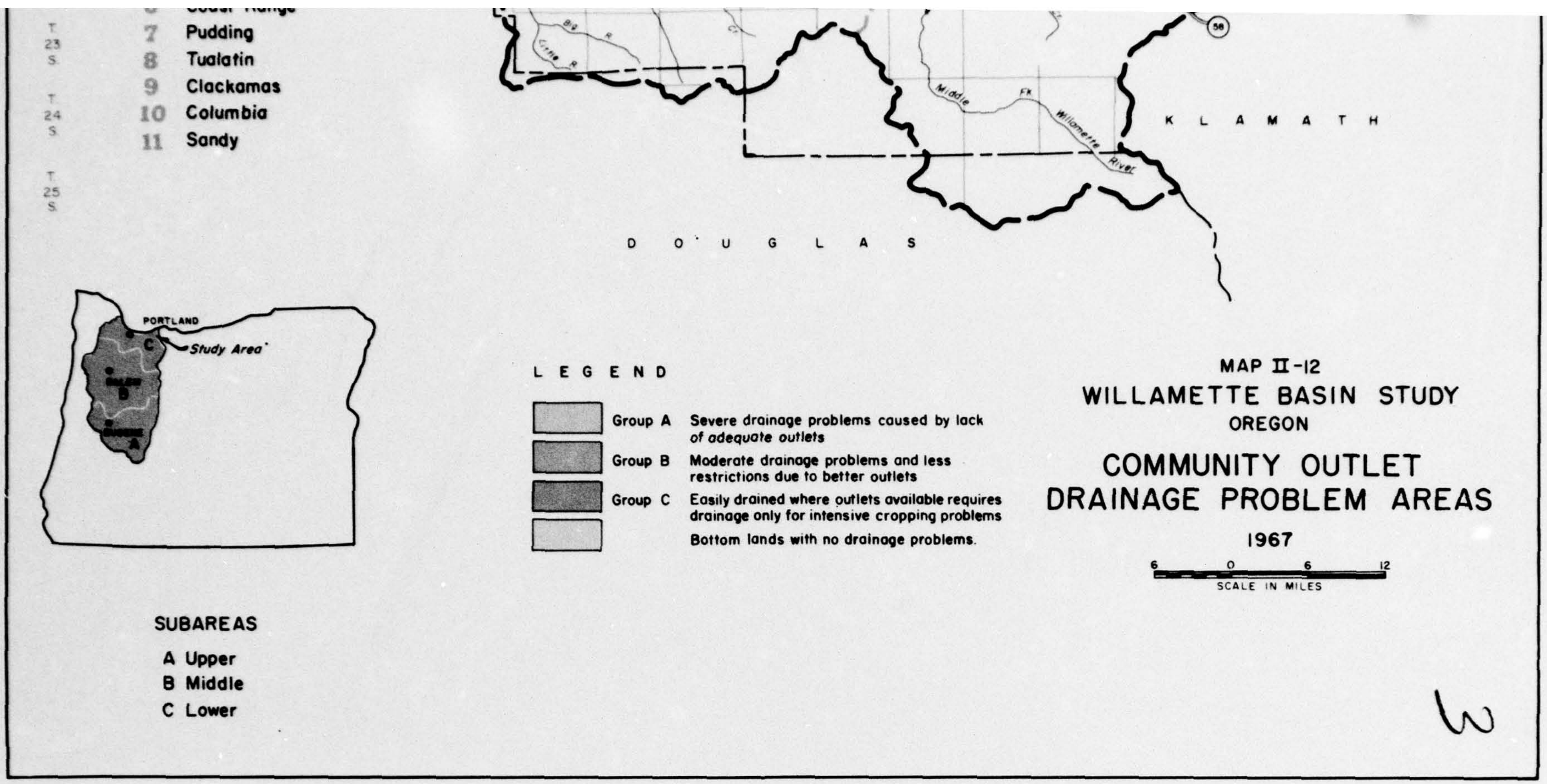


7 Pudding
8 Tualatin
9 Clackamas
10 Columbia
11 Sandy
T. 23 S.
T. 24 S.
T. 25 S.
Middle Fk Willamette River
KLAMATH
DOUGLAS
PORTLAND
Study Area
C
A
B
LEGEND
Group A Severe drainage problems caused by lack of adequate outlets
Group B Moderate drainage problems and less restrictions due to better outlets
Group C Easily drained where outlets available requires drainage only for intensive cropping problems
Bottom lands with no drainage problems.
SUBAREAS
A Upper
B Middle
C Lower
MAP II-12
WILLAMETTE BASIN STUDY
OREGON
COMMUNITY OUTLET
DRAINAGE PROBLEM AREAS
1967
6 0 6 12
SCALE IN MILES
3
WBTF-0-1041abc-LL

Photo II-26. Surface water disposal problem. Any intense rain will cause standing water because of no outlet. Lane County. (SCS Photo 7-723-3)

Photo II-27. Poorly designed tile interceptor drain system has fouled and has caused gullying. (SCS Photo 0-538-9)

Photo II-28. A multiple use drainage and irrigation ditch resulted in more profitable land use. Linn County.
(SCS Photo F-5-11)

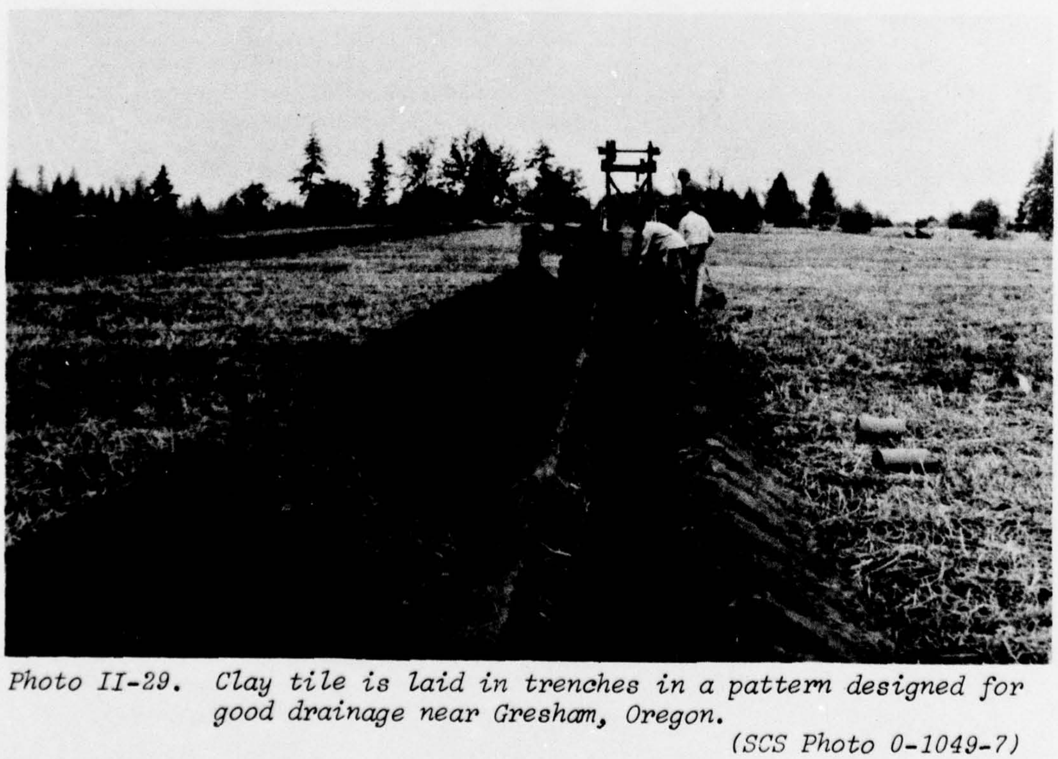


Photo II-29. Clay tile is laid in trenches in a pattern designed for good drainage near Gresham, Oregon.
(SCS Photo 0-1049-7)

Related Aspects of Drainage

Urban and Suburban

Soils with restricted drainage impose restrictions on urban and suburban development for residential and industrial purposes. Without the installation of community outlets and supplementary deep drains, soils with restricted drainage are saturated to the surface during much of the winter season. Periodically, water may be ponded on the surface.

Without drainage improvements, serious limitations may be imposed on construction of dwellings and other buildings, the construction of roads and streets, and the safe disposal of the discharge from septic tanks or of other effluents. Also, water obtained from wells may be contaminated beyond the point of suitability for human consumption.

With the installation of drainage improvements, some of the problems are alleviated. With drainage to adequate depth the construction of basements may be possible, but the problem of sewage disposal still remains. The physical character of these poorly drained soils is such that reasonable safe disposal of effluents by soil absorption is impractical unless substantial areas are available.

Transportation

Because of construction and maintenance difficulties, the early roads and highways were routed to avoid crossing areas with a high percentage of poorly drained soils. Modern construction methods make it possible to cross these areas with highways and railroads, but special measures are necessary including provision of local drainage and construction of suitable subgrades.

Vector Control and Parasites

Under natural conditions in the Willamette Valley, the substantial areas of poorly drained soils do not contribute to the maintenance of a dense population of mosquitoes and similar insects, nor to internal livestock parasites. Normally, the surface water completely disappears from the poorly drained areas by mid-May and does not return until after the fall rains, usually mid-November or the first of December. Except in areas immediately adjacent to streams, there is only limited habitat for these insects during the breeding season. As the population has grown in the Willamette Valley this situation has changed. Waste water from many sources reaches these poorly drained areas and because of poor percolation and runoff characteristics, collects in shallow ponds and provides an ideal breeding ground for insects. The problem is particularly acute in suburban developments adjacent to larger towns and cities.

The intensification of irrigation could contribute substantially to the vector problem unless precautionary measures are taken. Even the small quantities of surface waste from sprinkler irrigation can maintain sizable areas of suitable breeding grounds if allowed to flow uncontrolled into the lower wet land areas. The livestock parasite problem imposes a serious limitation on utilization of poorly drained soils for irrigation.

Fish and Wildlife

Land development, particularly drainage, may result in land use changes harmful to fish and wildlife. In some cases, wildlife must be a by-product to more economic land and water uses; in other areas, wildlife production could be the primary objective of land use. This subject is covered in detail in the Fish and Wildlife Appendix.

OTHER PROBLEMS

Some major problems exist in applying land measures for erosion control and water use. Sometimes a single restraint stops necessary adjustments, but more often it is a combination of them. The problems are discussed in four general groups: social, economic, institutional and physical.

Social

Age of the farm operator is an important factor in decision making for land use or change. Older farmers may have set farming patterns formed over a lifetime of work. They are reluctant to change because they are "getting by" now and need no added income or additional work. Also, some land measures are long-term investments with the benefits beyond the life span of the present operator.

Part-time farm operators may react differently than full time operators to the need to apply land measures. The size of the farm may be too small to economically apply land changes that would in turn change the major farm enterprise. The part-time farmer may wish merely for a rural way of life and seek no improvement. On the other hand, many part-time farmers have substantial outside income and make needed land treatment changes as a long-term investment and for capital gain.

Education plays an important role. One must be aware of the problems or opportunities before they can be real objects for management decisions. Without knowing the consequences of land problems, the farmer does not feel or see the need for corrective land measures.

Applying needed land measures or improvements often means a change in the entire farming program. Many times different types of crops should be grown to make full use of the improved land resources, and additional capital may be required for other types of equipment or livestock. If the farmer has a comfortable living with his present operation, he may be reluctant to try unfamiliar cropping patterns or cultural practices.

Economic

From an economic standpoint, the choices available in use and management of agricultural land and water may be classified as follows:

(1) invest to increase future productivity, (2) invest to maintain present productivity and (3) disinvest or mine the resource and reduce future productivity. Land treatment investments are usually made to increase or maintain productivity although they may also reduce the rate of disinvestment. The investments are made both by individuals and the public because interests in preserving land are both private and public.

Typical agricultural land treatments applied in the Willamette Basin are changes in cropping systems, establishment of cover crops, growing green manure in the rotation, land smoothing, land leveling, drainage and establishing grass waterways. Costs include the installation, technical assistance and annual costs of operating and maintaining the improvement. Benefits may result from increasing production, growing a higher value crop or lowering costs of production.

The capital and labor used or proposed for use in treatment of land are economic goods and have alternative uses. This is true whether the source of the funds is from the public treasuries or private accounts. As economic goods, these capital and labor resources are subject to the same scrutiny applied to other investments in resource development.

The justification for investing scarce resources in the treatment of land arises from an anticipated result, such as saving the soil and water from erosion and waste and making them more useful and, thus, valuable to individuals and society. The relevant economic variable is net revenues from the treatment--or all benefits less all costs. Although costs of land treatments may usually be readily estimated in monetary terms, the resulting benefits are not so easily determined.

One reason for the relative difficulty in estimating benefits is the timing; benefits occur as a revenue stream over time. Future uncertainties include shifts in land use, changes in types of products demanded and changes in prices of products, to mention only a few. An additional factor is the discount rate necessary since a dollar spent or obtained in the future has less value than one in hand today.

Another problem in valuing a stream of net revenues from land treatment is that the annual returns are not equal. Production may decline for the first years, i.e., while a pasture is being established or the topsoil is recovering from disturbance by leveling, then increase to an improved level. Experimental results, if available, may assist in valuing the benefits to land treatment over time. Costs may also vary from year to year, but the annual cost of operating and maintaining the land improvement is usually less difficult to determine than the return.

Institutional

Factors of an institutional nature which affect the use and conservation of agricultural land and water resources are many and varied. They include public arrangements in research, planning, education, and other types of programs, as well as legal rules which regulate the actions of groups and individuals. They also include public and private tenure arrangements for the ownership and control of land and water resources. They modify and act as constraints on attainment of physical requirements or economic objectives.

Use of a land resource by a town or city for its specific purposes, exclusive of all other potential, is not uncommon. A large water district may exclude all uses of a given watershed except those that are functions of producing high quality water for municipal water supply. In such a situation, erosion may be stabilized and optimum amounts of high quality water produced, but the land resources and productive potential remain substantially unused.

Federal, state and county programs also influence land use and applied land measures. Each of these bodies has specific objectives and long-range plans for development. Because of public ownership and policy, many of these areas may not be producing to their productive potential.

Closely allied with governmental influence are those areas in control of large private corporations and individuals. In this case, however, these lands may be managed for immediate production, and overuse or poor land management practices result in deterioration of the productive potential of the land.

Education, research and resource planning are all on the plus side of influences toward proper land measures. Research evaluates the effect of land abuse or land development. Education carries this information to the people and facilitates informed planning by both individuals and groups, by corporations and by government.

Physical

Many times there is an awareness of problems or potentials, but no way for individuals to solve them because of physical influences.

Natural restrictions, such as flooding, limit land use and reduce income to farm operators because of less profitable crop alternatives or additional farming costs. As an individual, the farmer cannot reduce or stop the flooding, but must live with it. Group flood control projects may be required to overcome this problem.

Lack of drainage outlets is a major problem in the Willamette Basin. Without group projects, there are hundreds of thousands of acres of valley lands that cannot be drained.

In many places, irrigation is limited due to lack of water sources. Even in areas where water can be otained, irrigation may be limited because drainage or flood control cannot be accomplished.

Some land measure problems are caused by individuals. Sediment deposition may come from the erosion of another farmer's fields. Flooding may be increased because upstream improvements are made in channels without making improvements to already restricted outlets.

PRESENT STATUS OF APPLIED LAND MEASURES

Land measures necessary to maintain or improve the quantity, quality or use of water are many and varied. Generally they do not exist as independent measures but are groups of practices which are applied for not one but several purposes. As has been pointed out, the need for land measures changes as the types of crops change. A continuing but ever-changing land measure program is needed to meet this situation.

The current status of applied land measures is summarized in Table II-9. This listing is based on the Soil Conservation Service annual report but represents the accumulated effects of all individual and governmental efforts to accomplish conservation land measures on privately owned agricultural and woodland areas. The 1965 report is on a county-boundary basis, and includes some areas outside the basin. These areas are primarily forested and in Federal or state ownership, and thus are not involved in the tabulation. The data should be representative.

Table II-9
Current Status of Applied Land Measures by County

Item	Unit	Marion	Linn	Lane	Washington	Multnomah	Yamhill	Polk	Clackamas	Benton	Total
Contour Farming	Ac.	4,250	-	-	128	1,769	350	-	30	-	6,527
Chiseling and Subsoiling	Ac.	4,407	740	-	-	11,155	16,500	-	185	-	32,987
Brush Control	Ac.	3,787	87	240	-	5,270	38,000	-	362	-	47,746
Cons. Cropping System	Ac.	78,829	142,204	53,188	86,530	27,260	60,000	-	91,610	15,800	555,421
Cover and Green Manure Crop	Ac.	23,910	18,965	20,158	17,300	11,205	26,000	-	2,515	1,086	121,139
Critical Area Planting	Ac.	45	-	9	-	155	-	-	520	-	729
Crop Residue Use	Ac.	85,837	125,809	29,395	55,000	11,668	60,000	-	6,850	7,100	381,659
Dam, Diversion	No.	4	11	36	-	-	1	-	5	-	57
Dike and Levee	Ft.	41,047	45,040	120,744	50,000	275,730	8,000	4,750	-	11,275	556,586
Ditch Bank Seeding	Ft.	29,220	3,300	-	-	11,950	2,000	-	2,315	-	48,785
Diversion	Ft.	-	-	1,854	2,400	121,402	11,000	-	-	-	136,656
Farm Pond	No.	273	149	98	1	71	84	47	25	41	789
Fishpond Stocking	No.	12	16	24	12	5	30	-	46	-	145
Floodwater Diversion	Ft.	-	143	40,500	-	-	-	-	-	-	40,643
Floodway	Ft.	30,100	-	50,350	-	-	-	13,900	-	-	94,350
Grade Stab. Structure	No.	-	-	13	-	-	-	-	-	-	13
Grassed Waterway or Outlet	Ac.	829	327	433	1,300	26	42	8	163	60	3,188
Irrigation Pipeline	Ft.	44,471	78,636	24,000	-	-	25,000	-	19,210	-	191,317
Irrigation Storage Res.	No.	16	10	37	55	6	65	20	35	-	244
Irrig. System Sprinkler	No.	548	446	516	220	280	350	-	472	353	3,185
Irrig. Water Mng.	Ac.	24,594	44,582	13,129	30,347	6,823	12,000	-	8,057	-	139,532
Land Clearing	Ac.	10,027	17,892	8,892	1,002	771	640	-	1,038	-	40,262
Drainage Land Grading	Ac.	-	-	790	5	-	-	-	-	-	795
Land Smoothing	Ac.	630	17,642	14,083	-	-	6,000	-	-	1,188	39,543
Drainage Main or Lateral	Ft.	1,242,038	1,629,714	1,134,740	174,923	337,183	1,146,000	3,500	62,235	257,457	5,987,790
Woodland Natural Seeding	Ac.	76	10,830	3,667	-	-	60	-	700	-	15,333
Pasture and Hayland Renovation	Ac.	249	192	253	20	75	-	-	1,005	-	1,794
Pasture and Hayland Planting	Ac.	17,752	5,459	24,857	4,252	6,396	16,717	-	876	800	77,109
Irrig. Land Leveling	Ac.	-	504	336	-	-	-	-	-	-	840
Proper Pasture Use	Ac.	26,450	29,964	4,000	8,797	382	22,000	-	9,730	4,402	105,725

Table II-9 (Cont'd)

Item	Unit	Marion	Linn	Lane	Washington	Multnomah	Yamhill	Polk	Clackamas	Benton	Total
Woodland Proper Grazing	Ac.	606	1,958	245	-	91	-	-	1,032	-	3,932
Spoilbank Spreading	Ft.	310,591	1,504,868	922,658	160,398	362,144	1,140,000	-	35,330	170,233	4,606,222
Spring Development	No.	41	34	62	-	3	22	-	65	-	227
Streambank Protection	Ft.	38,500	14,275	6,243	200	-	3,100	5,850	18,320	10,483	96,971
Stream Channel Improvement	Ft.	266,235	259,285	340,759	44,078	194,645	58,000	66,050	121,114	51,476	1,401,642
Wildlife Wetland Development	Ac.	29	1,477	90	85	87	80	-	19	-	1,867
Wildlife Wetland Preservation	Ac.	-	800	30	-	-	-	-	-	-	830
Stream Channel Stabilization	Ft.	980	109,335	54,140	-	-	-	-	-	-	164,455
Structure for Water Control	No.	57	147	53	-	78	1	5	1	-	342
Drainage Field Ditch	Ft.	41,917	109,684	166,978	-	26,700	5,800	-	-	25,511	376,590
Tile Drain	Ft.	7,272,788	1,401,958	347,427	4,317,156	2,612,055	10,424,000	872,158	3,732,735	496,741	31,477,018
Tree Planting	Ac.	2,702	977	8,874	493	255	8,120	-	3,140	1,927	26,458
Wildlife Habitat Development	Ac.	6,199	10,945	5,098	282	230	1,500	-	38	930	25,222
Wildlife Habitat Preservation	Ac.	4,174	20,196	439	-	31	60	-	-	-	24,900
Woodland Harvest Cutting	Ac.	350	19,132	131,984	17	303	15,000	-	3,505	-	170,291
Woodland Direct Seeding	Ac.	187	2,822	-	-	-	-	-	-	-	3,009
Woodland Intermediate Cutting	Ac.	270	162	3,250	53	174	-	-	2,280	240	6,429
Woodland Pruning	Ac.	195	267	1,356	664	3	320	-	430	-	3,235
Woodland Thinning	Ac.	651	1,520	1,751	246	-	1,000	-	1,107	-	6,275
Woodland Weeding	Ac.	64	300	380	32	5	-	-	461	-	1,242
Cropland to Grassland	Ac.	538	620	2,205	-	1,640	278	-	220	900	6,401
Cropland to Woodland	Ac.	299	10	60	-	-	15	-	300	550	1,234
Cropland to Wildlife-Rec.	Ac.	15	12	120	160	909	10	-	-	410	1,636
Cropland to Other	Ac.	2,981	280	1,600	700	2,700	20	-	1,211	600	10,092
All Other Uses to Cropland	Ac.	576	1,109	528	-	47	120	-	358	540	3,278
All Other Uses to Wildlife-Rec.	Ac.	14	-	105	-	-	10	-	-	90	219
Wildlife Water Facilities	No.	-	-	-	-	-	3	-	-	-	3

Photo II-30. Truck farm operation contributes to Salem's role as a leading food processing area of the nation.
(Del Monte Foods Photo)

forestry

The forest watershed of the Willamette Basin is an important source of building materials and a vast reservoir from which modern technology is deriving an abundance of products and services. However, the basin's forests are more than a warehouse for man's material needs--their protective cover conserves soil and water and moderates local climate.

The generally good condition of Willamette Basin's forests and waters is due largely to unusual soils and climate. These forest soils are more stable than those in most other parts of the West. When the first settlers arrived, magnificent stands of fir and hemlock covered most of the basin.

The early settlers chopped, sawed, and burned their way through the stands, especially at the lower elevations. Most of the soils recovered quickly, even after drastic disturbance, because the favorable growing climate and copious, low-intensity rainfall fostered quick regrowth.

Until about 60 years ago, few people felt that forests should be given organized protection from fire and trespass, or that forest soils and waters should be protected and developed. Today it is widely recognized that forest soils and waters are a basic resource, and fire protection is a basic tenet of forest management.

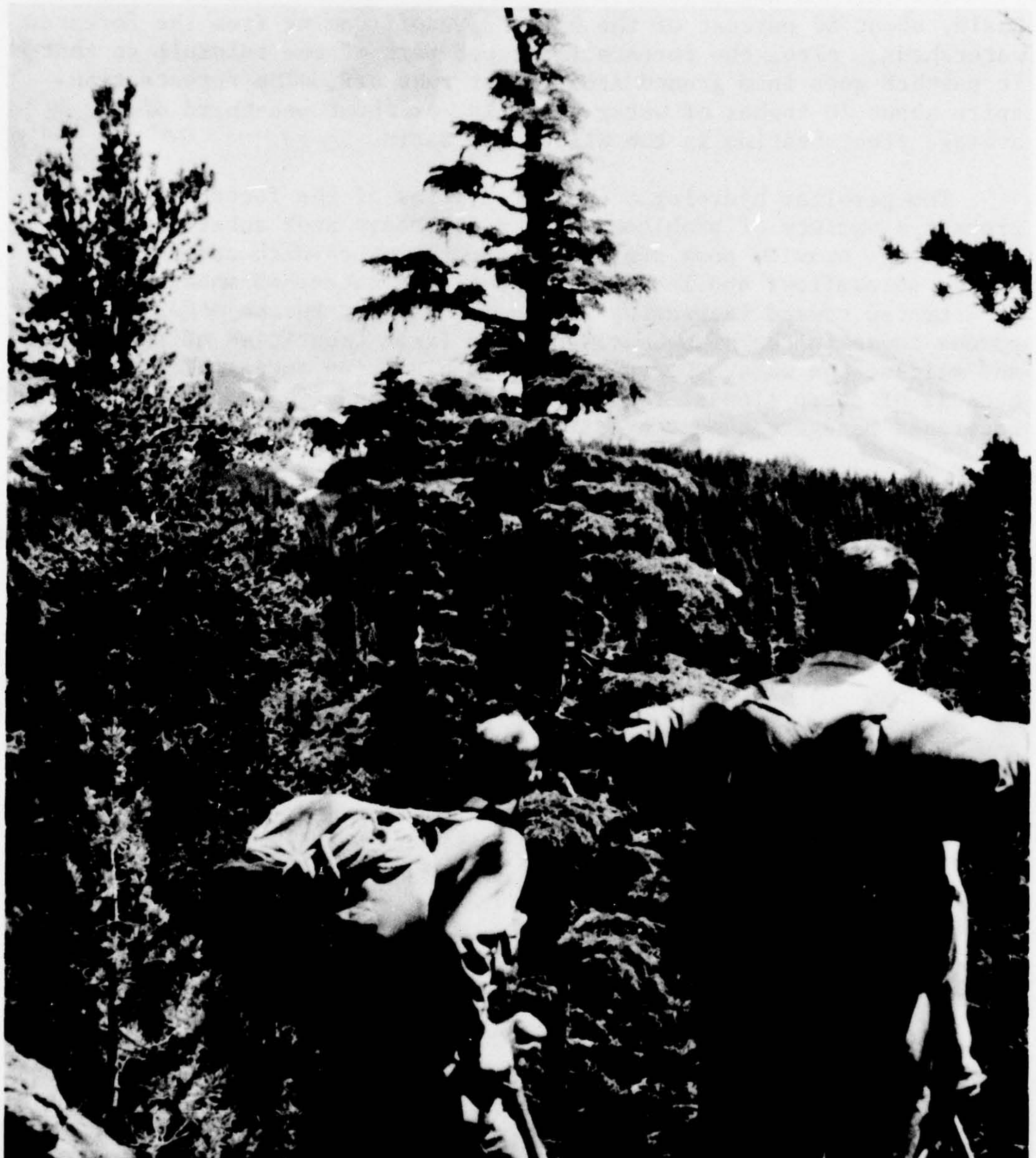


Photo II-31. Two hikers rest momentarily and gaze at the famous peaks in the Three Sisters Wilderness Area.
(U. S. Forest Service Photo 483585)

C H A R A C T E R I S T I C S   O F   F O R E S T   A R E A S

The forests significantly influence the streamflows of Willamette Basin, about 86 percent of the basin's runoff coming from the forested watersheds. Also, the forests intercept part of the rainfall so that it neither goes into ground storage nor runs off. The forests transpire about 20 inches of water annually, or about one-third of the average precipitation in the Willamette Basin.

The peculiar hydrologic characteristics of the forested watershed present a variety of problems. The sedimentary rock substrata in the Coast Range provide poor storage of ground water--with attendant high winter streamflows and low summer flows--and watershed management must be directed toward increasing the summer flows. On the other hand, the porous lavas in the high Cascades store large quantities of snowmelt and release the water gradually--although erosion potential is great because of steep slopes, shallow soil mantle and high precipitation--and watershed management must be directed toward preserving water quality.

FOREST ZONES

The basin's forests differ because of widely varying elevations and natural features. The forests can be divided into four zones: valley woodland, principal forest, upper slope forest and subalpine forest.

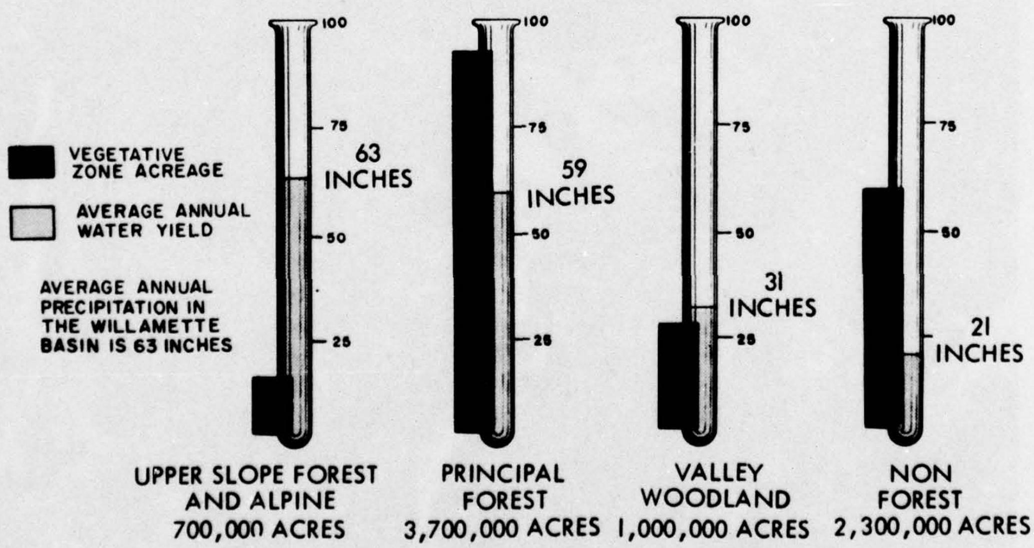


Figure II-2. Forest Vegetative Zones and Water Yield.

Valley Woodland

The valley woodland zone generally lies below 1,000 feet elevation and has the warmest climate. Precipitation is moderate (about 50 inches) with most rain occurring during the winter. Soils are generally deep and textures vary from loams to clay loams. This textural variation is the principal reason why soils respond so differently to water management.

The early settlers found this zone only partially forested. Most of the land in this area has since been cleared for agricultural, urban, residential and other uses. The remaining forest stands are scattered among agricultural tracts and occupy less than 30 percent of the total area.

Most of the wooded areas are found on steeper slopes or on areas unsuited for agriculture. They are normally in blocks of less than 500 acres and are owned by farmers and ranchers. Hardwood stands flourish in this zone. Streams and rivers are meandering and slow moving. Streambank scouring is the primary source of sediments produced in the valley woodland area.

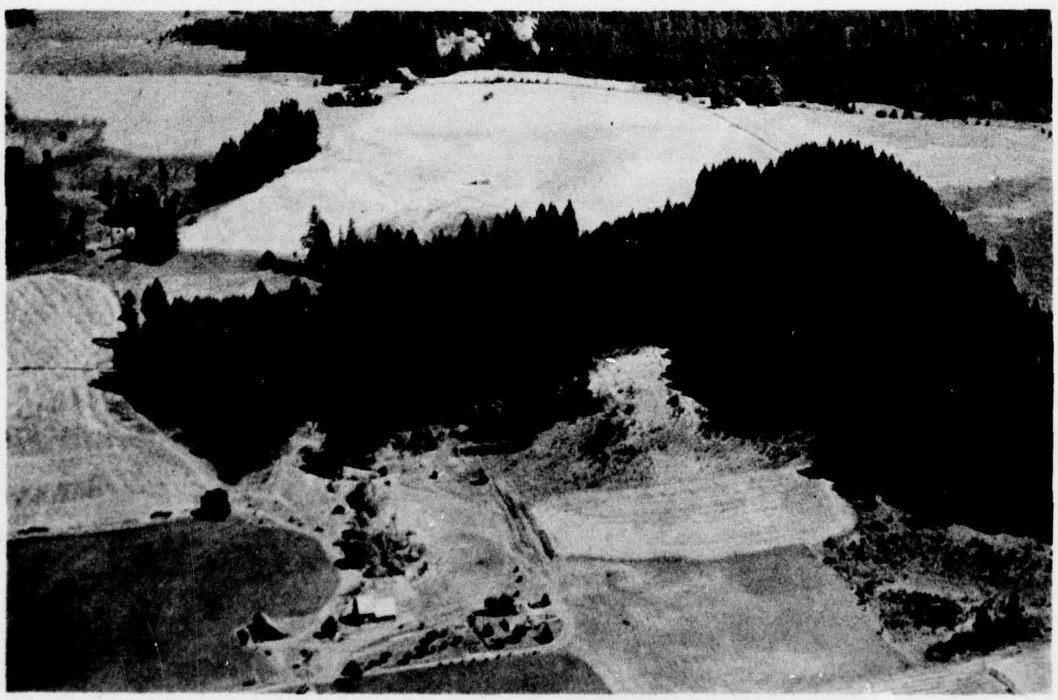


Photo II-32. Valuable forest lands mix with agricultural lands in the Valley Woodland Zone. Coast Range Subbasin. (Oregon Dept. of Forestry Photo)

Principal Forest

The principal forest zone begins between 500 to 1,000 feet elevation and extends up to 3,000 to 4,000 feet elevation. The bulk of the basin's wood crops are produced in this zone. Rainfall ranges from 60 to 140 inches per year. Soils derived from compacted volcanic ashes (tuffs and tuff breccias) are common. Soils are typically heavy textured. Slopes are often well dissected, with potential for landslides in many places.

There is moderate winter snowfall and snowpack development in the higher reaches, and temperatures are cooler than found in the valley woodland area.

Forests cover most of this area; Douglas fir forests often occur in large pure stands. The public and large timber companies own most of the forest lands. Hydrologically, forest vegetation removal (as by logging) appears to exert its major influence during periods of lowest streamflow from August to mid-November.

Photo II-33. The principal forest zone contains large areas of virgin timber. Much of this land is in large private holdings, Little Fall Creek, Middle Fork Subbasin.

(Georgia Pacific Photo)

Upper Slope Forest

The upper slope forest zone starts at 3,000 to 4,000 feet elevation and extends upward to 5,000 to 6,000 feet. Upper slope forests cover large areas in the Cascade Range but exist only on the highest peaks in the Coast Range. Soils in these mountain areas are more coarsely textured than the principal forest soils, and are more susceptible to accelerated erosion when disturbed. Precipitation ranges from 90 to 140 inches, and winter snowfall is heavy with moderately heavy snowpack development.

The deep snows, heavy rainfall, the shading effect of trees, and good water bearing soil layers result in better distribution of late-season streamflow. About 80 percent of the area is forested--mostly true fir-mountain hemlock stands, the remainder consisting of rock outcrops, meadows, lakes and lava beds. Most of the upper slope zone is in National Forests.

Photo II-34. Upper slope forests are high producers of water.
(SCS Photo)

Alpine Forest

The alpine forest zone begins at 5,500 to 6,500 feet elevation in the Cascades and extends to timberline. Much of it is a natural scenic and recreational area. This zone receives a heavy snowpack and has a short summer season. Soils are usually thin and fragile, and denuded meadow areas are very susceptible to erosion. The principal tree species are sub-alpine fir, mountain hemlock, whitebark pine, and ground juniper. These species occur in scattered stands which are interspersed with meadows, barren areas and lakes. Most of this zone is in National Forests.

Photo II-35. Alpine forest stands normally mix with scenic meadows and barren areas. Clackamas Subbasin. (FS Photo)

SUBBASIN DESCRIPTION

Subbasin 1--Coast Fork

This subbasin lies on the northern slope of the Calapooya Mountains and includes part of the Western Cascades. Over 90 percent is mountainous, with about 75 percent lying above 1,000 feet and 40 percent above 2,000 feet. The mountains are dissected by numerous streams; only the larger ones have developed valleys. About 37 percent of the subbasin is under Federal administration.

All drainages in this subbasin are forested except the Coast Fork proper. The streams of this subbasin annually yield an average of 1,750 acre-feet of water per square mile. Commercial forests cover 84 percent of the subbasin. Lands in the Calapooya Mountains have perhaps the greatest water erosion potential in the subbasin.

Subbasin 2--Middle Fork

Seventy-four percent of the Middle Fork Subbasin is classified as forest land, a large percentage in upper-elevation sub-alpine areas. Except for a small area around Oakridge, the only agricultural land is located downstream from Dexter Reservoir. About 83 percent of the subbasin is federally owned; nearly the entire watershed above Lookout Point Dam is National Forest land. The streams of this subbasin annually yield an average of 2,060 acre-feet of water per square mile.

A large portion of the upper watershed falls within the Diamond Peak Wilderness Area and the Waldo Lake Limited Area. These areas are not subject to development and intensive management at this time. The only hazard they present to soil and water management are those resulting from natural catastrophes and biological contamination by recreationists.

Subbasin 3--McKenzie

Seventy percent of the McKenzie Subbasin is forested. Much of the nonforested area is located in the higher-elevation sub-alpine areas. The lower portions of the McKenzie River and Mohawk Creek drainages are agricultural land. The streams of this subbasin annually yield an average of 2,860 acre-feet of water per square mile.

A large part of the upper watershed falls within the Mt. Washington and Three Sisters Wilderness Areas. These areas are not subject to timber harvest or road construction. Quality of water coming from these areas is affected only by natural catastrophes and high levels of recreation use.

The heavily timbered areas of the middle slopes are mainly within the Willamette National Forest. Although timber harvesting has been in progress for many years, much of the area still remains in old-growth yet to be harvested. Several drainage areas have had little or no timber harvesting or access development.

The forests of the lower slope areas of the subbasin are mostly in private ownership with a scattering of public ownership. Although timber harvesting has been more intensive in this portion of the subbasin, large areas of virgin timber can still be found. The road development has progressed further in the lower slope areas.

Subbasin 4--Long Tom

The Long Tom Subbasin is about 40 percent forested, but varies greatly (5-85 percent) among watersheds. The extent of forested area in the various drainages depends on whether they include mostly valley or upland area. The streams of this subbasin annually yield an average of 1,570 acre-feet of water per square mile.

The type of cover is equally variable. Along streams and on the gentle lower slopes the hardwood species predominate, with Oregon Oak most prevalent. On the upper slopes and ridges conifers are the principal species, mostly Douglas fir. All the old growth has been cut. Vast stands of young growth are approaching sawtimber size. In the upper drainages a major portion of the land (alternate sections) is managed by the Bureau of Land Management. The intermediate areas are largely held by industry, with no consolidated holdings by any one company. Both industry and Bureau of Land Management are managing their lands on a sustained-yield basis. The valley lands are largely devoted to agricultural and urban uses.

Subbasin 5--Santiam

The Santiam Subbasin is one of the major water-producing areas of the basin. Average precipitation in the Cascades is from 100 to 150 inches per year, much of it in the form of snow. The streams of this subbasin annually yield an average of 2,757 acre-feet of water per square mile. The principal forest zone in the Middle Santiam River drainage contains extensive areas of unstable, erosive soils. Salem and several other communities depend on this source for municipal and industrial water. The subbasin is 72 percent forested.

Subbasin 6--Coast Range

The Coast Range Subbasin is 56 percent forested. Most of it has been cut over and supports a fair cover of Douglas fir reproduction. This subbasin annually yields an average of 2,030 acre-feet of water per square mile; the North Yamhill has the highest yield, averaging 2,480 acre-feet per square mile. By far the greatest use of water in this subbasin is for irrigation. Substantial quantities also are required for municipal and industrial use.

Subbasin 7--Pudding

The Pudding Subbasin is 47 percent forested. The upper tributaries are well stocked with coniferous timber. The lower drainages have dense growth of hardwoods along the streams and intermingled patches of coniferous timber and farm land. Elevations range from 50 to 4,100 feet above mean sea level. A good share of the forest land has been logged and is now in second growth, although some of the BLM lands have considerable mature timber.

The average annual precipitation ranges from 40 to 130 inches. Streamflows are generally high from November through April and low through the summer months; low discharges have been observed on the Pudding River near Mt. Angel. The streams of this subbasin annually yield an average of 1,789 acre-feet of water per square mile. The average annual surface water yield for the subbasin is about 2,120,000 acre-feet, of which the Pudding and Molalla Rivers supply 930,000 and 856,000 acre-feet respectively.

Subbasin 8--Tualatin

The Tualatin Subbasin is 50 percent forested. The streams of this subbasin annually yield an average of 1,500 acre-feet per square mile. Most of the upper and middle parts of the drainages are well stocked with second growth conifers and hardwoods. The lower drainages have dense growth of hardwoods along the streams, and coniferous patches intermingled with agricultural lands. A small area of old-growth remains in the Tanner Creek drainage. The second-growth Douglas fir is in young age classes and in mixtures with hardwood species.

The forest land is about 83 percent privately owned and under varying degrees of planned management. The public and large private ownerships are managed for sustained yields of forest products. The small private forest lands, which represent nearly 60 percent of the forested area, have good cover for watershed protection. Most of the present activity in these stands has been confined to selective logging and small clear cut areas. The clear cuts have been promptly restocked, and the disturbed ground has been quickly covered with protective vegetation.

Subbasin 9--Clackamas

The Clackamas Subbasin is 85 percent forested, with all drainages except Deep Creek and the Lower Clackamas River mostly covered with dense evergreen forest. About 4/5 of the total forested area is in Federal ownership; most of these lands are in Mt. Hood National Forest. The subbasin's main tributaries have high sustained yields of good water. The streams of this subbasin annually yield an average of 2,370 acre-feet of water per square mile.

The higher watersheds in the Cascade Range (except Roaring River) are mostly virgin old growth. A sustained timber harvest program in the last 25 years has changed parts of the upper watersheds to young seedling and sapling stands. Access and development is well along but generally incomplete because only a portion of the public lands has been harvested to date.

The forests in the lower tributaries have also passed through a timber harvest cycle and are now in second growth. The second growth in Eagle Creek and much of Clear Creek is large industrial forest under intensive management; access is excellent and watershed problems and erosion are minor. Beaver and Abernethy Creeks have many woodlands intermingled with agriculture, mostly on the more gently sloping land.

Subbasin 10--Columbia

The Columbia Subbasin is 30 percent forested and the remainder is mainly urban area except for Sauvie Island. The streams of this subbasin annually yield an average of 1,320 acre-feet of water per square mile. Most of the forested portion is west of the Willamette River and northwest of the Portland residential area. The upper slopes are covered with dense stands of young growth Douglas fir interspersed with patches of alder and maple. The lower slopes have greater amounts of hardwoods, and the valley floor has groves predominantly of hardwoods. Elevations range from sea level to over 2,000 feet.

The industrial forests are confined to Scappoose and Milton Creeks where extensive stands of young growth have reached pole-timber and sawtimber size. Between Scappoose and Portland, the high ridge paralleling the Willamette is well forested.

Access to all parts of the subbasin is very good. Besides the main roads along the ridgetop and the Willamette, there are several hard-surfaced roads crossing the ridge. Since removal of old growth timber and establishment of adequate fire protection, watershed conditions are very good over much of the area. Some problems will arise as suburban development extends into the forest area.

The nation's largest municipal park within city limits is Portland's 6,000 acre Forest Park in the hills northwest of downtown Portland. The Bureau of Land Management manages about 6,800 acres of Federal land in the hills just northwest of Portland. In the Milton Creek watershed, the City of St. Helens owns about 1,500 acres.

Subbasin 11--Sandy

The Sandy Subbasin is 90 percent forested. It produces the highest average annual per acre water yield of any subbasin. The streams of this subbasin annually yield an average of 3,770 acre-feet of water per square mile. All of the tributaries except the lower part of the Sandy drainage area are covered with dense forests. The upper Sandy and Zigzag River drainages have large areas of Alpine landscape, bare slopes and active glaciers. The forest lands in most of the Bull Run, upper Sandy, Zigzag and Salmon River drainages are in the Mt. Hood National Forest. Access is generally poor to non-existent. The headwaters of the Zigzag and Sandy Rivers are within the Mt. Hood Wilderness and are being maintained as natural free-flowing rivers.

Large amounts of old growth still remain in the upper Sandy, Zigzag and Bull Run drainages. The latter, the source of Portland's municipal water, is one of the largest single stands of old-growth timber in the nation. A large wildfire burned over much of the Salmon River drainage about 1900; a new stand of second-growth is just now reaching merchantable size.

The forests in the lower part of the Sandy and short tributaries draining directly to Columbia River were cut many years ago and are now in second-growth forests and brush. These forest lands are mainly in the hands of small owners who in many cases are holding them for speculative purposes. Water quality within the subbasin is variable. Some waters from the slopes of Mt. Hood contain glacial silt and sand, and are thus of poor quality. In the winter, the upper Sandy and Zigzag Rivers often run wild with silt-laden waters. The waters of the Bonneville, Bull Run River and Salmon River drainage are higher quality due to less influence of Mt. Hood soils and glaciers.

F O R E S T   L A N D   D I S T U R B A N C E

Man's activities in the forests do affect the water. There is an increase of water, especially low summer flows, as much as 50 percent, for several years following vegetative removal. It is realistically measurable only if a substantial percent of the watershed in question is denuded. A long term sustained removal of vegetation results in sustained flow; whereas, an eratic removal (planned or unplanned) will cause erratic fluctuation of low summer flows. There is a perpetual variable impact to water quality basin-wide depending on the locations of forest activity. Unlike water quantity, a very small forest area misused usually causes massive increases of sediment loads to water flows; on the other hand, large areas of intelligent land use and disturbance on a given watershed often only causes modest amounts of temporary water pollution.

As our society becomes more complicated and populations increase, the forested watershed becomes more subject to varied use pressures. It must also produce a high yield of timber, provide recreation and be subjected to a number of other activities such as reservoir construction, powerlines, etc. The problem facing the forest land manager is how to harvest timber and provide for other uses without disruption of streamflow or damage to its quality.

In Willamette Basin the problem is not one of total yield of usable water. The problem is one of seasonal distribution--too much at times in winter, too little in late summer. As population increases and the land is put to increasingly intensive use, winter floods become more damaging. There is an increasing demand in late summer for water for domestic, industrial and irrigation uses and for pollution abatement.

Water of the highest quality is expected from a forested watershed; but modification of the forest environment, resulting from intensive use, can cause excessive sediment in streams--one form of water pollution.

Harvesting the timber crop in the Douglas fir region does affect the soil, but the important point is how much. The cause and effect relationship between the harvest and damage to the soil and water varies widely due to such common variables as logging methods, soil types, management cycle, and management objectives. The soil is compacted and the vegetation is removed. The soil absorbs rainfall less efficiently and overland flows increase. Erosion increases. The soil loss varies significantly though. For example, cable logging temporarily disturbs deeply only about 1/5 of the entire harvest area; whereas tractor logging on the same type of area often disturbs deeply over 1/2 of the harvest area.1/ This scientific fact is widely known and widely used in forest practice on case by case basis. On the other hand the principal is surprisingly ignored by land managers to coordinate total water quality objectives (suspended sediment) at downstream points.

1/ *Pacific Northwest Range and Experiment Station, Research Note, PNW-55, June 1967.*

The shelterwood system of harvest has less effect on hydrologic conditions than does clearcutting. Soil compaction is less drastic at any one time. Intermediate cutting results in repeated entry into an area, but change in the vegetative cover is not drastic. In addition, recent silvicultural research has shown that clearcutting is usually undesirable on upper-forest slopes because it is difficult to reestablish new forests. Noncommercial thinning and pruning has had little influence on the water cycle, but the trend towards chipping this material to add mulch and humus to the soil can increase water infiltration, contributing to ground water storage.

Severe slash fire burns have been found to reduce water percolation rates by over 70 percent. Both soil structure and the soil microorganisms needed to rebuild the soil are destroyed.

Road building permanently disrupts soil-water relationships. Almost all the precipitation on the road surface runs off, and the cuts and fills may become unstable for a long time. Skid trails may change the drainage patterns, concentrate runoff and cause gullying.

Excessive use of the watershed by livestock and wildlife may cause deterioriation of the vegetative cover, soil compaction in areas where they congregate and soil disturbance in wet weather. Recreational use leads to sanitation and biological problems affecting water quality.

The Willamette River annually transports about 2.5 million tons of sediment from eroding forest lands. The fact that this amount is less than 1/2 of the total sediment production and comes from more than 2/3 of the total land area is significant. Most of the sediment produced from forest lands is the result of natural geologic processes such as bank wasting, stream cutting and erosion of specific critical areas. Use of forest lands often aggravates these processes and may cause additional production of sediments due to the soil and water disturbance inherent in the use. Table II-10 portrays an estimate of the average rates of sediment production from forest lands. Map II-13 depicts the broad risk disturbance potential and sedimentation risks of forest lands within the basin.

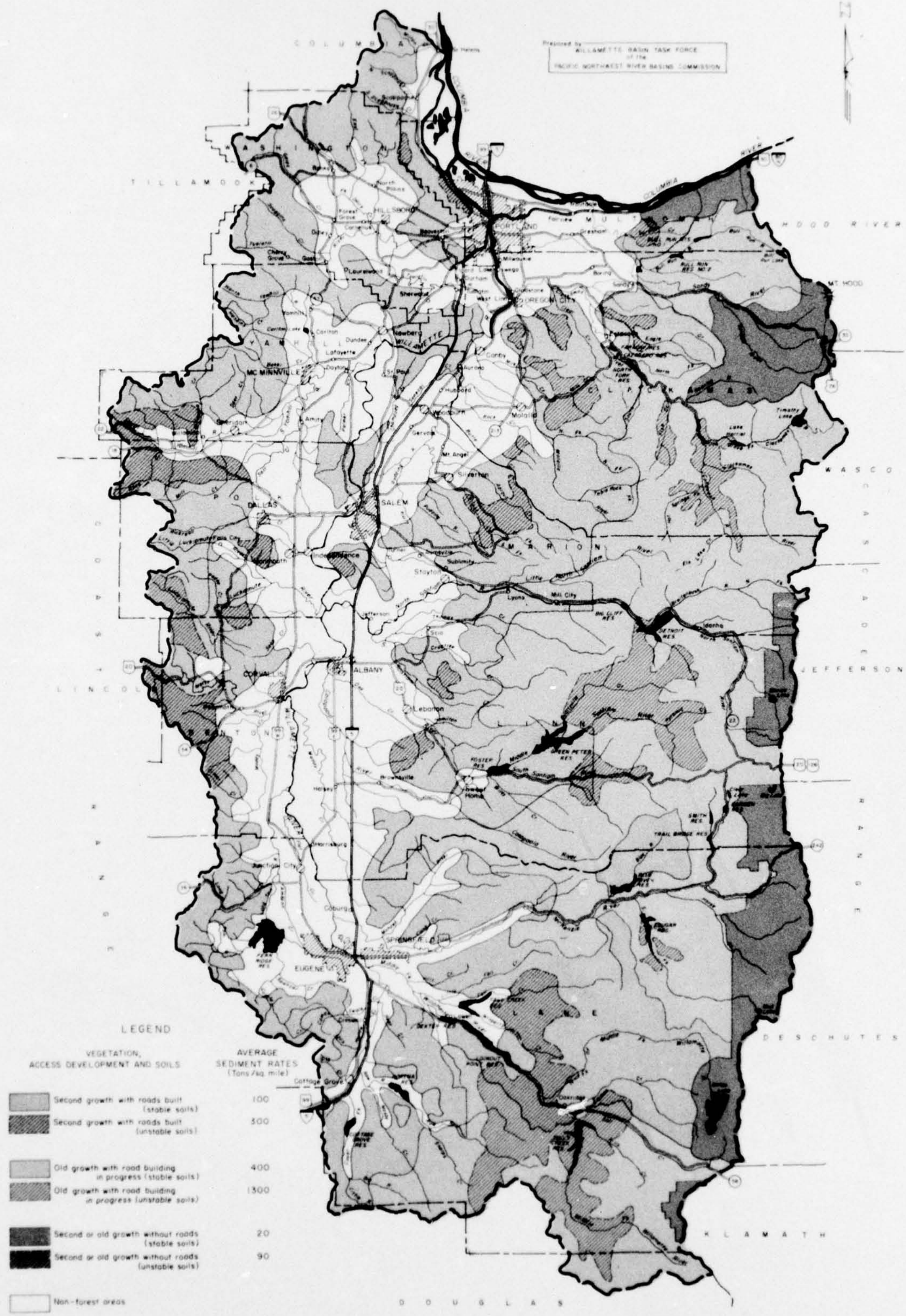
Table II-10
Suspended Sediment From Forest Lands

Forest Lands by Ownership	Upper Subarea % of Area	Upper Subarea Average Tons/ sq.mi.	Middle Subarea % of Area	Middle Subarea Average Tons/ sq.mi.	Lower Subarea 1/ % of Area	Lower Subarea 1/ Average Tons/ sq.mi.	Willamette Basin Area % of Area	Willamette Basin Area Average Tons/ sq.mi.
	Rates of Sediment Production							
Public								
State of Oregon	3/	205	2	262	2	104	1	219
Co. & Municipal	3/	353 2/	3/	386 2/	1	114	3/	221
National Forests	70	369 2/	23	568 2/	52	487 2/	48	430 2/
Other Federal	5	262	6	380 2/	2	199	5	318
Private								
Large Private	16	276	23	387 2/	5	129	16	332 2/
Small Private	9	138	46	147	38	127	29	142
Average Rate		328		315		315		320
TOTAL AREA (sq. mi.)	100	3,380	100	3,350	100	1,220	100	7,950

1/ *Tualatin and Clackamas Subbasins only.*

2/ *Exceeds average basin rate of 320 tons per square mile.*

3/ *Less than one percent.*



MAP II-13
WILLAMETTE BASIN STUDY
OREGON

PRESENT SOIL & WATER DISTURBANCE HAZARD ON FOREST LANDS

DECEMBER, 1968

SCALE IN MILES

Roads and Trails

Roads are an important source of sediment from the basin's watersheds. Large amounts of soil are laid bare and underground seepage channels are severed by road cuts. Modern earth moving machinery has made it possible to economically build logging roads into the farthest reaches of the forest areas. Clearing for right-of-way may affect as much as one acre out of every twenty, and on steep topography roads and log landings may occupy one acre out of every eight. Often four-five miles of road are required to harvest one square mile of timber.

Roads are major investments, generally built for permanent use. They are basic to modern forest land uses--recreation development and timber harvest. Proper planning, engineering and protective measures reduce impairment of water quality. About 5,000 miles of permanent road system form a transportation network on National Forest lands. The Bureau of Land Management has constructed and maintains 681 miles of forest access roads. Road mileage on private forest lands equals or exceeds these figures.

Road failures are costly, not only from the expense of repairs, but because of the economic loss from stoppage of timber supplies and the social cost of the huge amounts of silt added to drainages.

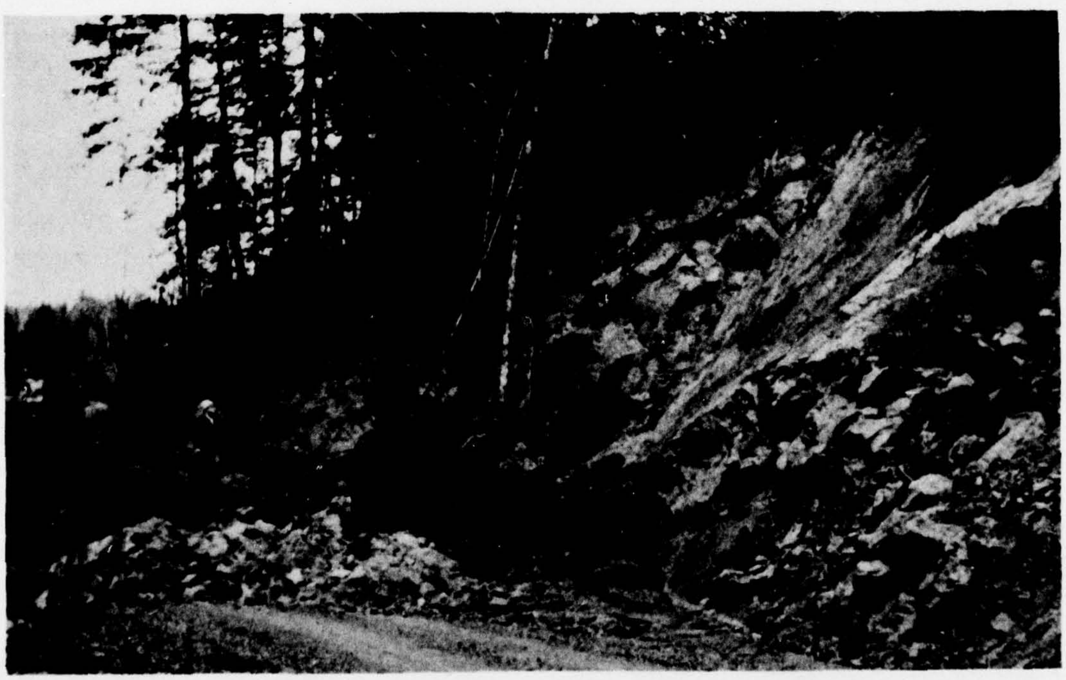


Photo II-36. Stabilization of roads from slides and washouts is needed to reduce erosion damage. *(BLM Photo)*

Silt is frequently washed into streams from overcasts of excess rock and soil and from cut and fill slopes. Failures have resulted from improper road locations in unstable ground areas, poorly placed cuts and fills, poorly installed drainage structures, and improper placement of surfacing.

Existing roads on public lands in the basin contain about 5,000 acres of critical area, amounting to 5-10 percent of the total cleared road rights-of-way. Surveys show that $393,000 is needed to stabilize critical roadway areas on the public lands in the basin and $655,000 to take care of roads on small private forest lands (Tables II-14 and -15). Data are not available for large private holdings. The most critical areas are in the Clackamas Subbasin. Some of the critical area, mostly the newly constructed roads, needs quick attention to protect the slopes and fills. The bigger job is to maintain and restore existing roads through slide stabilization, slide removal and riprapping of culvert sites.

Timber Management

The Douglas fir covering the basin's watershed does not reproduce well under shade. Because the Douglas fir is the most valuable native conifer, it is harvested by clearcutting large patches of land to produce a site favorable to its reproduction. This leaves the ground bare without protective vegetative cover for several years until brush and seedlings grow back. It is during this period that water problems arise, especially those affecting water quality.

Photo II-37. Tractor logging causes soil disturbance. Heavy equipment use must be coordinated carefully to prevent permanent damage to the soil and water. (BLM Photo)

Photo II-38. Poor locations of skid trails and temporary logging roads plus inadequate drainage cause accelerated erosion.
(U. S. Forest Service Photo 484291)

Roughly 54,000 acres are harvested on the basin's forest lands each year; about 30,000 acres of this total are on the National Forest lands. Most timber is harvested in clear cuts. Managers of both public and large private forest properties attempt to restore forest cover as soon as possible.

Timber harvest operations are found to be the cause of over half the critical areas in the basin needing rehabilitation. Cumulative sediment yields from this disturbance may equal that caused by roads and trails. Treatment costs (including planting costs) for rehabilitation following logging are twice those related to road building. However, clearcut-induced areas of instability are less concentrated than those resulting from road construction. Table II-11 shows acres and costs of some of the tree planting done in the basin.

Each logging site presents its own problems of access, topography, type of soil, and operational economics, as well as impact on water quality. There are several alternative methods of removing timber from the forest. Tractor yarding on wet ground sometimes results in skid-trail cuts several feet deep, which channel water and contribute to erosion problems.

Photo II-39. Horse logging often does a better job in young growth forests under intensive management. Heavy equipment would damage uncut trees and disturb too much soil.
(U. S. Forest Service Photo 507416)

Studies by Steinbrenner and Gessel in 1956 found that skid trails occupy 26 percent of the logging area and reduce soil permeability 92 percent. An alternative is cable logging, in which logs are pulled to a stationary engine. Here, too, the logs gouge a trough as they are pulled over the ground, but the channels are usually not so deep as in tractor yarding.

Table II-11
Reforestation Activity

Reforestation of Public Lands in 1964

Location	Acres Reforested	Cost 1/
Upper Subarea	9,503	$324,600
Middle Subarea	7,431	184,100
Lower Subarea	5,426	150,620
Willamette Basin	22,360	$659,320

Reforestation on Small Private Forest Properties 1960-64 2/

Location	No. Farms	Acres Reforested	Dollars Assistance
Upper Subarea	35	195	$ 3,500
Middle Subarea	265	2,404	52,100
Lower Subarea	164	1,482	36,100
Willamette Basin	464	4,081	$91,700

1/ *Costs do not include site preparation, animal and disease control, or seed procurement.*

2/ *Assistance is public cost only and covers only those lands receiving assistance through the Agriculture Conservation Program.*

Natural Disasters

Fire, windstorm, insects, disease and floods can cause great loss to forest soil and watershed values. After a forest fire devastates an area, every effort must be made to reestablish protective vegetative cover. Large fires in the basin are now infrequent due to increased public cooperation and improved protection procedures. A fire may occur in only one drainage in the basin, but its downstream effects, particularly on fish life, may be far reaching. The number of fires and acreages burned on various ownerships during the last 10 years are shown on Table II-12.

Table II-12

Forest Fire Record, 1956-1965

Location	Number of Fires	Acreage Burned
Private and State Forest Lands		
Upper Subarea	471	1,425
Middle Subarea	640	3,164
Lower Subarea	471	1,042
Willamette Basin	1,582	5,631
National Forest, Public Domain, and O&C Revested Lands		
Upper Subarea	745	2,280
Middle Subarea	394	1,462
Lower Subarea	412	480
Willamette Basin	1,551	4,222

Windstorms have disrupted forest management operations throughout Willamette Basin. The Columbus Day 1962 storm blew down about 1.5 billion board feet of timber in the basin. Downed trees provide prime breeding grounds for insects. In the resulting epidemics, insects attack live timber nearby and cause further losses to protective vegetative cover. Also, the accumulation of enormous quantities of dead fuels makes these areas a high fire hazard. A massive cooperative salvage program has brought this particular situation under control. Timber harvest programs were adjusted to give priority to the blowdown areas, and needed watershed rehabilitation measures such as revegetation and stream clearance were emphasized.

Flood damage accounts for three-quarters of the present land treatment needs on the forested watersheds. The December 1964 flood severely damaged many forest areas in the basin.

Roads, campgrounds, and other improvements suffered damages exceeding $10 million on the National Forests alone. Natural wood debris and logging wastes, moved into the stream channels by the floodwaters, are an obstacle to fish and pose a threat downstream until removed. Major efforts are underway in stream clearance, channel restoration, and replacement of roads, bridges and culverts. The Forest Service alone has completed about 45 projects at a cost of about $250,000.

Photo II-40. Forest roads increase overland water flows and may cause erosion problems. *(BLM Photo)*

Occupancy

Use of forest land for special purposes such as water storage reservoirs, electric transmission lines, rock pits, and human habitation often result in special watershed management problems and needs for specific land measures.

Transmission lines and water storage sites have in some cases been located in unstable areas. Occasionally aggravated soil and water disturbance results from construction and land clearing. Usually power line failures occur in the winter when the soil is wet and relatively unstable, and repair crews must bring in machinery over temporary unsurfaced roads, causing a great deal of soil disturbance and initiating erosion problems. Construction of water storage reservoirs often requires the relocation of existing roads from valley floors to the more unstable hillsides.

More intensive management of the lands surrounding and upstream from the new reservoir may be needed not only to reduce earth slippage and the amount of forest debris entering the reservoir, but to enhance the aesthetic attributes of the site.

Treatment needs for present reservoir areas consist mainly of revegetation of rights-of-way, stabilization of reservoir slopes, and structural erosion control on steep roads around reservoir perimeters.

Photo II-41. Part of the clearing process for a new reservoir is the controlled burning of slash after logging, Bull Run River, Clackamas County, 1957. (City of Portland Photo)

Grazing

In early days the upper slope forest zones were heavily used by sheep, and effects of past overgrazing are still visible. Growing seasons are so short and temperatures so cool that some of these sites have never recovered. Now, domestic livestock make very little use of the major forest watersheds. However, grazing is an important use on many of the small private forest lands. Overgrazing is evident on some of these small holdings.

Heavy use of trails in wilderness areas by pack and riding stock of recreationists and overgrazing around campsites by these animals now gives reason for alarm. Continued overgrazing reduces plant density and the amount of litter available for soil humus. Soil compaction from trampling may result in increased overland flows, endangering soil stability and water quality.

Big game use nearly all the forest watershed. Big game grazing in or near streams adds to pollution. Access for hunters must be provided to control excessive game population and overgrazing. Habitat requirements for big game are considered an important part of the total natural resource management program.

Photo II-42. Intense use of fragile alpine meadows by trail stock often causes serious damage and erosion, Lane County. (Willamette National Forest Photo)

Recreation

Most recreation developments in forest lands, such as campgrounds and picnic areas, are located near lakes, streams or rivers. Recreational use, including hunting and fishing, increases the hazards from human waste. Sanitation problems also develop in heavily used winter sports areas, as well as at recreation developments, administrative sites, work camps and summer homes. Improper garbage disposal at these places may introduce bacterial contamination into surface waters. Forest recreation can affect soil stability and water quality through compaction of soils at heavily used recreation areas, resulting in increased overland water flows and erosion.

Present programs of recreation area design, layout and controlled use are reducing site disturbance problems. Improvements are continually being made in design, installation and testing of sanitary facilities to minimize biological contamination of forest streams.

Photo II-43. Boaters crowd the shoreline at North Waldo Lake Campground, Lane County. (FS Photo)

FOREST LAND MEASURES

Specific land treatment measures used to overcome disturbances caused by various land uses are presented in the following paragraphs.

Roads and Trails

Increase the number and size of culverts to get better road drainage and reduce road washing, gullying and siltation of water courses. Doubling the number of existing culverts on forest roads may be needed; increasing average culvert size from 12 inches to 24 inches and adding four per mile costs at least $1,500 per mile. Better protection is also needed under culvert outflows; either stone or concrete aprons or flumes to toe of fills can be used.

Seeding, fertilizing and mulching of road cut banks and fills, costing about $300 per acre, are needed to stabilize the soil in many areas.

Many times forest roads are built in narrow draws adjacent to stream channels. Sometimes the road construction fill material erodes directly into the water. In such situations the full width of the road should be excavated and the waste material end-hauled away from the stream area. An alternative would be to construct retaining walls to stabilize the fill and prevent erosion of this exposed material. High cost of retaining walls has limited their use in forest road construction.

Timber Management

Many timber management alternatives have major impact on water quality: size of the clearcut area; time of year and method of logging; the need for leaving the timber cover on delicate, unstable soil areas; the need to log only one side of a stream at a time; and keeping clearcut units small in size when on unstable soils or adjacent to streams.

Alternatives for protection of water quality involve additional expense. Tractor yarding costs about $2.00 per thousand bd. ft. less than high-lead yarding, but on steep ground causes serious washing and erosion of the skid trails, and may result in soil compaction which limits natural reforestation. Slack-line logging causes very little soil disturbance but costs about $2.50 per thousand bd. ft. more than high-lead yarding, which causes some soil disturbance.

In winter logging, sediment settling basins should be constructed in drainages below log landings; however, this is seldom done due to additional expense.

There is need to provide for drainage on skid trails, spur roads, and log landings. Temporary culverts and bridges should be removed when logging is finished, instead of being left to wash out in subsequent storms.

On private lands, logging and other vegetative debris is not always yarded away from stream channels as it should be to prevent flood damage. Salvage sales and intermediate cuts tend to reduce amounts of fuel for forest fires and reduce loss of soil cover from fire.

Natural Disasters

The fire problem is of greatest concern in view of accelerating population and demands for recreation on forest lands. Windstorms and accompanying tree blowdown require prompt cleanup and salvage measures. The measures may require emergency funding for development of inaccessible areas. Chemical controls for forest insects and disease can have adverse effect on water quality. Less toxic materials are often used in areas where there is danger of water contamination, although they are not so effective and may be more expensive. Another measure of control is a high level of monitoring during application of chemicals.

Grazing

Land measures needed are fencing and reseeding to protect and restore soil cover and to keep livestock out of the streams.

Recreation

Extensive recreation use is made of forest lands which have no facilities. This results in water contamination as well as litter accumulation. Water quality requirements make the old pit toilet obsolete. The need for flush type toilets greatly increases recreation facility construction costs.

WATERSHED TREATMENT NEEDS

During the summer of 1965, a survey was made by Federal and State agencies to determine present areas of disturbance on forest lands. Estimates of critical area and treatment costs for the basin are shown in Table II-14 and II-15 for public and small private forest lands, respectively. Data are not available for the large private holdings.

In Tables II-14 and II-15, "Total Area of Impact" is the acreage used or affected by the specific disturbance factor, such as "roads and trails". "Critical area" is the acreage disturbed to the degree that it has become a watershed management problem, i.e., is contributing to water quality problems; some of this area may not be subject to treatment or may be uneconomical to treat. "Treatment area" is that portion of the "total area of impact" which needs treatment to correct water quality problems or to prevent site deterioriation which could result in water quality problems. The acreages and treatment costs identified in this table are the accumulative totals which will not be taken care of under funded programs. Additional funding over and above existing programs will be needed to remedy the problems. These costs do not include watershed oriented land treatment measures which were adequately funded in 1965 as a part of the standard operating procedures by Federal and State agencies and private owners for such programs as timber harvesting, road and trail construction, reforestation, erosion and debris control, fire control and recreation management. It is probable that over 75 percent of the total watershed treatment needs on the Federal and State lands were adequately funded in 1965.

COST OF PRESENT WATERSHED MANAGEMENT PROGRAMS

How much of the investment in forestry today is spent exclusively to protect the soil and water value? It is a capital expenditure that is more significant than commonly realized.

Parts I and II defined watershed management and practices in elaborate detail. A study and conservative estimate shows that the economic cost of present practices (in forest use situations) to simply conserve the soil and water exceeds 12 million dollars per year in the Willamette River Basin. This is an average of about $2.49 per acre per year for forest land (see Table II-13). Compare this with 25 cents per acre per year spent on forest fire protection in the basin. Most Watershed Management costs are usually hidden within the total costs in any use situation. In road building, for example, total road building costs were 48 cents per acre per year in 1968; this cost is actually less than 1/5 of the total engineering and construction costs to build 550 miles of permanent forest roads.

The estimate of present costs may be viewed as a maintenance expenditure to protect and enhance our basic non-renewable resource--soil and water. It is one way to gain valuable perspective in the economic evaluation of the present soil and water program. Except for fire protection and research, the study indicated that in general the public sector spends more than the private sector and that large ownerships spend more than smaller ownerships for watershed considerations on a per acre basis. The extent that the owner or manager presently foregoes exploitive forestry to protect and maintain the basic soil and water values will be an overriding long-term economic factor.

Table II-13
Average Annual Watershed Management Costs 1/
On All Forest Lands, Willamette River Basin, 1968

Basin Activities and Major Uses	Explanation	Cost Per Acre
Fire protection	Prevention and detection (suppression not included)	$.25
Research 2/	H. J. Andrews Experimental Forest and Corvallis Laboratory	less than $.01
Management	Basic planning, resource surveys, administrative and technical studies, etc.	$.02
Soil and water restoration	Debris removal, gully stabilization, sheet erosion control, rehabilitation	$.02
Recreation	Facility development and maintenance	$.01
Road building	About 550 miles of roads built	$.48
Timber harvest 3/	About 48 thousand acres actually harvested	$1.70
Others	Fish and wildlife habitat, catastrophic weather, reservoir and powerline construction	$.01

1/ *Basis of 5 million acres of commercial forest land, all ownerships.*

2/ *Costs are assigned to 25 million acres in Douglas-fir subregion.*

3/ *Includes reforestation.*

Table II-14

Public Forest Lands in Willamette River Basin
Needing Supplemental Treatment, 1965

Location	Total Area of Impact 1000 A.	Critical Area 1000 A.	Treatment Area 1000 A.	Treatment Cost (dollars)
Upper Subarea				
Roads & Trails	15.2	3.4	2.5	$109,600
Tbr. Mgmt.	88.8 1/	13.9	6.7	118,400
Natural Disasters	48.6 2/	2.2	1.7	172,100
Occupancy	10.0 3/	0.4	1.2	13,400
Grazing	44.3	0.8	0.7	2,700
Recreation	1.0	0.2	1.5	125,700
Total	-	20.9	14.3	$541,900
Middle Subarea				
Roads & Trails	10.4	0.8	.4	12,500
Tbr. Mgmt.	61.4	2.3	1.7	43,000
Natural Disasters	37.8	2.2	1.7	59,800
Occupancy	5.3	.4	.3	31,000
Grazing	22.6	1.0	-	-
Recreation	1.0	.1	.1	10,500
Total	-	6.8	4.2	$156,800
Lower Subarea				
Roads & Trails	10.8	.8	1.4	270,700
Tbr. Mgmt.	39.8	2.9	11.0	596,200
Natural Disasters	46.9	3.0	4.6	544,000
Occupancy	4.7	.2	.5	31,600
Grazing	27.7	-	-	-
Recreation	2.5	-	.1	35,000
Total	-	6.9	17.6	$1,477,500
WILLAMETTE BASIN				
Roads & Trails	36.4	5.0	4.3	392,800
Timber Mgmt. 1/	190.0	19.1	19.4	757,600
Natural Disasters 2/	133.3	7.4	8.0	775,900
Occupancy 3/	20.0	1.0	2.0	76,000
Grazing	94.6	1.8	0.7	2,700
Recreation	4.5	.3	1.7	171,200
Total	-	34.6	36.1	$2,176,200

1/ Area harvested last 5 years only
2/ Since 1950 only
3/ Since 1940 only

Table II-15
Small Private Forest Lands in Willamette River Basin Needing Supplemental Treatment, 1965

Location	Total Area of Impact 1000 A.	Critical Area 1000 A.	Treatment Area 1000 A.	Treatment Cost (Dollars)
Upper Subarea				
Roads & Trails	3.3	.2	.2	$126,000
Tbr. Mgmt.	49.8 1/	.2	.2	10,800
Natural Disasters	2.3 2/	.3	.4	23,800
Occupancy	4.0 3/	.3	.3	1,500
Grazing	22.7	.2	-	-
Recreation	.1	-	-	-
Total	82.2	1.2	1.1	$162,100
Middle Subarea				
Roads & Trails	6.2	.7	.7	405,000
Tbr. Mgmt.	134.4 1/	.1	.1	7,200
Natural Disasters	23.2 2/	2.2	2.2	52,100
Occupancy	4.1 3/	.5	.5	94,000
Grazing	29.5	.3	.3	-
Recreation	1.2	-	-	-
Total	198.6	3.8	3.8	$558,300
Lower Subarea				
Roads & Trails	3.0	.2	.2	124,000
Tbr. Mgmt.	64.4 1/	.1	.1	4,800
Natural Disasters	14.2 2/	2.4	2.4	13,300
Occupancy	2.5 3/	.4	.4	4,000
Grazing	8.4	.4	.4	-
Recreation	.6	-	-	-
Total	93.1	3.5	3.5	$146,100
WILLAMETTE BASIN				
Roads & Trails	12.5	1.1	1.1	655,000
Timber Mgmt.	248.6 1/	.4	.4	22,800
Natural Disasters	39.7 2/	4.9	5.0	89,200
Occupancy	10.6 3/	1.2	1.2	99,900
Grazing	60.6	.9	.7	-
Recreation	1.9	-	-	-
Total	373.9	8.5	8.4	$866,900

1/ Area harvested last 5 years only
2/ Since 1950 only
3/ Since 1940 only

WATERSHED MANAGEMENT PROGRAMS

Water is a product of an individual watershed where climate, soil, plant cover, topography and drainage patterns are key variables, and management can influence the quality and amount of water in a forest stream. As basic data on the nature of forest soils, cover and waters become available, control of streamflows becomes more effective and practicable.

VALUE OF WATER

The value of waters is dependent on the type of use--industrial, domestic, agricultural, or other. As a basic resource, much like air and soil, water exceeds the value of other forest resources in most of the basin's watersheds. A forested watershed on the Cascade slopes in good condition is releasing water at an average annual rate of 4-6 cubic feet per second per square mile.

OBJECTIVES AND POLICY

Goals for land measures in watershed management vary not only between owners, but even at different locations within the same ownership. In the American Forestry Association's policy statement for 1964, it is recommended that:

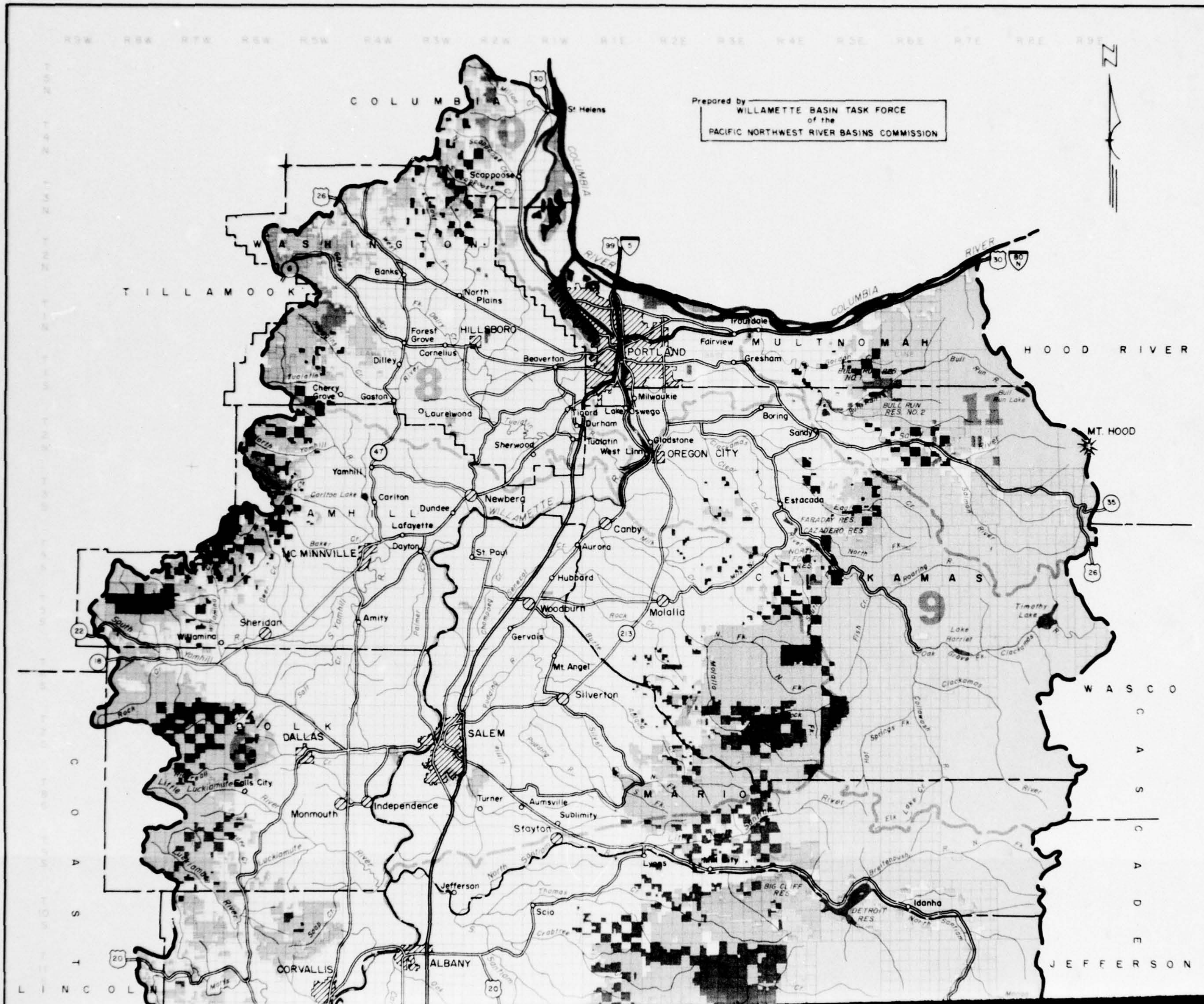
> "Soil as a basic forest resource must be protected at all costs."
>
> "Institution of forest and other vegetative management practices be made, where it has been demonstrated that greater and better timed water yields result and risks from erosion are minimal. Research should be continued and intensified to determine the physical and economic consequences of such programs."

Owners of basin forest lands are conducting different levels of forest management. Forest management with comparatively large per-acre investments is consistent with forest conservation in the sense of foregoing some immediate yields for the promise of greater yields later on. This is "conservative" or "intensive" management. Different intensities of timber management result in a variety of watershed conditions.

Public Lands

Public forest lands--Federal, State, county, and municipal--amount to about 3.1 million acres in the basin. This is over half of the forest lands in the basin (Map II-14).

The Bureau of Land Management is responsible for the multiple-use management of about 0.5 million acres of forest land lying in the "principal forest" zone. Management is complicated by locations intermingled with private lands. BLM lands are administered under an intensive resource management program authorized by the O&C Act of August 28, 1967


Prepared by
WILLAMETTE BASIN TASK FORCE
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PACIFIC NORTHWEST RIVER BASINS COMMISSION
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CASCADE
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COAST
LINCOLN
COLUMBIA RIVER
WILLAMETTE
MT. HOOD
PORTLAND
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HILLSBORO
MC MINNVILLE
DALLAS
CORVALLIS
ALBANY
St Helens
Scappoose
Banks
North Plains
Forest Grove
Cornelius
Dilley
Gaston
Cherry Grove
Laurelwood
Beaverton
Tigard
Lake Oswego
Durham
Tualatin
West Linn
Gladstone
Milwaukie
Sherwood
Newberg
Yamhill
Carlton
Dundee
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Sheridan
Willamina
Amity
St Paul
Aurora
Canby
Hubbard
Woodburn
Gervais
Mt Angel
Silverton
Molalla
Troutdale
Fairview
Gresham
Boring
Sandy
Estacada
FARADAY RES.
CAZADERO RES.
BULL RUN RES. NO. 2
Timothy Lake
Lake Harriet
Independence
Monmouth
Falls City
Turner
Aumsville
Sublimity
Stayton
Lyons
Jefferson
Scio
BIG CLIFF RES.
DETROIT RES.
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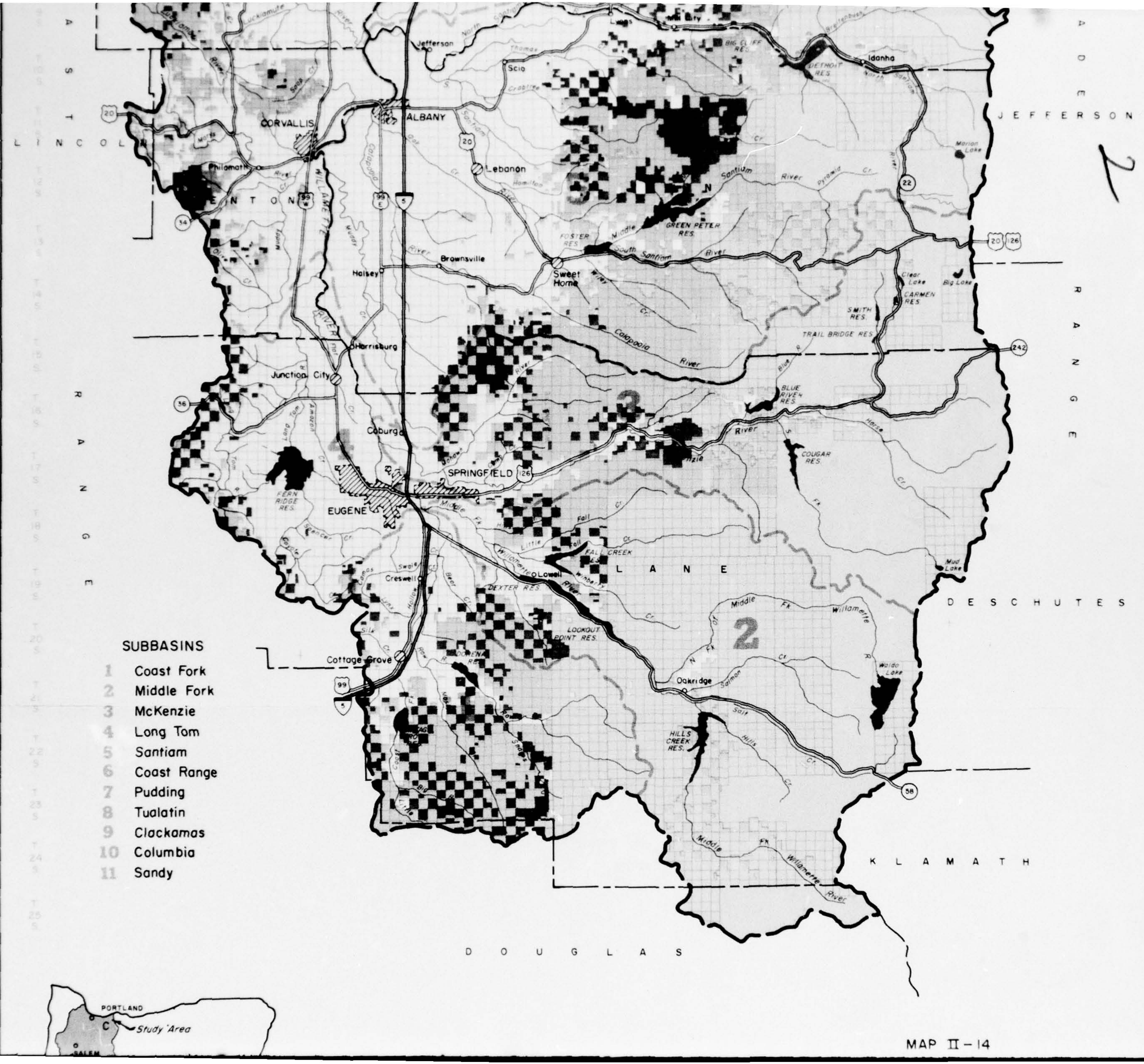
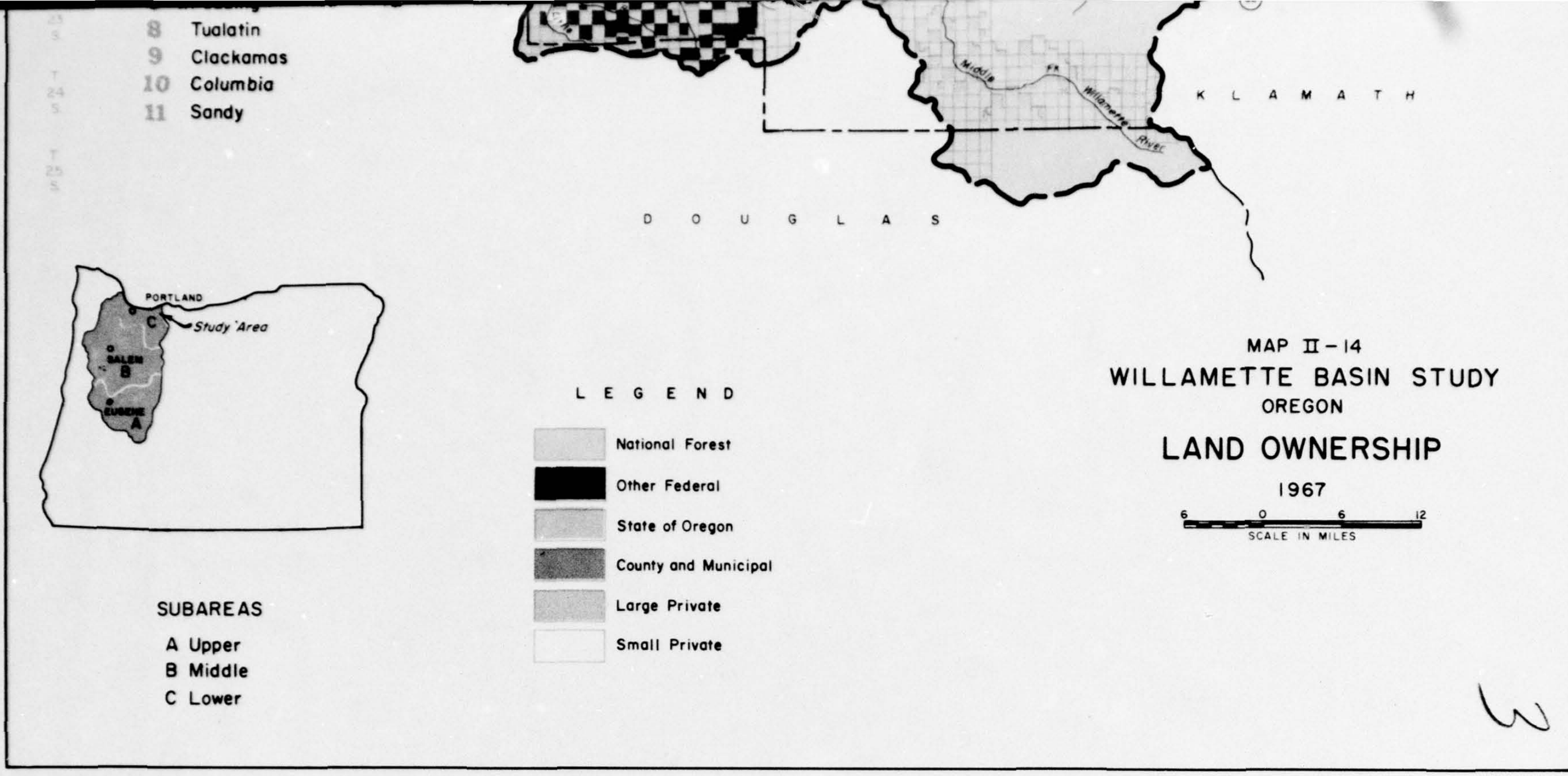


SUBBASINS
1 Coast Fork
2 Middle Fork
3 McKenzie
4 Long Tom
5 Santiam
6 Coast Range
7 Pudding
8 Tualatin
9 Clackamas
10 Columbia
11 Sandy
JEFFERSON
RANGE
DESCHUTES
KLAMATH
DOUGLAS
LANE
LINCOLN
BENTON
CORVALLIS
ALBANY
EUGENE
SPRINGFIELD
Lebanon
Sweet Home
Brownsville
Halsey
Harrisburg
Junction City
Coburg
Creswell
Cottage Grove
Oakridge
Lowell
Philomath
Jefferson
Scio
Idanha
DETROIT RES.
BIG CLIFF RES.
GREEN PETER RES.
FOSTER RES.
FERN RIDGE RES.
DEXTER RES.
LOOKOUT POINT RES.
HILLS CREEK RES.
COUGAR RES.
BLUE RIVER RES.
TRAIL BRIDGE RES.
SMITH RES.
CARMEN RES.
FALL CREEK RES.
Waldo Lake
Marion Lake
Clear Lake
Big Lake
Mud Lake
PORTLAND
Study Area

MAP II-14

2



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(50 Stat. 874) which provides that the lands "--shall be managed for permanent forest production--in conformity with the principal of sustained yield for the purpose of providing a permanent source of timber supply, protecting watersheds, regulating streamflow, contributing to the economic stability of local communities and industries, and providing recreational facilities." Of the Salem district's annual budget (about 1/3) or $740,270, is expended directly benefiting water quality or watershed stabilization. In the Eugene district 34 percent of its budget, or $452,460 is used where watershed management factors receive major benefits, including gully control, erosion control, road and trail restoration and water quality protection.

National forests occupy about 2.5 million acres in the basin, principally in the "principal", "upper slope" and "sub-alpine" forest zones. The primary purpose of the National Forests, stated in the Act of June 4, 1897, is "to improve and protect the forests within the reservation, or for the purpose of securing favorable conditions of water flow, and to furnish a continuous supply of timber for the use and necessities of the citizens of the United States." The Multiple Use Sustained Yield Act of June 12, 1960 (P. L. 86-519) further authorizes and directs that National Forests be managed under principals of multiple use to produce a sustained yield of products and services, and for other purposes. This includes management of National Forest lands for production of water.

State forest lands occupy about 100,000 acres in the basin. Oregon Revised Statute 530.050 provides that the State Board of Forestry shall manage the lands so as to secure the maximum value of such lands to the state. The multiple-use policy of the Board of Forestry recognizes other uses of State forest lands in addition to the yield of forest products. Such uses include watershed protection and development, recreation, mining, fish and wildlife management, research and education, grazing, erosion control, and administration. As to watershed protection and development, the Board's policy states that the growing and harvesting of forest products shall be regulated so as to reasonably protect watersheds and reservoir intakes of domestic water supply and to protect watershed and streamflow necessary for hydroelectric development and for the preservation of commercial and sport fishing.

Counties and cities own or control significant forest acreages in some subbasins. Counties are attempting to bring forest lands to "intensive" management levels, particularly Clackamas, Lane and Washington Counties. Cities such as Corvallis and Portland own small but vital segments of their municipal supply watersheds. In these cases, cooperative agreements with the Forest Service ensure that both Federal and City lands receive coordinated management for production of municipal and industrial water supplies.

<u>Private Lands</u>

Private forest lands, widely dispersed throughout the basin, amount to about 2.5 million acres. These lands range from very small woodlands on individual family farms to large tracts of forest lands which are part of industrial forest operations.

About 60 percent of the privately owned forest lands are in "large private" ownerships (more than 5,000 acres each). These ownerships amount to about 1.5 million acres, most of which are integrated into industrial forestry operations. Most large companies apply basic watershed management practices as a part of intensive timber management programs, although there is some difference in application of forestry programs by individual industrial enterprises. C. W. Richen, of Crown-Zellerbach Corporation, stated at an Oregon Water Resources Conference, in 1964, that:

> "The forest industries of our State are irrevocably committed to the concept of managed forests for permanent future wood supply. Many companies own and manage tree farms which are dedicated to continuous production of forest crops."
>
> * * *
>
> "The establishment of managed forests, whether privately or publicly owned, is a process of growing and harvesting trees continuously for the best interests of the owner. In the process we do more than manage timber. We manage the watershed. We manage the soil. In reality, the owner manipulates the vegetation in order to coax out of the soil the maximum of products he may desire."

About 40 percent of the private lands--1 million acres--are in "small private" ownerships (less than 5,000 acres each). The majority of these holdings are in the valley woodland zone. Most of those ownerships are less than 100 acres in size and are usually associated with full- or part-time farming operations.

On small private lands, the practice of watershed management is often a by-product of the level of forestry being practiced on the land. Some owners employ the best watershed management practices and treatments in the use of their woodlands, but others have practiced "exploitive" forestry due to economic pressures, lack of knowledge, or absentee ownership. These deinvestment practices often leave watersheds in a poor condition of readiness for future forestry outputs.

P R O B L E M S

Water management and the management of the forest land that yields water flows is complex, because of competing uses. There is pressure to increase products and services from the basin's forests. Usually, the highest quality of water is produced by undisturbed forest land, yet forests must be used and some disturbance is unavoidable. The problem is to identify the practical limits of watershed management practices that meet the owner's basic land use objectives.

GENERAL PROBLEMS

More information is needed as to the origin of the water flows and the hydrologic aspects of the watershed. Detailed soil surveys are needed for all the forest areas of the basin so managers can anticipate water response to various uses and disturbances of the soil and its vegetative cover. Some surveys are underway but much of this work remains to be done.

Public managers are handicapped by the lack of a price tag on water for use in project cost-benefit analyses. There is no incentive other than public opinion for the private landowner to manage the watershed to produce high-quality water. Perhaps tax benefits to these owners are needed in recognition of the public interest in this valuable resource, much of which comes from these lands.

Water quantity and quality demands vary widely over the basin. There is need to identify both general water quality criteria and specific criteria to meet local needs. Major efforts should be expended on those watersheds where quantity and quality criteria show the greatest need.

Improved forest practices are needed to maintain watersheds. Intense storms often sluice out debris and slash clogging stream courses. Guidelines are needed for determining distance above normal water flow lines that such debris should be moved so as to avoid high water.

Many forest managers feel that disposal of slash by fire after clearcutting is necessary to prepare the site for new stands of trees and to reduce fire hazards. This practice is employed in all forest zones. Foresters need to know whether these hot fires are more harmful to the soil than the benefits gained through slash disposal. An evaluation is needed of the effects of various logging practices and types of logging equipment on erosion and sedimentation. Criteria must be improved for delineating hazardous areas and modifying logging methods and equipment as needed. Managers need better procedures for controlling soil disturbance resulting from logging.

In road development, watershed considerations need to be emphasized in the reconnaissance and preconstruction phases. Identification of unstable construction areas and stabilization of slide areas need continued emphasis. Because roads are major contributors to stream

BEFORE

AFTER

Photos II-44, II-45. Stream clearance projects improve fish passage and open additional spawning gravel for migratory fish - Quentin Creek - Lane County. (U. S. Forest Service Photos) turbidity, the opportunities to apply new techniques and test better ways of revegetation of disturbed construction areas need constant attention.

Heavy recreational use of lakes and streams leads to problems of site restoration. There is need for improvement in sanitary controls as well as development of new recreation areas to meet expanding demands. New areas would also tend to disperse the concentration of users.

Some key locations within the approximately 1/3 million acres of wilderness within the basin are deteriorating from overuse. The wilderness users congregate at the more accessible streams, lakes and springs. Horses trample springs and some thoughtless campers leave their dishwashing wastes there also. Some fishermen clean their fish in lakes and drop guts and heads into the clear blue waters. The complete lack of toilet facilities and the occasional inconsiderate user combine to often ruin this lovely outdoor experience for others. Wilderness management and user attitudes are changing very rapidly today. Until recently, however, the idea of maintenance of this pristine resource, construction of primitive sanitary facilities and aggressive public relations to educate the user to govern himself in these fragile landscapes were thoroughly offensive to the average user and manager alike.

Population pressures are increasing the demand for multiple use of the municipal supply watersheds. Someday there will be severe pressure for these forested areas to be used for other benefits in addition to municipal and industrial water supplies.

SUBBASIN PROBLEMS

The severity of watershed problems in Willamette Basin varies considerably from subbasin to subbasin. Varying patterns of land ownership, land and water use, stream runoff and precipitation influence the character of problems in each subbasin.

Subbasin 1--Coast Fork

Watershed management variables are the highly unstable soils found in some areas, depth of soils, topography, the nature and location of developments such as Dorena and Cottage Grove Reservoirs, condition of stream channels, the extremes of water flow in the various drainages, and the various uses to which the water will be put. Low summer streamflows and absence of natural lakes makes this area less attractive to recreationists than the Cascade Range areas.

Water supplies for major water-using industries are considered adequate. Recreation requirements for water are large; water-based recreation is an item of major economic and social value. Low base summer streamflows create problems in disposal of industrial waste, discouraging industrial development.

Some watershed management problems are bank cutting at high water, stream blockage by log jams and gravel bars, and sheet erosion from poorly stocked cutover timber areas, logging roads and fire trails. In the Cloverdale area, the major damage occurs from deposition of sediment and debris on farm lands and facilities. In the Gettings Creek area, streambank erosion from upstream tributaries results in sediment damage to farm lands and improvements; channel clearing and improvement is needed. On the Silk Creek watershed, croplands are subject to sedimentation and debris deposition. Erosion damage occurs from logging roads and skid trails on Martin Creek watershed. Table II-16 shows the stream sediment loading from upland erosion in the Coast Fork Subbasin.

Table II-16

Coast Fork Stream Sediment Loading

Station	Drainage Area	Sediment Con. Max.	Sediment Con. Min.	Total Sediment Load 1/ 1949	1950	1951 2/
	(sq. mi.)	(p.p.m.)		-------	(tons)	--------
Coast Fork						
London (above res.)	69	400	T.	13,000	7,650	13,640
Below reservoir	104	260	T.	8,890	9,420	15,110
Row River						
Star (above res.)	211	330	T.	27,150	12,550	8,490
Below reservoir	265	130	T.	-	-	32,780

1/ *"Report on Sedimentation - Willamette River Basin - December 1948 to July 1951", Dept. of Army, Corps of Engineers. (Reflects one year's sediment load based on 80 lbs. dry soil weight.)*

2/ *Based on October to June data only.*

Subbasin 2--Middle Fork

The watershed management variables within the subbasin are areas of unstable soils, the nature and location of conservation developments, special water requirements, and unusual weather conditions. All tributaries have had timber harvest operating in the past and several have very well developed road systems, but land managers in the area feel they are still working under "old growth" management principles.

The Salem Creek tributary has the highest water quality demand within the subbasin. The city of Oakridge uses this creek for its municipal supply, and both the Oregon Game Commission and Fish Commission have hatcheries using water from Salmon Creek for their operations.

Subbasin 3--McKenzie

The principal watershed management variables within the subbasin are areas of unstable soils, the nature and location of conservation development, special water requirements, and unusual weather conditions. The steepness of the terrain in combination with high rainfall and run-off plus areas of unstable soils have an effect on water quality and must be adequately considered in any program of timber harvest or access development. In virgin forest areas, conservation developments such as road construction and logging tend to accelerate the movement of soils. Highly unstable soils are found in several locations, primarily in the South Fork and Blue River drainages.

The McKenzie Subbasin has a very significant recreational use, supports an important resident and anadromous fishery, and supplies water for industrial and municipal purposes. The manner in which the forest lands are managed will have a pronounced effect on water temperature, color, sediment loading and biological contamination.

Subbasin 4--Long Tom

Land problems related to conservation appear in varying degrees in the Long Tom Subbasin. Its proximity to Eugene and good access roads have encouraged people to settle on forest land. Since many rely entirely on outside income and may have little interest in the land, conservation practices for them are not a way of life. Stock ranchers also convert forest lands to range by burning and grass seeding; fortunately, this practice is declining, but restoration of lands already abused is a slow process.

Timber harvesting by owners unconcerned about a future crop or not knowledgeable on the best method of logging has left some lands unproductive and subject to erosion. Skid trails and access roads on steep pitches cause the most erosion. This situation exists only on scattered tracts.

Measures have been taken to minimize erosion on the steep slopes and unstable ground by requiring cable logging and designing roads to reduce sediment movement. Well surfaced roads have substantially reduced movement of sediment into the streams.

Subbasin 5--Santiam

Major water impoundments needing upstream watershed protection are Foster and Green Peter Reservoirs on the South Fork of the Middle Santiam River and Big Cliff and Detroit on the North Santiam River. A fairly large area of high-erosion-hazard soils lies on both the Middle Santiam and Quartzville Creek above Green Peter Dam. A vast amount of timber awaits harvest in this area. Extreme care in management is needed to prevent excessive reservoir siltation and loss of site productivity. Fortunately, the North Santiam watershed is composed of fairly stable soils, but protective watershed management practices are needed to safeguard the large public investment in Detroit Dam.

Logging debris has accumulated in Crabtree Creek and several of its tributaries, blocking fish migration and threatening farmlands downstream. Considerable erosion is occurring on spur logging roads, old lands and skid trails.

In cutover land on Hamilton Creek watershed, considerable erosion is occurring on spur logging roads and abandoned landings and skid trails; treatment is needed to reduce this source of stream sedimentation. In the McDowell Creek watershed, erosion is limited to a few old logging roads and skid trails.

Subbasin 6--Coast Range

The tight structure of the sedimentary rocks of the Coast Range tends to repel water infiltration and storage. Streamflows then are closely related to intensity of precipitation, being high in winter and very low or dry in summer. Also, soils formed from these rocks tend to slump and present high erosion hazards when disturbed. Some erosion is occurring on cutover timber areas, mainly on skid trails and landings. There are no water impoundments of any size on the streams in this subbasin. Since a large part of the subarea has already been logged, the major impact on water quality from road construction has taken place. However, any relocations, improvements and extensions of logging roads still have serious impact on water quality from siltation. Headwaters of the South Yamhill River, Rickreall Creek, Luckiamute River, Tum Tum River, Rock Creek, Beaver Creek and Oliver Creek originate in unstable soil areas. Land management activities on these watersheds must be conducted accordingly.

Watershed management problems exist on steep forest lands being overgrazed by livestock. Streambank erosion is occurring in some areas, especially on Willamina, Mill and Agency Creeks; other South Yamhill River tributaries; Rickreall Creek; and Luckiamute River. There are problems of silt and debris deposition on cropland from floodwater overflows. Stream channel clearing is needed on Panther Creek, Deer Creek and Mill Creek to permit faster runoff of high water and less bank cutting and flooding. Sedimentation of selected Coast Range streams is shown in Table II-17. Cleanup expenses on farmlands from siltation and deposition on farmlands from upstream erosion in the 1964-1965 floods are shown in Table II-18.

Table II-17
Sedimentation of Selected Coast Range Streams

Station	Stream	Drainage Area (sq.mi.)	Sediment Concentration Max. (p.p.m.)	Sediment Concentration Min. (p.p.m.)	Total Sediment Load 1/ 1949 (tons)	Total Sediment Load 1/ 1950 (tons)	Total Sediment Load 1/ 1951 2/ (tons)
Whiteson	So. Yamhill R.	502	800	12	280,480	112,380	134,180
Suver	Luckiamute R.	240	410	T.	90,700	46,240	49,150
Philomath	Marys R.	155	500	T.	65,700	28,080	46,390

1/ *"Report on Sedimentation - Willamette River Basin - December 1948 to July 1951", Dept. of Army, Corps of Engineers. (Reflects one year's sediment load based on 80 lbs. dry soil weight.)*

2/ *Based on October to June data only.*

Table II-18
Agriculture Damages on Farmlands, 1964-65 Floods

Stream	Agricultural Acres Affected	Cleanup Expenses	Total Flood Damage --All Resources
Marys River	2,000	$ 4,000	$ 636,000
Luckiamute River	7,000	71,000	1,521,000
Yamhill River	11,000	35,000	2,247,000
Total	20,000	$110,000	$4,404,000

Subbasin 7--Pudding

The bulk of the forested lands are in the Molalla and Milk Creek drainages, where precipitation and stream gradients are the highest. These lands are mostly in private, industrial, or Bureau of Land Management ownership. They are all under intensive forest management, and cutover lands are quickly restocked. Some erosion may occur for brief periods during road construction, but is soon alleviated when ditches and culverts are in place.

The principal area most subject to erosion and flooding is Pudding River and its tributaries, particularly Butte and Rock Creeks. The loss of forest cover has been the principal cause of erosion and flooding in the area; considerable woodland has been converted to agriculture in recent years. Flooding also occurs in the Molalla drainage near Canby and along Milk and Gribble Creeks.

Subbasin 8--Tualatin

In general, the watershed management is concerned with the seasonal high and low streamflows, housing developments, some unstable areas and special water demands. Some part of every tributary is subject to flooding in the Tualatin Subbasin. The main Tualatin River floods from its mouth to the Gaston area annually. During the summer months the streamflow is too low to meet the needs. Water storage measures and maintenance of good forest cover are necessary to assure a year-round supply of water and to meet demands for recreation, irrigation and fishlife. Some of the Upper Gales Creek and Scoggins drainages are in a portion of the Tillamook Burn that has not been completely rehabilitated. Projects are underway to establish cover and keep the soil in place.

Housing developments and scattered single homesites are being established in many parts of the subbasin. Some are hillside view lots located in the upper forested reaches of the watersheds. Where the forest cover has been removed without regard to soil type, some problems with runoff, erosion, and stream pollution have resulted.

Because of their proximity to heavily populated areas, the forested lands of the Tualatin Subbasin are subject to frequent and large influxes of people seeking recreation. This situation has caused many problems for the fire protection agencies and some concern to the landowners and logging operators. The principal damage to watersheds, in addition to fires, has been some erosion on dirt roads and skid trails from excessive use by motorcycles.

Subbasin 9--Clackamas

Unusual weather conditions, the nature and location of conservation developments, unstable areas, and special water requirements are the principal watershed management variables within the subbasin. The steep country, large water concentrations, and some unstable soils reduce water quality and cause flood damages. Water discharges from Clackamas River, for instance, have been recorded as high as 90,000 c.f.s. in winter runoff; and at these times storm and sediment damages are severe. Losses often intensify as use and development occur. For example, the Fish Creek drainage (developed) sustained significantly more losses to soil, water and improvements than the Roaring River tributary (undeveloped) during the 1964 flood.

Conservation developments such as road building and timber harvest operations disturb soils and water, especially in virgin forest areas. Highly unstable areas and erosive soils are prevalent in the Abernethy, Lower Eagle Creek, Middle Clackamas and Collowash River tributaries.

In the Clackamas Subbasin, there is a need for high quality water which is cool, clear, free of sediment and debris, and low in biological contamination to meet municipal water, recreation and anadromous fishery demands. For example, the Eagle Creek fish hatchery requires a constant supply of high quality water, and any misuse of forest areas upstream would seriously jeopardize the young fish. Nine cities (i.e. Estacada, Redlands, Oaklodge, Oregon City, Gladstone, etc.) take their water from Clackamas River.

Subbasin 10--Columbia

Considerable areas near Portland are becoming urbanized to the extent that forestry is a minor factor, particularly in the Fairview and Johnson Creek watersheds. In other forested areas, homesite development is creating some watershed management problems.

With rapid industrial development in the vicinity of St. Helens, urban sprawl may create hydrologic and sanitation problems which do not exist today. During heavy winter rains, parts of St. Helens are subject to flooding; but this is strictly a local problem and not caused by adverse conditions on forest land. As long as the burned area is kept within the present bounds and the forest lands are managed as tree farms, the hydrologic condition will remain very good.

Along the North Fork of Scappoose Creek, sections of road banks are subject to slides where the highway rises out of the bottom.

Otherwise, erosion is very limited. The channel is choked with logging debris in some places, causing water and soil problems.

Greater activity in the hills northwest of Portland is likely to cause more land disturbances and water quality and soil erosion problems. Suburban homesite development is likely to mushroom in the near future. The recently logged areas present an extreme fire hazard during dry periods. Also, land abuse near Cornelius Pass, including overgrazing, poor road construction, and indiscriminate cutting, has left some slopes subject to erosion.

Subbasin 11--Sandy

The principal watershed management variables within the subbasin are the intense storms in the upper Sandy and Zigzag Rivers, the demands for high quality municipal water, and the lack of access and development in some drainages. There are scattered areas of unstable soils in all drainages, but no widespread problems as in some other parts of the Willamette Basin. The Sandy River watershed is highly prized for summer cabins and homes on both public and private lands. Expensive facilities and improvements within this flood plain are occasionally subjected to severe flood and debris damages. Fish spawning areas also need protection during any use of nearby lands.

FUTURE DEMANDS

All projections of future growth and development underscore the increasing appetite for better diets, better housing, more cars, additional consumer goods, better educational and cultural opportunities, and more facilities for outdoor recreation. Projections vary with source and purpose of estimation, but the trends are unmistakable. The demand on our land and water resources in the next few decades will be greatly increased.

Pyramiding numbers of people is the core of the resource allocation problem. This, coupled with higher disposable incomes and more leisure time, helps account for spiraling land and water resource needs.

If it were merely a matter of increasing farm and ranch production to feed the added population, the resource allocation problem would not be so difficult. The higher demand for farm products expected by 1980 will be met nationally using less crop acreage than we have today. This crop production increase will result even though lands with increasing conservation problems will have to be used as better lands go out of production.

The problem is also more complex than just providing a certain qualtity of food. Changing times and elevated standards of living are bringing major changes in diets and dietary habits. Demands for certain types of foods will increase while others will decrease. This will shift the locale of food production, not only because of population concentrations, but also because of soil and water requirements related to changing food trends.

Technology that will enable us to grow more food on the same or fewer acres of cropland must be augmented and refined by increased attention to suitability of soil sites for specific crops and uses.

Non-agricultural demands for land are accelerating faster than agricultural demands. This further complicates the land and water resources situation. To illustrate the increasing physical demand for land, national predictions of Resources for the Future for the year 2000 are:

Land for recreation - up 300 percent over today's levels
Land for homes, schools, factories - up 215 percent
Land for transportation - up 125 percent
Land for wildlife refuges - up 133 percent
Land for reservoirs - up 180 percent

These are indications that land needs in the next few decades will total far more than our full land area. It will be necessary to make land serve more than one purpose at the same time--the multiple-use concept--which accentuates the need for both technology and the political and social arrangement that will insure wise selection and efficient management of resources.

agriculture

Photo III-1. Increasing food requirements may result in double cropping or inter-planting crops like squash in a cherry orchard. (SCS Photo 0-1450-11)

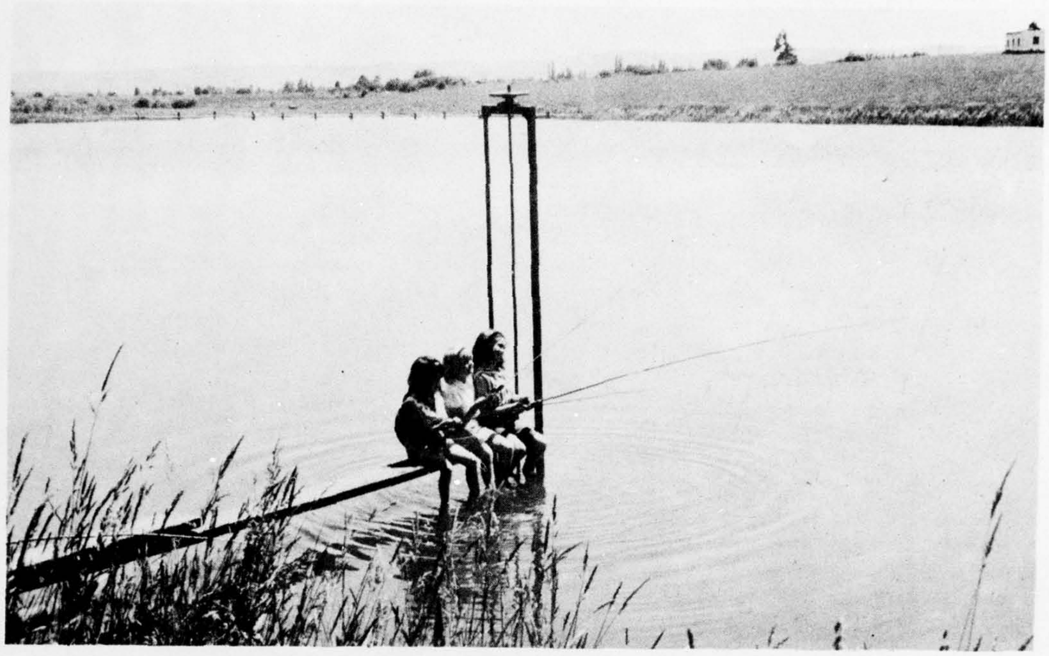


Photo III-2. More land will be required for recreational developments, Washington County. (SCS Photo 0-1252-2)

Photo III-3. Reservoir construction is increasing rapidly--especially on the west side of the basin. (SCS Photo 0-1995-12)

Photo III-4. Wildlife developments are becoming increasingly common on basin farms, Marion County. (SCS Photo 0-1492-5)

Photo III-5. Urban encroachment on prime agricultural lands in the lower subbasin. Multnomah County. (SCS Photo B-465-1)

G O A L S   A N D   O B J E C T I V E S

National objectives of the soil and water conservation program on agricultural land are to achieve land use adjustments and treatment that will conserve land and water resources, reduce the hazards of flood and sedimentation, assure the most efficient long-term use of soil and water, establish a permanent stable agriculture, and otherwise help to insure the orderly development and prosperity of rural areas.

The local objective of conservation planning by farmers and ranchers is a sound soil and water conservation program coordinating physical, economic, and human resources of the farm, forest, or ranch unit to achieve the highest personal goals of landowner and operator and to meet the long-term needs of our nation.

The objective of conservation planning on lands devoted or to be devoted to non-agricultural uses is to prevent unwise use from adversely affecting or constituting a hazard to itself, agricultural land, or other resources.

Soil and water conservation is the product of knowledge, experience, and desires of the farmer or rancher and the conservation skill and knowledge of the technician. Continuing efforts should be made to (1) achieve public awareness of the problem, (2) create desire in the landowner to practice land and water conservation measures, and (3) establish favorable legislation to assist in meeting the private and public needs.

Sound conservation for the use and treatment of all tracts or parcels of land, large or small, may be difficult and require different types of treatment. It is on the individual tracts of land where most problems start--where the rain and snow fall, where the runoff and erosion begin, and where the production of our food, fiber, timber, forage and wildlife originates.

Watershed protection and conservation land measures for problem solution or resource development are not limited to specific land users. Group action, varying from two or more users with a few acres to hundreds of users with thousands of acres, may be needed to apply desirable land measures to meet these goals and objectives.

PROJECTED LAND USE ADJUSTMENTS

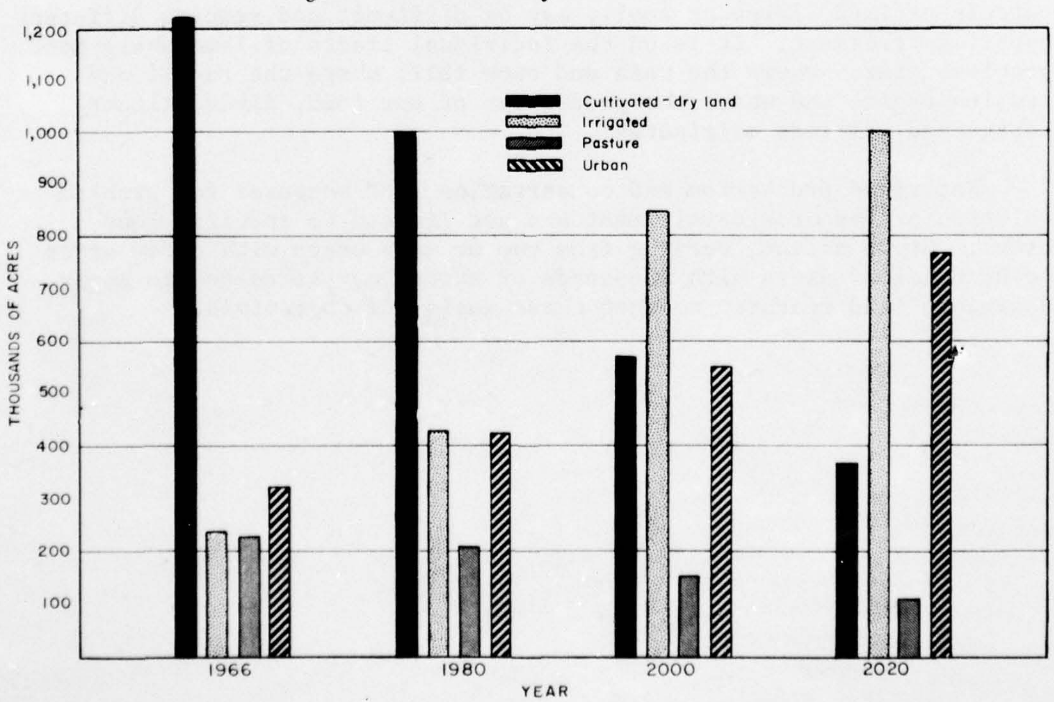
A significant increase in urban and suburban land use is anticipated in the future. Continued growth can be expected to reduce the agricultural land base. Much of the urban buildup will take place on lands generally located near the existing towns and transportation systems. These lands often include some of the most productive agricultural areas.

A rapid increase in irrigation is projected in Willamette Basin. This "vertical" expansion is gaining momentum as increasing taxes and operating expenses cause the farmer to look for ways of expanding his business base. Capital investments in the land are becoming an attractive alternative to adding more acreage.

The interplay of land going out of agricultural production and dry farm land being developed for irrigation will cause marked shifts in both the use and intensity of use of the agricultural lands. The overall shifts in land use are shown in Figure III-1.

Location and extent of the present urban buildup, existing irrigated lands and lands suitable for irrigation was determined from the detailed land mapping survey completed in 1965 by the Bureau of Reclamation. Additionally, they provided the projections of urban and irrigated lands for the three evaluation periods. These data were tabulated for the eleven subbasins. These elements served as the base for estimating land use changes. Other types of land use information were developed from the interim USDA study, published in 1964.

Figure III-1. Shifts in Land Use.



Development of irrigation is a key factor in determining the future needs for land measures primarily due to the relationship of drainage and of proper irrigation water management to irrigated land. Many of the future irrigated lands on stepper slopes will be in areas where erosion is an increasing hazard. Careful attention should be given to such farming practices as contour plantings and close growing crops in order to avoid excessive erosion.

Table III-1 presents the major land uses by subbasins, present and projected. Several conclusions may be drawn:

1. Forest and woodland acreage will remain relatively stable. Most of this land is owned either by the Government or large timber companies. It is not readily accessible to urban centers and the land suitable for cultivation is normally found only in smaller tracts. The bulk of the Federally-owned land is located on the south and east sides of the basin. Subbasin 4 (Long Tom) is expected to lose significant forest land to urban uses by the Eugene complex. Subbasin 10 (Columbia) is expected to lose nearly all of its woodland to Portland metropolitan uses by 2020.

2. Urban land use acreage in the Upper and Lower Subareas is projected to increase 2.5 times by 2020. The Upper Subarea with Eugene and the Lower Subarea with Portland already have the bulk of the basin's population. In the Middle Subarea (Subbasins 5, 6 and 7) the average and urban use growth will double, centered primarily in the Albany-Corvallis area.

3. Irrigation. The basin will undergo a significant shift from dryland, extensive farming to irrigated intensive agriculture. Much of the land to be irrigated is currently cultivated, but additional small areas of pasture and some woodland will also be irrigated as the agricultural lands become increasingly scarce.

   The Upper Subarea is the source of much of the basin's runoff water. It contains numerous long narrow stringer valleys which are expected to be largely irrigated in the future. Subbasin 3 shows little change in irrigated acreage over time because much of the existing irrigated areas will be lost to urban encroachment by 2020.

   The amount of irrigation in the Middle Subarea (Subbasins 5, 6 and 7) is expected to increase nearly 5 times by 2020. Subbasin 6 will have the largest gain. The major portion of the basin's agricultural production will continue to be located in this subarea.

Table III-1

Present and Projected Land Use Acreage by Subbasin

Land Use	1965-1966	1980	2000	2020
Subbasin 1--Coast Fork				
Dryland crop	16,530	9,000	2,000	1,000
Irrigated	3,500	8,000	16,000	20,000
Native pasture	13,600	12,000	9,000	5,000
Woodland	381,440	382,000	380,000	374,500
Urban	9,900	14,000	18,000	24,500
"Other"	430	400	400	400
Total	425,400	425,400	425,400	425,400
Subbasin 2--Middle Fork				
Dryland crop	4,520	4,000	2,000	1,000
Irrigated	2,100	3,000	5,000	7,000
Native pasture	1,540	1,000	1,000	0
Woodland	645,240	641,400	639,400	638,000
Urban	3,200	4,000	6,000	8,000
"Other"	209,800	213,000	213,000	212,400
Total	866,400	866,400	866,400	866,400
Subbasin 3--McKenzie				
Dryland crop	6,300	5,000	2,000	1,000
Irrigated	7,800	9,000	12,000	10,000
Native pasture	4,000	3,000	3,000	3,000
Woodland	599,080	599,100	598,100	597,000
Urban	6,600	9,000	12,000	16,300
"Other"	235,320	234,000	232,000	231,800
Total	859,100	859,100	859,100	859,100
Subbasin 4--Long Tom				
Dryland crop	93,340	73,000	47,000	20,000
Irrigated	20,700	30,000	47,000	63,000
Native pasture	28,500	24,000	16,000	10,000
Woodland	149,620	148,800	147,800	138,800
Urban	41,500	58,000	76,000	102,000
"Other"	3,140	3,000	3,000	3,000
Total	336,800	336,800	336,800	336,800

Land Use	1965-1966	1980	2000	2020
Subbasin 5--Santiam				
Dryland crop	266,310	238,000	130,000	91,000
Irrigated	54,800	83,000	192,000	233,000
Native pasture	52,540	48,000	43,000	37,000
Woodland	1,118,560	1,117,600	1,116,600	1,114,600
Urban	20,200	27,000	33,000	41,000
"Other"	49,190	48,000	47,000	45,000
Total	1,561,600	1,561,600	1,561,600	1,561,600
Subbasin 6--Coast Range				
Dryland crop	337,920	260,000	137,000	88,000
Irrigated	44,000	133,000	262,000	309,000
Native pasture	54,270	40,000	28,000	21,000
Woodland	647,020	637,200	630,200	622,000
Urban	40,900	54,000	67,000	84,000
"Other"	24,090	24,000	24,000	24,200
Total	1,148,200	1,148,200	1,148,200	1,148,200
Subbasin 7--Pudding				
Dryland crop	257,520	227,000	119,000	72,000
Irrigated	72,800	104,000	216,000	258,000
Native pasture	27,190	23,000	17,000	11,000
Woodland	355,660	348,100	339,500	336,100
Urban	33,600	45,000	55,000	69,000
"Other"	12,330	12,000	12,600	13,000
Total	759,100	759,100	759,100	759,100
Subbasin 8--Tualatin				
Dryland crop	132,480	100,000	70,000	62,000
Irrigated	19,100	43,000	74,000	68,000
Native pasture	17,440	15,000	10,000	7,000
Woodland	231,360	229,100	213,100	192,100
Urban	46,300	59,000	79,000	116,000
"Other"	8,420	9,000	9,000	10,000
Total	455,100	455,100	455,100	455,100

1

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Table III-1 (Cont'd.)

Land Use	1965-1966	1980	2000	2020
Subbasin 9--Clackamas				
Dryland crop	48,820	48,000	33,000	30,000
Irrigated	6,300	7,000	22,000	25,000
Native pasture	20,350	20,000	18,000	16,000
Woodland	556,630	554,000	551,000	545,000
Urban	10,400	13,000	18,000	26,000
"Other"	6,500	7,000	7,000	7,000
Total	649,000	649,000	649,000	649,000
Subbasin 10--Columbia				
Dryland crop	36,960	30,000	20,000	0
Irrigated	10,760	8,000	0	0
Native pasture	11,250	10,000	7,000	0
Woodland	85,800	67,200	37,400	400
Urban	113,630	144,000	195,400	273,000
"Other"	17,400	16,600	16,000	2,400
Total	275,800	275,800	275,800	275,800
Subbasin 11--Sandy				
Dryland crop	11,780	11,000	9,000	6,000
Irrigated	1,800	2,000	4,000	7,000
Native pasture	6,260	6,000	4,000	3,000
Woodland	330,560	329,800	329,500	326,500
Urban	5,300	6,700	9,000	13,000
"Other"	16,800	17,000	17,000	17,000
Total	372,500	372,500	372,500	372,500
Willamette Basin Totals				
Dryland crop	1,212,480	1,005,000	571,000	372,000
Irrigated	243,660	430,000	850,000	1,000,000
Native pasture	236,940	202,000	156,000	113,000
Woodland	5,100,970	5,054,300	4,982,600	4,885,000
Urban	331,530	433,700	568,400	772,800
"Other"	583,420	584,000	581,000	566,200
Total	7,709,000	7,709,000	7,709,000	7,709,000

In the Lower Subarea, irrigation will increase by about 4 times in Subbasins 9 and 11. Subbasin 10 is expected to go out of agriculture.

4. Dryland cropping. These lands have an inverse relationship to urban and irrigation expansion. In every case they decrease markedly over time. By 2020 only 10-20 percent of the presently cropped dryland will remain in the Upper Subarea, and 30-40 percent in both the Middle and Lower Subareas.

5. "Other" land is projected to remain relatively stable in most cases. These uses are predominantly suburban buildup areas, water areas, idle land, parks, farmsteads, roads, railroads, wildlife areas and others. There will be shifts both out and in this category by location, but it will not be too significant from a basin standpoint.

FUTURE USE AND DEVELOPMENT OF RURAL LAND

The demand for agricultural land measures is somewhat different than the demand for many other things. The demand for agricultural land or improvements is derived from the anticipated value of crops or livestock which can be raised on the land. Another type of demand for land arises primarily from space, location and environmental characteristics. Demand for land protection or improvements is interdependent with demand for the land itself. As agricultural land becomes more valuable, the value of works of protection or improvement will become greater.

LAND FOR AGRICULTURAL PRODUCTION

The future management of agricultural land is determined by the value of its production. For example, the benefit for flood protection of a given tract of agricultural land results from the value of added production greater than the cost of the works of protection. Several variables--market for product, cost and alternative land measures--affect future demand for investments in specific land maintenance or improvement. None of these variables can be determined with a high degree of certainty for 10, 30 or 50 years in the future. However, general types of change in land use and the amenable land measures can provide guides to effective and efficient land management decisions.

Flood Plain

Future use of agricultural land on flood plains will probably be intensive agricultural production, with large inputs and high value of production. Flood-plain lands are productive, easily managed and close to a water source for irrigation. Detrimental characteristics include poor drainage and flooding susceptibility. High water in streams often cuts large parts of adjacent banks. These characteristics make this land more adaptable to agricultural production or recreational use than to urban uses.

Land management includes a desirable degree of flood protection, investment in land drainage, reduction in bank cutting, agronomic measures and investment in irrigation. Future demand for any of these measures depends on other land treatment practices adopted as well as the availability and productivity of agricultural land located elsewhere.

Terrace Land

Future use of agricultural land on terraces will likely be intensive farming. This land may be less amenable to irrigation from the standpoint of distance from water sources, but does not have the hazard of flooding. Possible land improvements include land drainage, irrigation, increased use of cover crops and other agronomic measures. Many other inputs such as fertilizer, chemicals for weed and insect control and improved plant varieties will also add to the productivity of land.

Hill Land

Hill lands are generally not well suited for intensive agricultural production. The steep slopes are susceptible to soil erosion, which over time has reduced the thickness of the productive topsoil. Also, the steep slopes make the use of heavy machinery more difficult.

On the hill lands, possibilities for irrigation are limited. North from Mt. Angel on the eastern side of the valley and from McMinnville on the western side of the valley (Lower Subarea), the land ownership pattern includes a large number of rural residences which prevent commercial agriculture. The demand for land within this hill area for residential, recreation and other purposes has forced sales prices upward to a point where it is difficult for agriculture to bid for them on the open market. Concurrent increased taxes further adversely affect possible farm income. The scattered location of lands suitable for commercial agriculture means increased costs for materials, services and for marketing. It is probable that within this hill area, commercial agriculture may be confined to well established fruit or nut orchards.

There are also opportunities for increased development of recreation, wildlife and supplementary forest production in the foothills of the Lower Subarea.

LAND FOR SPACE, LOCATION AND ENVIRONMENT

The primary issue in future management of land for space, location and environmental qualities is changes in land use and control. Future use will affect environment, for example, when timberland is cleared for rural or urban residence. Individual use of land in private ownership is usually less restricted than publicly owned land. Public interest in private use will likely be an issue in consideration of green strips and public access to hunting and fishing locations.

Space and location qualities will result in high market values of rural land adjacent to urban areas. Social values may be enhanced by maintaining some part of a rural environment in these areas and may be greater than private values obtained from use for residence and business. Attempts at public control of the private use of these lands will be confronted by private demands and high market values as population increases.

More land use planning and a higher degree of social control and regulation may be required if excessive abuse and waste of rural land are to be prevented. The goals of maintaining a desirable rural environment and making rational use of space may not now be well understood or strongly expressed. Thus, the determination of goals in use of land is a first step. Study of alternative means of achieving the goals follows. Formulation of plans and methods of achieving them are a third step just prior to initiation of the actions themselves.

FUTURE DEMANDS FOR LAND MEASURES

There is no strictly objective method of projecting demands for land improvements or uses because of the uncertainties of future conditions. Investment in a land improvement has value insofar as the returns from the investment are greater than the costs. Interdependencies in production among types of improvements affect the value for any individual one. For example, if both drainage improvement and irrigation are used to achieve a given increase in production, the value of irrigation depends upon the cost of improvement through drainage. Value of irrigation is similarly affected by costs and production from fertilization and other production-increasing inputs including technological innovations.

CONSERVATION NEEDS

Conservation needs presently and for 1980, 2000 and 2020 have been based on how the land is used in relation to its capability, physical use, and hazards. For present needs, the land use estimates are based on inventory data for the 126 tributary areas of the Willamette Basin (Table III-1). Land use for future periods will constantly change and projections of use are based primarily on the physical potential of individual areas for agricultural uses. Such use will be directly influenced by future urban and irrigation expansion.

Present and future land treatment needs are determined in two ways: first, by the application cost to the farmer or landowner which cost may be annually recurring, periodic, or even a one-term investment; second, by the amount of technical assistance needed to get the needed land measures applied and maintained.

The tables show the total conservation need at any one point in time. Many of these needs are being met through the various "going programs" of governmental agencies and by efforts of individual land users. A second point should also be emphasized. Proper land use practices are a never-ending job and much of the "need" is a continuing one, e.g. cover cropping or contour farming. Some measures, however, are cumulative such as construction of farm ponds.

Watershed protection and land measures must consider the overall resource needs, the basic resources available and the influence of the local resources on interpretations of the broad concepts. These programs require developing workable criteria for conservation practices and groups of practices, and adjusting the practices and specifications to local conditions. Table III-2 lists land treatment costs by subbasin for Willamette Basin based on the present situation and on land use shifts over time. This information, shown for the three time projections, is given by the following categories: dryland, irrigated land pasture, woodland, urban, other, conservation planning, soils interpretations and soils mapping.

Table III-2

Present and Projected Land Treatment Needs by Subbasin (Includes Costs for Technical Assistance and for Actual Application)

	Subbasin	1965	1980	2000	2020
1.	Coast Fork	$ 3,404,000	$ 5,455,000	$ 6,195,000	$ 7,205,000
2.	Middle Fork	2,445,000	2,906,000	3,434,000	3,722,000
3.	McKenzie	3,896,000	4,224,000	5,304,000	4,582,000
4.	Long Tom	11,581,000	14,533,000	19,528,000	22,602,000
5.	Santiam	29,150,000	38,774,000	70,028,000	66,086,000
6.	Coast Range	27,708,000	50,645,000	85,584,000	81,373,000
7.	Pudding	28,817,000	39,489,000	71,849,000	67,767,000
8.	Tualatin	12,374,000	20,638,000	27,636,000	23,662,000
9.	Clackamas	6,807,000	7,060,000	12,268,000	11,131,000
10.	Columbia	8,640,000	10,301,000	11,080,000	15,711,000
11.	Sandy	2,646,000	2,743,000	3,604,000	4,227,000
Willamette Basin Total		$137,468,000	$196,768,000	$316,510,000	$308,068,000

The factors for technician time and application costs were applied to the conservation practice needs to arrive at a total technical assistance time needs and cost, to the landowner, of applying needed practices to the land. Table III-3 lists the total cost, by land use, for Willamette Basin based on the present situation, 1980, 2000, and the year 2020.

Table III-3

Present and Projected Land Treatment Needs by Land Uses

Land Use	Acres	Dollars	Acres	Dollars
	1965		1980	
Dryland crop	1,212,480	$ 44,907,000	1,005,000	$ 37,103,000
Irrigated	243,660	49,712,000	430,000	112,652,000
Native pasture	236,940	13,092,000	202,000	11,167,000
Woodland	5,100,970	14,735,000	5,054,300	14,580,000
Urban	331,530	14,760,000	433,700	21,069,000
"Other"	583,420	262,000	584,000	197,000
Basin total	7,709,000	$137,468,000	7,709,000	$196,768,000
	2000		2020	
Dryland crop	571,000	$ 21,067,000	372,000	$ 13,737,000
Irrigated	850,000	244,537,000	1,000,000	232,533,000
Native pasture	156,000	8,653,000	113,000	6,257,000
Woodland	4,982,600	14,364,000	4,885,000	14,079,000
Urban	568,400	27,711,000	772,800	41,291,000
"Other"	581,000	178,000	566,200	171,000
Basin total	7,709,000	$316,510,000	7,709,000	$308,068,000

GROUP ENTERPRISE NEEDS

An important consideration in the application of soil and water conservation measures is the part which local landowners play by collectively solving some of their mutual problems. This phase of a soil and water conservation program is concerned with relatively small groups of landowners acting together on an informal basis and with a minimum of legal commitments. Guidance and help of the USDA agencies and other agencies and groups through technical and financial assistance is available when requested.

The possibilities for resource development on a small project basis are numerous and greatly varied in scope and purpose in Willamette Basin. These small projects will involve from two to twenty-five or possibly more landowners depending on the measures considered. Important types of these projects from the standpoint of needs and frequency of occurrences are:

1. Drainage projects involving tile, open drains and outlet facilities.

2. Irrigation projects involving joint use of pumping plants, pipelines or ditches, irrigation reservoirs or a combination of these.

3. Streambank stabilization involving the use of rock riprap, or vegetative plantings along a stream, with group action necessary to insure that the improvement will remain effective.

4. Stream channel improvement involving joint effort to improve the discharge capacity by resectioning or enlarging the channel.

5. Stream channel clearing involving the removal of snags, logs, debris and vegetative growth which inhibits the flow.

6. Dikes constructed of earth or other suitable material to protect land against overflow.

Information on small project potentials in the Willamette Valley is presented in Table III-4. This information was gathered by personnel of different agencies working at the field level and represents the small projects in which there has been local interest shown. It is not intended to indicate the total conservation needs for small projects in the Valley.

The USDA action programs provide landowners and groups of landowners with technical assistance, financial assistance, loans and information through the Soil Conservation Service, Agricultural Stabilization and Conservation Service, the Farm Home Administration, and the Oregon State Extension Service respectively.

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Table III-4
Small Project Program - Unmet Needs - 1965 to 1980

	Subbasin 1				Subbasin 2				Subbasin 3				Subbasin 4				Upper Subarea Total			
	No. of Jobs	No. of People Served	Acres Bene-fited	Size of Job (feet)	No. of Jobs	No. of People Served	Acres Bene-fited	Size of Job (feet)	No. of Jobs	No. of People Served	Acres Bene-fited	Size of Job (feet)	No. of Jobs	No. of People Served	Acres Bene-fited	Size of Job (feet)	No. of Jobs	No. of People Served	Acres Bene-fited	Size of Job (feet)
Irrigation													2	35	1,600		2	35	1,600	
Drainage	1	2	100	2,500	1	6	30	1,800					2	8	250	26,500	4	16	380	30,800
Streambank Stabilization	1	20		1,200					2	3		1,350	1	3		1,200	4	26		3,750
Stream Channel Improvement	1	2		2,500	3	6		1,720					2	3	1,500		6	11		5,720
Stream Channel Clearing	3	62		55,320	1	40		31,680	1	2		1,500	6	66		35,640	11	170		124,140
Dikes	1	4	130	1,200													1	4	130	1,200

	Subbasin 5				Subbasin 6				Subbasin 7				Middle Subarea Total			
	No. of Jobs	No. of People Served	Acres Bene-fited	Size of Job (feet)	No. of Jobs	No. of People Served	Acres Bene-fited	Size of Job (feet)	No. of Jobs	No. of People Served	Acres Bene-fited	Size of Job (feet)	No. of Jobs	No. of People Served	Acres Bene-fited	Size of Job (feet)
Irrigation	3	45	900		10	72	2,945		12	129	4,960		25	242	8,805	
Drainage	14	204	18,250	193,160	21	163	9,855	137,970	10	142	11,750	178,960	45	509	39,855	510,090
Streambank Stabilization					5	40		11,600	7	60		132,000	12	100		143,600
Stream Channel Improvement	1	10		11,880	2	30		1,750	1	1		105,600	4	41		119,230
Stream Channel Clearing					5	49		62,700	8	190		179,520	14	254		252,720
Dikes	1	15	200	10,500	11	94	6,847	60,500	1	10	1,800	7,920	12	104	8,647	68,420

	Subbasin 8				Subbasin 9				Subbasin 10				Subbasin 11				Lower Subarea Total				Willamette Basin Total			
	No. of Jobs	No. of People Served	Acres Bene-fited	Size of Job (feet)	No. of Jobs	No. of People Served	Acres Bene-fited	Size of Job (feet)	No. of Jobs	No. of People Served	Acres Bene-fited	Size of Job (feet)	No. of Jobs	No. of People Served	Acres Bene-fited	Size of Job (feet)	No. of Jobs	No. of People Served	Acres Bene-fited	Size of Job (feet)	No. of Jobs	No. of People Served	Acres Bene-fited	Size of Job (feet)
Irrigation	8	61	4,300		1	8	400						N/A	N/A	N/A	N/A	9	69	4,700		36	350	15,105	
Drainage	7	106	9,150	110,880	1	35	300	4,200	3	8	385	35,360	N/A	N/A	N/A	N/A	11	149	9,835	150,440	60	674	50,070	691,330
Streambank Stabilization	3	28		68,640					1	5		4,000	N/A	N/A	N/A	N/A	4	33		72,640	20	159		219,990
Stream Channel Improvement	7	205		153,120									N/A	N/A	N/A	N/A	7	205		153,120	17	257		278,070
Stream Channel Clearing													N/A	N/A	N/A	N/A					25	424		376,860
Dikes	1	8	320	5,200									N/A	N/A	N/A	N/A	1	8	320	5,200	14	116	9,100	74,820

These small projects fit well into the Agricultural Stabilization and Conservation Service's special projects phase of the agricultural conservation program (ACP). Further assistance is also available through the Upper Willamette Resource and Conservation Development project, which includes 2+ million acres in the southern portion of the basin.

The above small projects are directly concerned with conservation of land and water resources. Larger projects such as those built by the Bureau of Reclamation, the Corps of Engineers, or the SCS under P. L. 566 also have a direct effect on land and watershed protection measures. Recommendation for future water resource developments of the larger projects are contained in Appendix M, Plan Formulation.

DRAINAGE

Some soils are naturally well drained, and others are poorly drained. The problem arises when the land is put to various uses. For example, wetness may not represent a drainage problem on a waterfowl development; but if the same area is used for agriculture, wetness is a severely limiting factor.

Future Needs

In the basin there are 1,310,000 acres in soil associations classified as having wetness problems. Some soils within these associations do not need drainage themselves but are inclusions in larger areas that do have a wetness problem. Lands with a wetness problem severe enough to limit their agricultural use may require "on-farm" drainage improvements. In addition, about three-fourths of these lands would need community (off-farm) outlets to remove water from the general area.

The lack of off-farm drainage outlets is the major drainage problem in the basin. An estimated 1,066,000 acres are in need of improved or new "off-farm" channels. Until these are provided it would not be possible for landowners to improve drainage on their farms. The "off-farm" channel work is usually accomplished on a project basis requiring the cooperation of two or more individuals. The size of the project and number of landowners depends upon the extent of the problem area.

The areas requiring off-farm drainage are divided into three main soil groups with different magnitudes of drainage problems. These groups are:

> <u>Group A</u> - These soils have severe problems caused by excess surface water and lack of adequate outlets. They further have soil textural problems that are related directly to on-farm drainage.
>
> <u>Group B</u> - These soils consist of Group A and Group C soils that have less restrictions for on-farm application of drainage measures.

Group C - These soils require drainage for intensive cropping and are considered easily drained where outlets are available. High water tables persist over extensive areas.

The acreage in each group, by subbasin, is presented in Table III-5.

Table III-5
Drainage Problem Areas (Acres)

Subbasin	Group A	Group B	Group C	Total
1	13,400	--	--	13,400
2	1,500	--	--	1,500
3	2,900	--	700	3,600
4	64,200	6,700	24,500	95,400
5	145,200	32,900	89,300	267,400
6	66,400	114,000	132,900	313,300
7	46,700	141,000	59,100	247,000
8	43,900	71,600	7,500	123,000
9	--	--	300	300
10	--	--	1,700	1,700
11	--	--	--	--
Total	384,200	366,400	316,000	1,066,600

Future Accomplishments

A number of factors are expected to accelerate the rate of drainage improvement in the basin, particularly the installation of community projects. The current cost-price squeeze is forcing rapid changes in agriculture. Many farmers are currently raising grass seed to the exclusion of all other crops due to the limitations of the wet soils. There is a growing awareness of the need to diversify and shift cropping patterns to meet market demands. Farmers also recognize the need for intensified production and that drainage is necessary to assure full returns from a wide range of improved production techniques. Without drainage, the poorly drained soils have limited cropping possibilities and yields of adapted wet-area crops are reduced.

The continuing expansion of irrigation will necessitate the installation of drainage improvements. Project development will assume an increasingly important role in future irrigation, with most irrigation project areas including substantial acreages of land needing community drainage outlets. The installation of drainage outlets with added on-farm surface or tile drainage will make it possible to profitably irrigate practically all suitable land in the project areas.

Community drainage channels for 307,100 acres have been provided to date. This total and the projections of accomplishments for 1980, 2000 and 2020 are shown in Table III-6, by subbasin. The figures are listed as accumulated totals.

Table III-6
Present and Projected Accomplishments
Community Drainage Facilities

Subbasin	Accomplishments To Date	1980	2000	2020
	----------	A c r e s	----------	
1	4,000	8,800		
2	500	800		
3	2,000	2,000		
4	44,000	59,200		
Upper Subarea	50,500	70,800	84,000	91,100
5	55,000	137,600		
6	94,000	184,800		
7	80,000	102,400		
Middle Subarea	229,000	424,800	578,900	661,700
8	27,000	47,200		
9	100	200		
10	500	900		
11	--	--		
Lower Subarea	27,600	48,300	81,600	99,800
Willamette Basin	307,100	543,900	744,500	852,600

The majority of the community drainage work is expected to take place in Subbasins 4 through 8. This progress is related to the number of flood control projects and irrigation developments being planned in these areas. Drainage is an associated feature of these developments and, therefore, the potential workload on community drainage facilities and on-farm facilities will increase greatly in the remaining time periods.

Farm drainage problems which can be solved by individual effort occur on approximately 466,000 acres in the basin. Most of this land is located on farms, footslopes, hill slopes and isolated valley floor areas.

Projections for on-farm drainage facilities are shown in Table III-7. This table includes the on-farm drainage which can be accomplished without community outlets as well as that made possible through their installation. The 1980 projections are based on an extension of the current annual rate of drainage installation. From 1980 to 2000, this rate of installation is expected to increase by about 40 percent because of the expected increase projected for new irrigation projects. After the year 2000, drainage installation is expected to level off at about the present rate.

Table III-7

Present and Projected Accomplishments
On-Farm Drainage Facilities

Subbasin	Accomplishments To Date	1980 1/	2000 1/	2020 1/
	- - - - - - - - - -	A c r e s	- - - - - -	- - - -
1	5,000	4,800		
2	1,000	1,100		
3	2,000	2,700		
4	36,000	52,800		
Upper Subarea	44,000	61,400	75,500	84,800
5	126,000	140,800		
6	110,000	144,000		
7	118,000	150,400		
Middle Subarea	354,000	435,200	637,600	723,200
8	42,000	57,600		
9	10,000	13,200		
10	13,000	15,100		
11	3,000	3,100		
Lower Subarea	68,000	89,000	156,200	240,000
Willamette Basin	466,000	585,600	869,300	1,048,000

1/ *Future projections of accomplishments include some specific areas that have already received varying degrees of drainage improvement at different times. Additionally, some of the area that is or will be drained will become urbanized at a later date.*

Subbasins 4 through 8 will show the most installation of on-farm drainage through the indicated time periods since they will benefit from the installation of community drainage improvements much more than all the other subbasins combined. Less drainage improvement will be accomplished in Subbasins 9, 10 and 11 where the urban and industrial expansion is expected to occupy much of the land area. Smaller acreages will also go to urban expansion in other subbasins.

Typical Drainage Costs

Costs of drainage vary significantly from location to location and it is difficult to obtain an "average" figure. One of the major factors in cost for community outlets is the size of the service drainage area in relationship to the distance required to construct a facility to an outlet. Records indicate that costs of community drainage projects have ranged from $10 to over $100 per acre. The normal range is $20 to $50 per acre. This includes an allowance for easements and rights-of-way, relocation of utilities, road crossings and administration of contracts.

More data are available for on-farm drainage costs. If outlets are available, this is the only cost considered, but when community drains are needed additional cost must be added. Costs of the two types of on-farm drainage are shown in Figure III-2--On-Farm Open Drains Cost Curve, and Table III-8--Tile Drainage Costs.

The open ditch drainage (Figure III-2) indicates an average of 50 to 75 feet of ditch required per acre at an average cost between $20 to $30 per acre. This cost figure is for construction only, as the work is done on the farmer's own land. Open ditch drainage is much more common for the Group A and B soils (Map II-11). Land use on these soil groups is usually restricted to grass seed or pasture.

The tile costs (Table III-8) can be used to reflect pattern drainage or other types such as random or interception systems using wide spacings. The key factor affecting costs is the required spacing to meet the drainage needs. Tile is primarily used on Soil Group C and to some extent Soil Group B.

Tile spacing is a function of soil characteristics and crop requirements. For intensive crops such as berries, nurseries and row crops, tile spacings of 40 to 80 feet are common and costs per acre typically range from $100 to $200 per acre. For grasses, pasture and grains the 80 to 120 foot spacings commonly used range in cost from $70 to $100 per acre. Records indicate that tile drains in the basin for the five-year period (1959-1964) ranged from $36 to $190 with an average per acre cost of $80.

Figure III-2. On-Farm Open Drain Cost Curve.

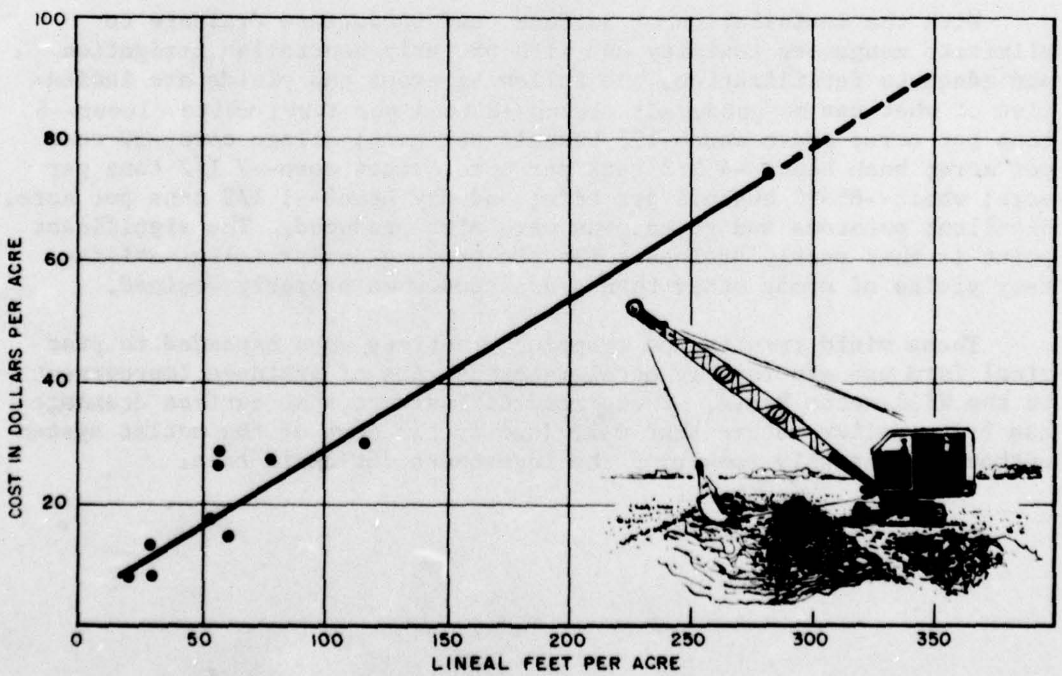

Table III-8
Tile Drainage Cost

Spacing Between Laterals (ft.)	Tile Required Per Acre (ft.)	4" Diameter Unit Cost (WRB Avg.)	4" Diameter Cost Per Acre	5" Diameter Unit Cost (WRB Avg.)	5" Diameter Cost Per Acre
40	1,080	$.20	$216.	$.30	$324.
60	726	.20	145.	.30	218.
80	545	.20	108.	.30	163.
100	436	.20	87.	.30	130.
120	363	.20	73.	.30	109.
150	290	.20	58.	.30	87.
200	218	.20	44.	.30	65.
250	174	.20	35.	.30	52.

Influence of Research on Future Trends

Recent research conducted by the OSU Experiment Station has revealed that poorly drained soils such as Dayton, Concord, Amity and related series, can produce a much wider range of crops than previously thought possible. An important discovery was that soluble manganese increased to toxic levels for certain crops when water remained at or above the soil surface during the winter months. When the water table was lowered to only a few inches below the surface and with an application of lime, toxic levels of soluble manganese did not occur.

With the installation of surface and subsurface drainage to eliminate manganese toxicity and with properly controlled irrigation and adequate fertilization, the following crops and yields are indicative of what can be produced: lotus--8 tons per acre; white clover--6 tons per acre; grain corn--125 bushels per acre; silage corn--30 tons per acre; bush beans--4 1/2 tons per acre; sweet corn--7 1/2 tons per acre; wheat--85-90 bushels per acre; and dry beans--1 1/2 tons per acre. Excellent potatoes and green peas were also produced. The significant point is that poorly drained soils can produce commercially satisfactory yields of crops other than grass seed when properly drained.

These yield results and cropping practices when expanded to practical farm use may rapidly accelerate the rate of drainage improvement in the Willamette Basin. These results indicate that surface drainage can bring dollar return that will justify the cost of the outlet system without necessarily requiring the investment for drain tile.

FUTURE PROBLEMS

In Part II, many of the social, economic, institutional and physical problems of the past were discussed in detail. These same problems will exist in the future and some will undoubtedly increase.

When land was cheap and abundant, there was little incentive for developing an intensive agriculture or conserving the soil. It was easier to obtain added production on new acres than to raise the yields on existing croplands. As a result, considerable basin land was farmed --abused--and it subsequently eroded and became unproductive.

Other land uses--towns, roads, parks and so forth--were located where it was most convenient to build. Transportation was a major determinant in locating development. In many cases towns were located on prime agricultural land in order to serve the then-agricultural community. Once the development pattern is set, additional expansion develops around the cities and can be expected to take up considerable more good farm land.

As land, and now water, become increasingly scarce, the trend is to more intensive land use to meet the rapidly increasing demands for food, fiber and space. With changing technology, more irrigation and drainage, the need for conservation measures is increasing. These changes are necessary because of a decreasing agricultural land base in the face of increasing demands for output.

Agricultural land of high quality in a particular location may be of much greater value for uses other than farming--buyers can afford to bid it out of agricultural use. The excellent row crop land being subdivided around Portland is evidence of this economic fact. As farm land of high quality is lost, lower quality land will tend to replace it, but will require considerable investment if it is to be equally productive. Some agricultural land today is no longer so productive as in the past because portions of its soil depth have been eroded away. Capital improvements can never entirely overcome this loss. Against these losses must be considered the prospective gains from investments made to increase the productive capacity of other lands.

The Willamette Basin has a large area of land suited to cultivation. Some of it is already in its highest agricultural use. Other areas have not been developed because even when cleared they would be only marginal cropland without other improvements. Basin farmers have found that in many cases it doesn't pay to make a single improvement if the land has other limitations.

When certain land improvements or groups of land improvements become profitable, the process of substituting inputs of labor and capital for inputs of land begins. Examples of capital and labor inputs are drainage, flood control, irrigation, fertilizer, pesticides and technology. Whether or not it pays to make required investments is determined by economic conditions of the time. In that sense, the resource base is not fixed. Consumer demand and facilities for improving the land will determine the effective annual agricultural acreage.

Photo III-6. Burning can control pests and disease on grass seed crops, but it also reduces desirable soil organic matter. Linn County. (SCS Photo 0-852-6)

Photo III-7. If special equipment is used on poorly drained soils, soil compaction is greatly decreased. (SCS Photo 0-1586-2)

To illustrate the interrelation of groups of measures upon each other consider the following:

Many Willamette Valley soils are flooded during the wet winter or early spring months. This flooding causes problems of soil erosion, crop damage, weed infestation, sedimentation and damage to fences, livestock, machinery, buildings, roads and bridges. Flood control results in more profitable farming and also allows the use of drainage and irrigation of many soils on which these practices would not have been feasible without flood control.

Following flood control, the installation of drainage allows a much wider increase in the selection of crops, a large increase in yields and reduced farming costs. Drainage, for example, reduces strawberry disease damage, lengthens the life of an alfalfa stand and increases crop production and quality of most crops even on soils with slight drainage problems. Orchards, fall grain, caneberries, vegetables and nursery stock are especially improved by drainage where needed.

Following flood control and drainage, irrigation becomes more economically feasible. This allows an even greater selection of crops to grow, higher yields and higher net farm income. Without irrigation, pole beans are not feasible, and strawberries are usually not profitable. Many vegetable crops cannot be grown under contract without irrigation. Pasture, hay and nearly all other crop yields are also improved. Irrigated pasture is important to profitable livestock development since summer and fall pastures make little growth without irrigation.

On soils with unsolved flooding or drainage problems, irrigation may cause increased wetness conditions that will hinder crop production and reduce the economic feasibility of installing an irrigation system. Flooding problems will also usually reduce the economic feasibility of installing a drainage system.

The interrelation of drainage, irrigation and flood control carries over to fertilizer responses, need and timing of pesticides, and how and when the crops can be seeded and cultivated.

The dependency of measures on each other depend in turn on the relationship of the problems. Not all lands have both flood control and drainage restrictions. Some lands have neither but will respond to irrigation if fertilizer, proper irrigation applications and pesticides are used. In almost every case more than one measure will be required.

No one practice is "first or last" in most cases because several are necessary and each becomes the key that makes possible the yield increases and wider crop adaptations that result from the addition of other measures.

Photo III-8. A helicopter swings low over the Big Lake Airstrip forest fire burn at Santiam Pass while spreading grass and tree seed to restore the landscape. (U. S. Forest Service Photo)

forestry

The major goal of forest watershed management is to make the best use of the watershed resources for meeting increasing public demands for such things as lumber, woodpulp, wildlife and recreation while at the same time conserving and protecting the water resource. Management alternatives include: (1) conservation programs without regard to future projects, maintaining the status quo for land and water resources, (2) conservation programs to meet intensified land needs resulting from accomplishment of potential project purposes such as flood control and irrigation, and (3) a program of individual projects for watershed protection to be accomplished by public agencies or private individuals or groups.

G O A L S   A N D   O B J E C T I V E S

A major goal is the identification of land treatment measures needed to protect the quality of the streams of the basin to the degree that they meet the water quality standards set by the State of Oregon, particularly in regard to turbidity, dissolved oxygen and temperature.

Forecasts of population and economic growth in Appendix C show a greater future demand on the limited forest resources of the basin. To meet this demand the forest land measures study recognizes five basic goals:

1. To increase the choice and protect the quality of outdoor leisure time activities consistent with people's desires.

2. To provide for the health, safety and well being of the people and animal life of the basin.

3. To achieve maximum production and economic expansion with the most efficient allocation of resources.

4. To conserve land and natural resources and preserve their latent capacity for future use.

5. To maintain a desirable forest environment for the aesthetic enjoyment of the people.

The objective of the identified forest land measures is to meet these goals by protecting, rehabilitating and improving the capacity of the forest lands to provide for such outputs as wood fiber, fish and wildlife, municipal and industrial water supply, recreation, open space, natural beauty, and to reduce water pollution and flood damage. Except for water taken from the ground by trees, these objectives are not water consumptive. They are water related. Major emphasis is on water quality for either on-site or downstream uses. For this reason it is difficult to evaluate the relationship of Appendix G to other appendices, except for the impact of new water storage projects on the forest environment and the basin's economy.

The watershed management required within the basin will vary among subbasins, tributaries and ownerships. Watershed goals are broad for the basin and specific for the subbasins. Multiple use of forests may result in some conflicts. Accomplishment of certain goals will depend on the land measure alternatives available and on the requirements imposed by other goals. The goals and their achievement must reflect the public's concern for all of the social and economic values at stake in the forested watersheds. There are many recognized uses and use problems of the forests. Some goals of watershed management are multiple-use, because some resources can readily be managed to serve more than one purpose. This is particularly true of water and related land resources, where providing access and maintaining high quality waters enhances recreation, fish life and other uses. Another important multiple-use goal is to disperse knowledge as to location of high-risk soil erosion areas so that suitable protective measures may be taken as required by the type of use.

Each specific use of a forest resource contributes to the total value of a watershed, yet poses some risk to the permanent value of the basic soil and water resource. These uses also provide an opportunity to maintain, regulate, or even improve the flow of water. General land measures which apply to major uses of forest watershed follow:

Timber

1. Use harvest methods which will minimize soil and water disturbance such as prompt reforestation to provide soil cover; use of skyline or balloon logging in unstable areas; scarify, reseed and waterbar abandoned log landings, skid trails and temporary roads; restrict tractor logging in wet weather and on steep slopes; prohibit logging on or across stream channels; remove log jams from stream channels, etc.

2. Develop cutting methods which would increase base streamflows during late summer and early autumn and regulate flow in the best manner throughout the rest of year.

3. Modify timber management in roadside and streamside strips to provide efficient buffers for the protection of the water resource and to keep slash and debris out of stream channels by gross yarding of woody material away from the stream flood zone.

4. Develop levels of wood utilization and disposal of debris that reduce the need for slash burning on logged lands including more use of chippers for utilization of waste wood fiber.

Occupancy

1. Construct and maintain roads, dams, transmission lines, and other improvements only in locations which cause minimal damage to soil and water values, or suitably protect unstable areas by reseeding, waterbarring or surfacing of access roads and seeding other disturbed areas.

2. Promote planning for an orderly sequence of any necessary extension of suburban areas into the forest zones in a manner which will preserve the soil and water resource by county zoning protection.

Grazing

1. Recognize the compatibility of grazing by livestock with other forest uses under certain circumstances.

2. In the few suitable areas encourage livestock management methods to achieve soil stabilization by increasing perennial vegetation.

3. Develop controls of livestock which will prevent water pollution by fencing livestock from streams and diverting drainage from feed grounds away from streams.

4. Discourage the conversion of forest land to range land by burning and grass seeding through education, zoning or incentives.

Recreation

1. Insure that the ground and surface water at future recreation locations and facilities near or within streamside or waterfront zones are protected from biological contamination.

2. Develop programs that emphasize user responsibility for preservation of pure waters in all forest areas.

3. Reserve from public access those areas required for specific conservation and development, safety, efficient operation or protection of public property.

4. Protect and develop the natural forest environment which exists along the Willamette River from Eugene to Portland as a "green way" with emphasis on adequate land measures.

Fish and Wildlife

1. Achieve a level of management of forest lands that maintains or improves both the forest and water environments for fish and game by protecting water quality and planting of browse, legumes and grass in selected areas for wildlife forage.

2. Remove obstructions to migratory fish passage on streams within forest lands.

Water

1. Use water quality criteria as a guide to applying definite watershed management practices to produce the required streamflows. Give first consideration to waters used for human consumption in the planning for protection and use of forest watersheds.

2. Intensify programs, studies and research to identify more accurately the relationships between forest land use and yields of water. Establish demonstration watershed areas to show best watershed management practices under various conditions and use. Complete the intensive inventory of the forest soils with hydrologic interpretations for all forest lands in the basin. Develop and use methods of weed, disease and pest control which do not contaminate forest waters.

3. Provide more protection to the forest watershed from fire, disease, insects, animals, wind, erosion, floods and abusive use by man.

4. Reduce storm and sediment damages from streamflows and debris in unusual weather and high runoff periods by removal of woody debris from stream flood zone, stabilization of stream channels and preservation of tree growth along streams to provide shade and serve as catchment area for silt and debris movement.

5. Evaluate the development of water storage impoundments to offset the low rainfall and streamflow during the summer season. These are particularly important in the Coast Range.

BASIC FOREST RESOURCES

AND LAND USE TRENDS

Present problems of watershed management and the expected changes in forest uses imply new watershed techniques and changing priorities. Water production from forest lands, desirable water quality and prevention of erosion will continue to be important objectives. It is therefore important to identify the land measure and protection requirements implied in the changing use and development of the basin's forests.

In the identification of future forest uses, the next 10 to 15 years (1970-1985) is the "immediate forecast period" while beyond 15 years (1985-2020) represents the "long-term forecast". It is necessary to predict rather precise use levels for the immediate forecast period in order to determine whether or not to accomplish specific land measure programs and projects.

Since 1960, an era of intensive forest management has been ushered in following the exploitive, protection and development periods of the past. The use of forests for multiple benefits is being recognized--in fact, on the public lands it is required by law. Intensification of use will increase on most forest areas because a relatively constant forest land base must support increasing demands for forest goods and services.

Demands on forest land will change forest land uses significantly in the next 50 years. For the most part, the forest environment will remain, but its use will change. Major shifts will be to recreation, highways, power line rights of way, water impoundments and to limited agricultural development. However, total forest acreage is expected to remain fairly constant to the year 2020, because marginal farm lands will revert to forest growth.

FISH AND WILDLIFE

The use of forest lands by sportsmen for fish and wildlife pursuits will increase greatly by 2020 due to the increasing number of access roads being built into these areas. It is estimated that about 3,000 miles of permanent forest development roads will be added to the existing road systems on public and private lands during the 1970-1980 period. Based on current trends, about a threefold increase in hunter use and eightfold increase in fishermen use will occur in the next 50 years (see Fish and Wildlife Appendix). However, few forest lands will be reserved exclusively for hunting and fishing use.

As the old growth timber is cut, more of the land comes under shorter rotations for management of second-growth timber. This creates extra wildlife habitat for 10-20 years. After this time, the habitat diminishes rapidly regardless of frequency of overstory removal or intensity of timber management. Increased road mileage will probably improve the hunter success ratio.

Most of the fish spawning grounds are found in forest areas. The spawning streams used by migratory fish can support larger runs and fish may be able to reach those areas in increased numbers when the new fish ladder at Oregon City is completed and when pollution in the lower Willamette River is reduced.

OUTDOOR RECREATION

Increasing mobility, income, leisure time and population will bring an increasing demand on the basin's forests for recreation. Recreational use will increase two to eight times in the various recreational areas of the basin by 2020 (see Recreation Appendix). Certain recreation uses are increasing faster than others, particularly in stream fishing, winter sports and picnicking. There is an unlimited interest by city dwellers in the forest for summer home or weekend cabin purposes. If near to the water in any form, this type of recreation potential assumes glamorous proportions. The need for this use on private lands will increase at a faster rate in the next 10-15 years as public lands become unavailable for these purposes. There is also indication that there will not be enough free-flowing streams of present quality to meet user demands in the basin after 2000.

An accelerating demand for forest lands is for summer homesites or vacation cabin use. Subdivision of forest lands for retirement and permanent year-round habitation is occurring in other Oregon areas and may be anticipated to occur in the basin. Sanitary facilities for such development are often inadequate and result in deterioration of water quality. County zoning and sanitary regulations will be needed to control unrestricted development for this type forest use.

A concern of watershed management is to bacteriological contamination of the basin's streams resulting from recreation uses. Also, the watershed should be managed to reduce stream turbidity, which limits recreational enjoyment of the water.

GRAZING IN WOODLANDS

The use of forest for grazing is a minor part of the basin's agriculture--only about 1/2 million acres of forest are used for summer grazing by livestock. Almost all of this area is on small private woodlands and timber tracts. Less than 10,000 acres of Federal and State lands are being grazed. The results of a recent grazing survey were too inconclusive to permit forecasting the long-term trend of grazing on private forest lands.

Most public and large private forest ownerships are maintained as commercial forest land for wood fiber production. As mature stands are harvested, physical opportunities for complementary grazing become a planning alternative. However, animal damage to young trees and ownership policies make it difficult to forecast future use.

TIMBER

Timber production will continue to be a principal use of the basin's forest lands. Continued heavy cutting on private lands is reducing inventory to the extent that past levels of cutting cannot be maintained between 1990 and 2020.

Although the commercial forest area will change very little, log production will drop off due to the uneven age stand distribution pattern of the basin's forests. The projected growth of the pulp and paper industry reflects a future need for large quantities of clean water to process the pulp.

Intensive timber management, in which forests are selectively cut at 3- to 10-year intervals to thin the stand, has major implications for watershed management. The frequent use of equipment may compact the ground and reduce the rate of water infiltration into the soil, but opening the forest canopy will allow more rain and snow to reach the soil and reduce transpiration losses.

More study is needed to determine the effect of intensive timber management practices on the basin's waters. Intensive timber cropping will reduce soil nutrients at a faster-than-normal rate, and it is unknown what effect this may have on the growth of timber and understory species or on watershed management. Fertilization of young forest stands is becoming an accepted practice, but nutrients may contaminate water runoff and promote growth of slimes and algae downstream.

WATER

The future uses of basin waters in and downstream from forest areas will require continued maintenance of the water quality, particularly for municipal and industrial, water-based recreation, fish propagation, and esthetic purposes. The demand for water will increase progressively throughout the study period. Part of this need can be satisfied by additional structural measures. An opportunity to gradually increase the amount of usable water may also be afforded by manipulating the forest cover. Research now in progress will indicate to what degree snow storage and spring and summer streamflows can be increased by controlling timber-cutting patterns.

Throughout the projection period, the forest lands will be subject to progressively more demands for goods and services. Timber cutting and more intensive development (roads, bridges, culverts, dam construction, and other improvements) will continue to disturb land and water areas and produce sediment. More cable logging, less tractor logging, and new harvest systems should decrease soil disturbance and erosion and sedimentation of the streams, but increased use of chemical sprays for brush control, insect and disease control, etc., may increase chemical contamination. Biological contamination may become one of the most serious threats to the maintenance of desirable water flows of most forest streams, because of the large increases anticipated in recreation use. As the demand for multiple uses of forest lands increases, watersheds now needing only minimum treatment because of limited use will require additional treatment because of more intensive use. Additional treatment means intensified practices to protect the soil and water resource; i.e. mulching and seeding road banks, balloon logging to protect sites in steep or unstable country, etc.

The reduction of storm and sediment damages represents one of the best opportunities for forest land treatment. The winter floods of 1964-1965 are recent reminders of severe damage caused by floodwaters and debris originating on medium- and high-elevation forest lands. Damaged, unstable, and abused forest lands jeopardize the effective life of downstream water structures and developments. Landslides, stream scouring, roads and logging areas are major sediment and debris producers. There is a need to inventory these high sediment and debris-producing areas so that sound management decisions may be made on the basis of different upstream conditions. Management decisions would specify improved practices in new use situation and would set priorities for rehabilitation of existing critical areas.

FUTURE FOREST LAND USES

AS RELATED TO WATER

WATERSHED DISTURBANCE FACTORS

The major forest influences affecting soil and water were identified in Part II as road and trail construction, timber harvest, natural disasters, occupancy (power lines, reservoirs, etc.) grazing, and recreation. The future impact of these in the basin is presented in the following discussion.

Road and Trail Construction

On the average, 5 miles of logging road are needed to log a section (640 acres) of timber. Hunters, fishermen and recreationists also make use of logging roads, as well as forest trails.

The road systems on Federal forest lands will be complete by about 1990, and State lands by about 2020. The transportation system of most forest areas is only 40 to 50 percent complete at present. Road construction on forest lands will never be 100 percent completed, however, due to the necessity of reconstruction, relocations and extensions. Water quality problems will constantly recur as long as the watershed must be disturbed in this manner.

Photo III-9. A modern concrete arch bridge crosses the Collawash River and at the same time protects the water resource by allowing free fish passage underneath and no dumping of road waste in stream - Clackamas Subbasin. (U. S. F S Photo)

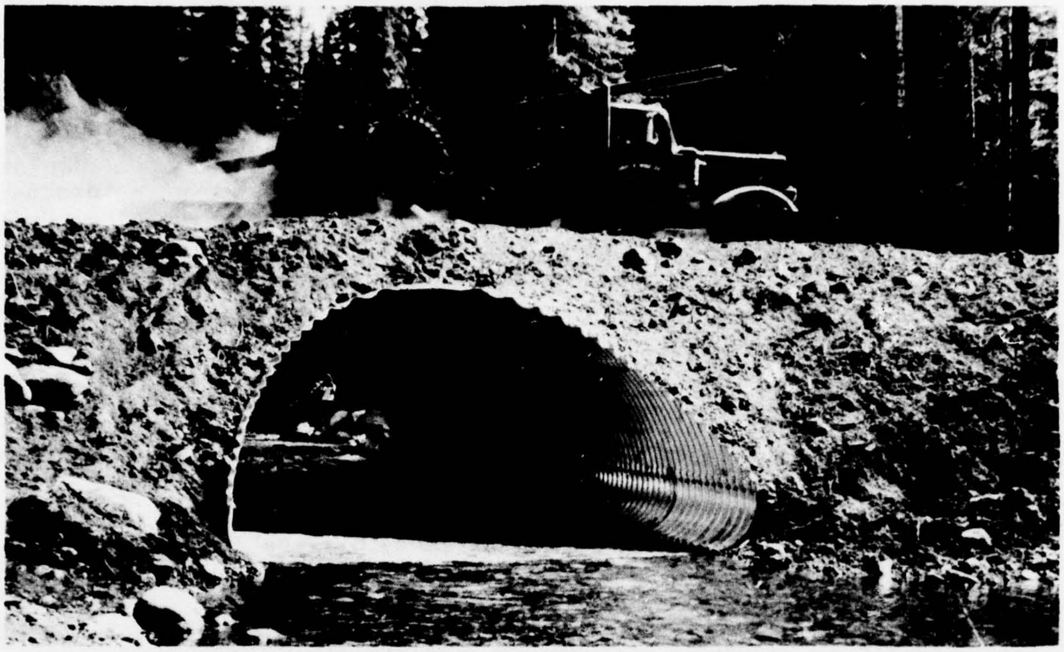

Photo III-10. Proper culvert placement is necessary to protect the road system and permit fish passage.
(State Department of Forestry Photo)

Land treatment on roads and trails will consist primarily of mulching, fertilizing and seeding of cut banks and fills. Other measures include improved planning in locating roads and bridges in relation to slide stabilization, adequate drainage and water barring, riprapping below culverts, scarifying and seeding abandoned roads.

Timber Harvest

Because of the importance of wood fiber to the basin's economy, the mills must have continued access to the timber on the basin's watersheds. However, more stringent controls over road building, timber harvest and slash disposal are needed to assure protection of both watershed uses and timber growing sites.

Photo III-11 shows a portable chipper which converts small trees and other cull material to chips for use in pulp mills. This reduces the amount of waste woody material left on the ground after logging and the need for slash fires for cleanup. Some chippers are used to grind up the material to be left on the ground to provide soil cover against erosion and to aid in reestablishment of forest vegetation.

Clear cutting and exposing mineral soil is the accepted method of securing Douglas-fir reproduction. This silvicultural method is required because the Douglas-fir is not a shade-tolerant tree. Clear cutting removes much of the vegetative cover, exposing the soil to erosion damage for two or three years after cutting, until brush, weeds and other vegetation grows over the area.

The disturbance of the watershed by timber harvest will be reduced as the larger old-growth timber is used up. Lighter, more flexible logging equipment can then be used on the smaller second-growth timber. In the 1965 to 1980 period, major land treatment costs will be related to road and trail construction required for timber harvest. This cost will diminish after 1980 as the road systems are completed and become stabilized. Beyond 1980, timber harvest methods will become of critical importance as logging operations move into the steeper, more unstable mountain slopes.

Timber stumpage prices should rise as the old-growth forests on private lands are liquidated. Public and private forest owners should put more emphasis on watershed management in future timber sales. More use could be made of skyline logging, balloon logging where practical, and other site protective measures where there is danger of major soil disturbance.

Treatment following logging may include seeding and planting logged-over areas; scarifying and planting tractor roads, swing roads and landings; and cleaning debris away from main draws and stream channels.

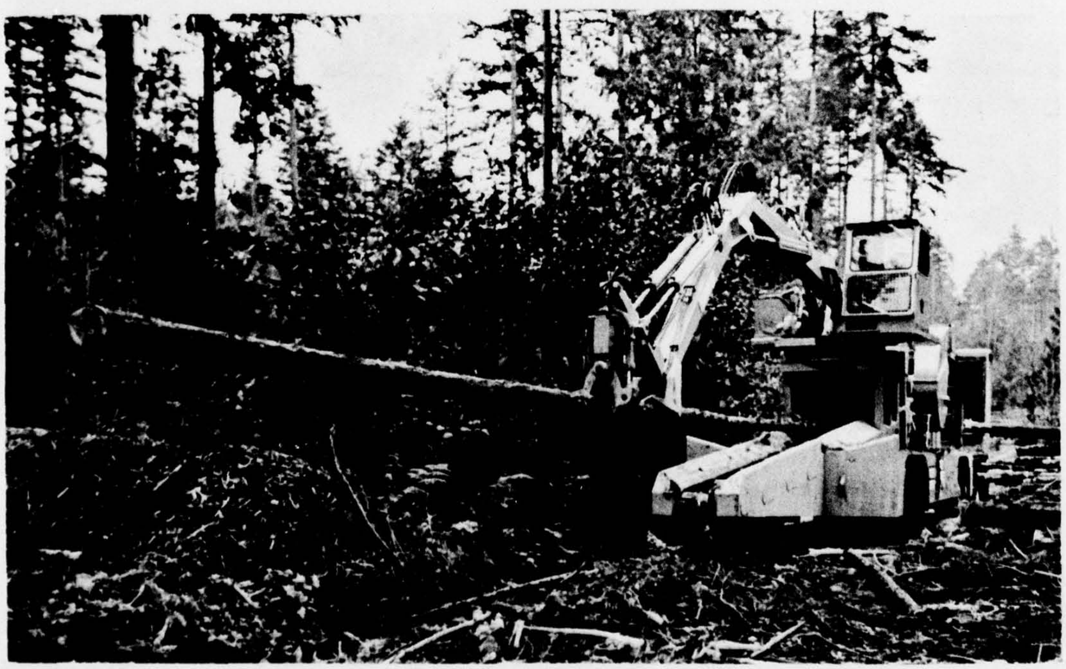

Photo III-11. New styles of logging equipment such as this portable chipping machine on a logging operation grind waste wood material into wood chips for use in pulp mills. (Crown Zellerbach Corporation Photo)

Natural Disasters

Natural disasters such as windthrow, fire, floods and insect damage are recurring problems over the entire watershed. Periodically hurricane winds cause widespread forest blowdown. Insect and disease infestations are closely related to windthrow, with bark beetle epidemics following bad windstorms. Forest fire, both man-caused and from lightning, will always be a threat. Some flood damage may be expected nearly every year. The forest manager cannot control nature, but he must anticipate disturbance caused by these natural disasters by preparing for them in advance or by quickly repairing the damage wrought. The watershed can perform its normal hydrologic function only as long as the soil and its protective cover can be maintained.

A soil survey of the forested watershed is a basic need for improving watershed management in the basin. Natural disasters are expected to occur on substantial acreage and result in a high level of land treatment costs. This well warrants the investment in a soil survey of the watershed. Soil inventories provide the land manager a guide to soil stability for use in locating roads to avoid land slumps and erosion hazards, and in planning timber cutting to avoid windthrow. These inventories also show soil productivity--a major determinant of tree vigor and resultant susceptibility to insects and disease. Currently there are few data on the forest soils of the basin.

Photo III-12. The Sardine Creek fire in 1951 as seen from a helicopter. Fire burned about 19 thousand acres of Federal and State forest lands and set into motion serious soil erosion problems - Marion County. (U. S. Forest Service Photo)

Natural disasters necessitate remedial actions such as stream channel clearance; construction of revetments, culverts and trash racks; riprapping stream banks; and planting and seeding of damaged areas.

Occupancy

Occupancy of forest lands (transmission lines, water storage reservoirs, mining claims, summer homes, etc.) will continue to have adverse impacts on water quality. Even though only modest amounts of watershed disturbance are expected from these uses, treatment costs will be relatively high. This presents a challenge to land managers and engineers to find ways to minimize damages to site values. There is opportunity for multiple use and increased production from lands devoted to rights-of-way and other restrictive occupancies.

Occupancy use of forest lands will result in needs to seed and plant cleared areas; seed, waterbar and rehabilitate temporary roads; and stabilize slide areas.

Photo III-13. Gully and rill erosion at borrow pit site just below Cougar Dam and Reservoir, Lane County. (SCS Photo)

Grazing

Demand for grazing on forest watershed lands is diminishing. The shift from grazing to other forest uses will result in less disturbance to the watershed by domestic animals.

Protection of water quality from livestock grazing will require fencing stock away from streams, seeding and planting denuded areas, and waterbarring and bridging stock trails.

Recreation

Outdoor recreation demand is expected to rise sharply in the future. The increasing public demand for the fish and wildlife resources of the basin has already been identified. Construction of forest administrative and logging roads will open vast new areas of the watershed to recreationists.

Recreational use causes more widespread disturbance of the basin's watershed than any other activity. Forest soils and ecological systems are damaged by intensive use and soil compaction. Also, recreation demands on the watershed will compete with use of the land for timber production and will require careful management to preclude biological and other contamination of the basin's stream system.

It may become necessary to either rotate use of forest recreation sites or to limit the number of people using a site. Treatment costs for rehabilitating and protecting the watershed will increase greatly as the demand for recreational use expands.

Primary land measure needs for recreation will include construction of sanitary facilities, fertilizing and seeding trampled and denuded areas, debris clearing and disposal on streams and reservoirs, and stabilizing roads and trails.

WATERSHED MANAGEMENT RISKS

The demand for high quality water differs greatly between subbasins and even tributaries. Every forest use requires at least a minimum effort to prevent erosion and keep the soil in place in a given watershed and to maintain water quality downstream. The greater the demand, the greater the immediate risk in any land use operation.

An appraisal of the watershed management risks for each subbasin as a whole is given in Table III-9; the higher number signifies a greater risk.

Table III-9
Watershed Management Risks, 1970-1980

Subbasin	Management Activity Index 1/	Vegetative Cover & Access 2/	Soil Stability 3/	Water Quality Demands 4/	Composite Risk
1--Coast Fork	2	3	2	2	9
2--Middle Fork	2	2	4	3	11
3--McKenzie	5	3	3	5	16
4--Long Tom	3	1	2	3	9
5--Santiam	4	3	4	4	15
6--Coast Range	3	1	3	3	10
7--Pudding	1	1	2	3	7
8--Tualatin	3	1	2	3	9
9--Clackamas	3	3	3	4	13
10--Columbia	3	1	2	4	10
11--Sandy	5	4	2	5	16

1/ *Management Activity Index - Forest use, development and disaster analysis (an empirical rating of use pressure on the resource).*

2/ *Vegetative Cover and Access - Percent old growth remaining (0-20% = 1, 20-40% = 2, etc.). If access is ahead of old growth removal, rating is lowered, if behind the rating is raised.*

3/ *Soil Stability - Relative seriousness in acres of high hazard (1 = Low, 2 = Low-Medium, 3 = Medium, 4 = Medium-High, 5 = High).*

4/ *Water Quality Demands - Amount of significant water benefits due to forest use (i.e. municipal water supply, anadromous fish, hatcheries, outdoor recreation, etc.)*

Forest use-occurrences are the basis for all watershed management needs. These occurrences transform unstable landscapes into dirty water downstream, destroy improvements, or ruin downstream lands. There are general basinwide use trends, but these apply in a particular subbasin. For example, there is relatively little old growth timber left in Subbasin 7 (Pudding) or need for road access in the Clear Creek tributary in Subbasin 9 (Clackamas). Table III-10 forecasts the forest use-occurrences picture for the time periods of the study.

Table III-10

Past and Projected Forest Development and Significant Risks to Water Quality by Subbasin 1/

Forest Uses and Occurrences	Time Periods: Past	Present	1970-1980	1980-2000	2000-2020
Uses					
Grazing	2,3,5		4,6,8		
Fish and Game			11		
Timber Harvest	7,8,10	1,3,5,7,9,11	1,2,3,5,7,9,11	3,5,8,9,10	4,6,7,8,10
Mining	1				
Recreation		3,8,9,11	3,4,8,9,10,11	1,3,4,5,6,8,9,10,11	all
Water	2,4,5,11	3,5	3,4,5,6,8	5,6,7,8,9,10,11	all
Urban Sprawl	4,8,10	3,4,8,10,11	3,4,6,8,10,11	3,4,6,8,10,11	3,4,5,6,8,9,10,11
Development and Maintenance					
Roads	1,4,6,7,8,10	1,2,3,5,6,9,11	2,3,5,11	5,11	
Dams and Reservoirs	2,3,4,5,9,11	3,5	3,4,5,6,8	2,6,8,9,11	4,5,6,7,8,9,11
Power Transmission	3,5,9,11	5,11	3,5,11	4,5,6,11	4,6,8
Water diversion & transportation	3,11		3,6,8,11	4,5,6,8,11	all
Natural Disasters					
Floods	2,3,4,5,6,8,9,11	3,5,6,9,10,11	5,6,9,10,11	9,10,11	
Geologic erosion		1,2,3,5,9,11	1,2,3,5,9,11	11	11

All subbasins have been and will continue to be subject to risks of fire, insect and disease epidemics, and violent storms.

1/ Subbasin: 1-Coast Fork, 2-Middle Fork, 3-McKenzie, 4-Long Tom, 5-Santiam, 6-Coast Range, 7-Pudding, 8-Tualatin, 9-Clackamas, 10-Columbia, 11-Sandy

LAND TREATMENT NEEDS

Land treatment needs on various types of ownerships vary according to the uses made of the land. In the following discussion, the needs are classified by the type of watershed disturbance causing them. Specific data are not available for "large private" ownerships (more than 5,000 acres each) or for lands in county and municipal ownership.

Federal Lands

Public agencies rarely are financed adequately to meet total program needs. High priority programs must often be carried out by taking a calculated risk on their impact on the watershed. Adequate soils data are not available in the basin for making resource management decisions. Ordinarily funds are not available to undertake unanticipated major watershed rehabilitation measures which may result from resource management programs. The following land protective measures needs are based on past experience as applied to future resource management activities.

Road construction on Federal forest lands will cause soil disturbance requiring expenditures to preclude erosion and water siltation. About $2.2 and $1.2 million will be required during the periods 1965-1980 and 1980-2020, respectively. Since much of the new road construction will be completed early in the latter period, a smaller expenditure is forecast.

Timber harvesting will cause disturbances requiring special land measures to preclude soil washing and water pollution. About $845,000 and $4.5 million will be required during the periods 1965-1980 and 1980-2020, respectively, to carry on this work. The expenditure required during the latter period will be greater because timber harvest activities will move into the higher, more unstable portion of the forest watershed.

It is anticipated that damages from storms and other natural disasters will require expenditures of $754,000 and $3.1 million during the periods 1965-1980 and 1980-2020, respectively. In the latter period, more intensive use of forest lands will make them more vulnerable to damage from natural causes.

Power line rights-of-way usually are straight-line routes disregarding land contours in the mountainous forest watershed. Roads constructed for access and service have often been built to temporary standards and, moreover, followed the steep grades of the power lines. As a result, they are extremely vulnerable to washing and gullying. Use of these access roads in wet weather to make emergency repairs can create ruts which result in gullying and sedimentation. Based on past rates of deterioration, watershed rehabilitation work due to power lines and other occupancy would require expenditures of $197,000 and $358,000 for the periods 1965-1980 and 1980-2020, respectively.

Although the projected costs for land treatment resulting from livestock grazing are modest, these measures are extremely important because of the danger of soil disturbance and bacteriological contamination of water. Estimated costs for the 1965-1980 and 1980-2020 periods are $35,000 and $49,000 respectively.

Land treatment measures for recreation-induced disturbance include protection of sites from damage by wildlife (particularly elk), and road maintenance resulting from recreation and hunter use. The estimated $200,000 cost for 1965-1980 will be to protect sites from wildlife damages. The $725,000 estimate for 1980-2020 reflects the impact of increased big game populations and accelerating use of forest roads by recreationists and hunters.

Land treatment costs resulting from the various sources of disturbance on Federal forest lands are summarized in Table III-11 for the periods 1965-1980 and 1980-2020. In the entry "Area Disturbed" the intensity of disturbance for the various uses are not necessarily the same; the figures cited for recreation include the total land used for that purpose because it is assumed that all lands used are disturbed to some extent.

Table III-11

Future Land Restoration Needs on Federal Forest Lands, 1965-1980 and 1980-2020

Activity	Area Disturbed (acres)	Critical Area (acres)	Treatment Cost
		1965-1980	
Roads and Trails	39,894	9,385	$2,158,665
Timber Management	99,272	14,518	845,341
Natural Disasters	103,670	11,665	753,701
Occupancy	12,770	3,095	196,900
Grazing	100,234	1,920	35,000
Recreation	338,694	4,977	198,660
Total	694,534	45,560	$4,188,267
		1980-2020	
Roads and Trails	21,504	1,578	$1,215,915
Timber Management	313,010	58,137	4,510,487
Natural Disasters	148,080	28,090	3,053,108
Occupancy	32,875	8,610	358,200
Grazing	133,264	1,720	49,400
Recreation	578,411	7,495	725,008
Total	1,227,144	105,630	$9,912,118

State Forest Lands

Natural disasters are expected to cause the most extensive impairment to watershed values on State Forests throughout the period of study. However, the greatest amount of critical acreage will result from timber harvest. No damages from grazing or recreation use are anticipated. In all situations, problem areas are relatively small and will require only a small amount of emergency funding to remedy. Land treatment costs resulting from various sources of disturbance on State forest lands are shown in Table III-12. Data presented are for Subbasins 2, 3, 4 and 5 only, therefore presenting only a partial picture.

Table III-12
Future Land Restoration Needs on State Forests, 1965-1980 and 1980-2020

Activity	Area Disturbed (acres)	Critical Area (acres)	Total Treatment Cost
		1965-1980	
Roads and Trails	760	5	$ 300
Timber Harvest	400	170	900
Natural Disasters	3,760	40	3,500
Total	4,920	215	$4,700
		1980-2020	
Roads and Trails	910	5	$ 300
Timber Harvest	300	150	900
Natural Disasters	3,760	40	3,500
Total	4,970	195	$4,700

Private Forest Lands

Nearly two-thirds of the basin's privately owned forest land will need conservation treatment by 1975, according to the "Oregon Soil and Water Conservation Needs Inventory", conducted by Oregon State University and the Soil Conservation Service in 1962. In addition to being an important source of wood fiber needed by local industries, the privately owned forests also provide watershed protection, wildlife habitat, livestock grazing, recreation, open space and scenic areas. Watershed rehabilitation will be needed not only to increase wood fiber production, but also to provide better cover and stability for the soil.

Reestablishment of timber stands and erosion control are the most important measures needed for watershed protection and management. Reestablishment of forest cover on the land is needed on nearly one-sixth

(456,000 acres) of the private lands. At an average cost of $41 per acre, rehabilitating timber cover on these lands would cost $18.5 million. Erosion control measures will be needed on 13 percent (387,500 acres) of the private forest lands by 1975. At an average cost of $48 per acre, erosion control would also cost about $18.5 million.

The Middle Subarea, particularly Benton County, shows the greatest need for forest watershed conservation measures on private lands. Lands expected to shift to forest use from other uses, such as submarginal and abandoned farm lands, need to be replanted in trees to check erosion and to provide shelterbelts and windbreaks. Other lands either inadequately stocked or stocked with unsatisfactory species will require a major planting project to maximize watershed benefits. Still other lands need reinforcement planting to prevent soil disturbance from windthrow and other erosion problems.

Multnomah County in the Lower Subarea also shows great need for forest watershed rehabilitation measures on private lands. This may be due to the large amount of nonresident, speculative ownership of forest property in the county, much with high potential for suburban development. Long-term investments for improvement of timber stands or protection of watersheds have little attraction to the speculator. Since everyone benefits from an assured supply of clean water, it may not be realisitc to expect the landowners to pay the full cost of needed rehabilitation measures on private lands. As demands increase for greater supplies of good water, there will be more incentive and pressure to see that the forest watersheds are protected and rehabilitated.

Lane County in the Upper Subarea also shows major problems developing on private lands. This is to be expected since Lane County is the center of the basin's logging industry and there is much recently cutover private forest land.

Land treatment needed by 1975 on privately owned lands, as determined in the "Conservation Needs Inventory" is shown in Table III-13. The table includes both "large" and "small" private ownerships. Future treatment needs on small private lands only are shown in Table III-14 for the periods 1965-1980 and 1980-2020.

On "small" private forest lands, about 10,800 miles of logging and other roads will be built between now and 1980. This will disturb soils on about 19,000 acres, of which nearly 700 are estimated to be "critical". By the year 2020, it is expected that another 10,000 miles of road will be built on these lands, resulting in disturbance of an additional 17,000 acres. A minimum of erosion problems is expected from road building during the latter period. Higher resource values will warrant more careful management of the forest lands. Landowners are expected to be better informed on resource management, and technical and engineering assistance from public agencies should be more readily available by this time.

Natural disasters such as forest fire, windstorms and floods cause watershed damages which cannot be forecast or prevented by the small landowner. Ordinarily his operations are of too limited a scope to make possible the setting aside of emergency funds to cover watershed rehabilitation from such damage. Insects and disease damages are expected to disturb the greatest acreage in the period to 1980; flood damages and fire will require the greatest cost for land rehabilitation. The outlook for the years 1980 to 2020 indicates an improving situation.

Occupancy of small forest lands by rights-of-way for roads, power lines, mining and other adverse uses is expected to affect about 19,000 acres in the 1965 to 1980 period and about 18,000 from 1980 to 2020.

Recreational use of small forest ownerships is expected to expand by over 4,000 acres by 1980. No serious damage to the watershed is anticipated from this use. Between 1980 and 2020, about 13,000 acres more will be diverted to recreation and intensity of use will increase. Better public education and strict legal requirements for recreation facilities will minimize watershed disturbance. Livestock use of small private forest lands show a slight downward trend in acres used.

As is the case for all private land, the most extensive watershed problems on small forest landownerships are found in the Middle Subarea.

Table III-13

Expected Land Treatment Needs by 1975
On Privately Owned Forest Lands

County	Area in Private Forest Lands (acres)	Area Needing: Establishment of Timber Stand 1/ (acres)	(%)	Improvement of Timber Stand 1/ (acres)	(%)	Erosion Control 1/ (acres)	(%)
Lane	820,800	100,000	12	253,000	31	250,000	30
Upper Subarea	820,800	100,000	12	253,000	31	250,000	30
Clackamas	194,000	17,000	8	34,000	16	19,000	9
Benton	213,900	42,000	20	128,400	60	15,000	7
Linn	526,600	90,000	17	250,000	47	20,000	3
Marion	158,000	40,000	28	50,000	32	12,000	8
Polk	238,700	50,000	21	60,000	25	5,000	2
Yamhill	174,000	30,000	23	42,000	24	10,000	11
Middle Subarea	1,505,200	269,000	18	564,400	37	91,000	6
Multnomah	42,000	21,000	50	19,000	45	4,500	11
Columbia	163,400	13,000	8	28,000	17	15,000	9
Washington	244,600	45,000	19	30,000	12	18,000	7
Clackamas	100,000	8,000	8	16,000	16	9,000	9
Lower Subarea	550,000	87,000	16	93,000	17	46,500	8
Willamette Basin	2,876,000	456,000	15	910,400	31	387,500	13

1/ *Oregon Conservation Needs Inventory, 1962.*

Table III-14
Future Land Treatment Needs on Small Forest Ownerships, by Subbasin

Subbasin	Roads & Trails	Timber Harvest	Natural Disasters	Occupancy	Total	Treatment Cost
	Critical Area Needing Treatment (acres)					
1965-1980						
Coast Fork	50	20	130	100	300	$ 45,300
Middle Fork	10	30	200	-	240	13,100
McKenzie	-	-	100	100	200	3,000
Long Tom	100	-	30	100	230	77,000
Upper Subarea	160	50	460	300	970	$138,400
Santiam	100	-	200	100	400	$103,000
Coast Range	100	50	200	300	650	81,600
Pudding	100	10	300	50	460	76,200
Middle Subarea	300	60	700	450	1,510	$260,800
Tualatin	100	50	200	400	750	$ 82,700
Clackamas	70	40	200	100	410	56,900
Columbia	30	20	200	300	550	28,600
Sandy	30	30	200	100	360	25,310
Lower Subarea	230	140	800	900	2,070	$193,510
Willamette Basin	690	250	1,960	1,650	4,550	$592,710
1980-2020						
Coast Fork	-	-	-	150	150	$ 1,500
Middle Fork	-	20	50	-	70	8,600
McKenzie	-	-	40	100	140	7,500
Long Tom	-	-	-	200	200	3,000
Upper Subarea	-	20	90	450	560	$20,600
Santiam	-	-	-	100	100	$10,000
Coast Range	-	-	-	200	200	2,500
Pudding	-	-	-	-	-	-
Middle Subarea	-	-	-	300	300	$12,500
Tualatin	-	100	-	500	600	$ 3,800
Clackamas	-	-	-	200	200	2,500
Columbia	-	-	-	200	200	2,500
Sandy	-	-	-	100	100	1,300
Lower Subarea	-	100	-	1,000	1,100	$10,100
Willamette Basin	-	120	90	1,750	1,960	$43,200

ECONOMIC IMPACT OF WATERSHED PROTECTION

Water is one of the most important resources coming from the forested watershed of the basin. About 86 percent of the basin's water comes from these watersheds due to their higher elevation and greater precipitation. This represents about four acre-feet of water annually from each acre of forest land.

The value of water depends on its use. Due to man's basic needs municipal and industrial water has a higher inherent value than water used for transportation or pollution dispersion. For this reason protective resource measures are more easily justified on municipal watersheds. In the Pacific Northwest it costs an average of about $40 per million gallons to treat turbid or contaminated water.1/ Even with treatment the product is less desirable than water not so contaminated. Based on projections of increased population and municipal water demands in the basin about $10.6 and $18.6 million annually will be required to treat municipal and industrial water in 1985 and 2020 respectively as compared to a cost of about $6.9 million in 1965. The 40,000 tons annual sediment yield per square mile from logged forest land in the basin 2/ can be materially reduced through land treatment measures identified in this study. Based on the current and projected water treatment costs, an expenditure of $3,158,000 (estimated land restoration costs) is warranted on the 5 million acres forest land to treat the causes of water turbidity. Even with adequate forest land treatment (restoration and practices) some sediment will be found in the Willamette River following storms due to bank cutting and channel scour and runoff from agricultural lands.

A substantial amount of watershed protection and treatment cost is also warranted to prevent siltation of reservoirs. The construction cost of Federal impoundments average about $200 per acre foot of water storage capacity. Siltation of these projects averages about 1,000 acre feet per year on existing resources. This results in storage loss damages of about $200,000 per year, or about $20 million loss over the 100-year life of the projects (Table III-15). The Middle Fork Willamette (Subbasin 2) is subject to the highest damage from reservoir siltation. Watershed treatment measures should receive high priority for this subbasin.

1/ *"Watershed Control for Water Quality Management", Pollution Control Council Pacific Northwest Area, April 1961.*

2/ *"Water Quality Control and Management, Willamette River Basin" Federal Water Pollution Control Administration. 1967.*

Table III-15

Storage Loss Due to Siltation at Selected Reservoirs

Reservoir (Const. Comp.)	Drainage Area (sq. mi.)	Cost Per Ac.-ft. (1966 $)	Estimated Average Annual Siltation 2/ (ac.-ft.)	Annual Siltation Cost (1966 $)
Cottage Grove (1942)	104	$191	26	$ 4,966
Dorena (1949)	265	259	66	17,094
Hills Creek (1961)	389	141	97	13,677
Lookout Point (1953) Dexter (1955)	991	227	248	56,296
Fall Creek (1965)	184	176	46	8,096
Cougar (1963)	208	267	52	13,884
Blue River (1/)	88	354	22	7,788
Fern Ridge (1941)	275	125	92	11,500
Upper Subarea	2,504		649	$133,301
Detroit (1953) Big Cliff (1954)	438	167	109	$ 18,203
Green Peter (1966) Foster (1966)	771	167	193	32,231
Middle Subarea	1,209		302	$ 50,434
Willamette Basin	3,713	$193	951	$188,735

1/ *Under construction.*

2/ *H. D. 531, Vol. V, "Columbia River and Tributaries in N. W. United States" 1950, p. 2042.*

FORESTED LANDS NEEDED FOR WATER STORAGE SITES

Additional water impoundments may be needed in the basin to reduce flood damage and provide irrigation water plus the many other benefits for satisfying public needs. The Corps of Engineers, Bureau of Reclamation and the Soil Conservation Service under the Public Law 566 Program have been investigating additional sites in the basin for construction of water impoundments to satisfy these needs. Several hundred potential damsites have been identified mostly on the forested watersheds. Existing reservoirs built by the private and public sectors cover about 36,000 acres.

Construction of reservoirs takes large acreages out of timber production. The opportunity cost of taking this land out of forest use must be considered. This is only one of the land use alternatives which must be considered in choosing a site for construction of a reservoir.

The impact of 22 potential reservoir sites on the existing National Forest resource uses was studied. These dams would eliminate 126.5 miles of stream channel for fish spawning and stream fishing. They would flood about 31,000 acres of forest land, precluding production of about two-billion board feet of timber in the first rotation period. Loss of potential income to the timber industry would be about $5 million per year (Table III-16). Construction of these dams would require relocation of existing roads, recreation sites and rights-of-way for power lines and other occupancies. Some of the projects would adversely affect wildlife by reducing winter range and restricting migration routes for big game.

Additional potential sites are being studied to determine which will have the least adverse impact on other resources in the basin and which will yield the greatest benefit to the public. It is possible that the timber production loss from inundation may be recovered through more intensive management of other forest lands, through fertilization and/or irrigation of suitable areas or through genetic improvement of growing stock.

Table III-16

Potential Large Reservoirs on National Forest Lands

Reservoir Site	River	Dam Ht. (ft.)	Stream Channel Displ. (mi.)	Area Lost to Timber Prod. (ac.)	Forest Yield to Rotation Age (MM bd.ft.)	Timber Value Loss--All Ownerships ($ million)
Upper N. Fork	N.Fk. M.Fk. Willamette	279	4.5	1,300	82	$ 9.8
Moolack Mt.	" " "	240	4	1,000	84	10.1
Mile 56	Mid. Fk. Willamette	274	8	2,100	86	10.3
Campers Flat	" " "	295	4.5	1,000	44	5.3
Foley Ridge	McKenzie	276	7	3,000	237	28.4
Twisty Cr.	" "	235	6	1,300	82	9.8
Rebel Cr.	" "	345	4	1,500	87	10.4
Horse Cr.	" "	340	4.5	1,300	96	11.5
Elkhorn	Lit. N. Santiam	270	7	2,240	130	15.6
Canyon Cr.	" "	285	4.5	1,000	66	8.0
Byers Cr.	N. Santiam	345	5	1,100	73	8.8
Tunnel	" "	347	4.5	1,600	86	10.3
Packers Gulch	Mid. Santiam	385	9	1,600	91	10.9
Bear Cr.	" " "	353	6.5	900	51	6.1
Chimney Cr.	" " "	310	5	1 300	70	8.4
Wiley Cr.	S. Santiam	226	5.5	900	64	7.7
Patterson	" "	335	5	1,200	73	8.8
Upper Soda	" "	290	4	900	51	6.1
L. Austin Pt.	Clackamas	394	10.8	2,180	144	17.9
U. Austin Pt.	" "	410	8	2,100	135	16.2
Big Bottom	" "	210	4	1,400	108	12.9
Linney Cr.	Sandy	268	5.2	900	54	4.9
Total			126.5	31,820	1,994	$238.2

Source of Data: "National Forests and Twenty-two Reservoir Sites", August 1967, Pacific Northwest Region, Forest Service.

FUTURE NEEDS FOR WATER ON FOREST LANDS

Some water will be needed for forest irrigation. It is reasonable to expect by the year 2000 that the irrigated acreage for timber production in the basin will be at least 250,000 acres. With irrigation, an increased productivity of 1,000 board feet per acre per year is anticipated, increasing annual gross return by about $40 per acre at today's prices. Indications are that stumpage prices will be much higher by the time the irrigated tree planations reach maturity.

Land administered by the Bureau of Land Management and privately owned forest lands lie at lower elevations and less steep terrain than the National Forests. They are subject to a longer growing season and at the same time subject to a longer period of drought during the summer. Irrigation of timber crops on these lands appears more physically feasible than on the National Forests.

Other on-site consumptive uses of water on forest lands include domestic uses at administrative and recreation sites, livestock and wildlife use, industrial use and for fire control. Currently these uses amount to only 221 acre-feet on National Forest lands--an equal amount is probably used on other forest lands. Currently the greatest consumptive use of water on forest lands is at recreation sites; this use will increase in the future in proportion to the accelerating recreation use.

FUTURE WATER QUALITY AS RELATED TO FOREST MANAGEMENT

More emphasis must be given in future management of our watershed timber lands to meeting the rapidly increasing demands for high quality water in the basin. The quality of water supply must be maintained at a level adequate to meet the following needs: fisheries, recreation, riparian dwelling, domestic, power, navigation, irrigation, municipal, and industrial. Quality of the water is especially critical in meeting domestic, municipal, industrial, recreation and fisheries requirements. Domestic and municipal water supplies warrant special standards for protection.

No two watersheds in the basin are alike. Hydrologic differences occur due to variation in soils, topography, climate, size of area, vegetative cover and management. In many of these watersheds, traditions, past practices and precedents need to be overcome or replaced by modern concepts in order to establish management that will more nearly fulfill the present and future demands. Management includes protection from forest fire, forest insects and tree diseases; maintenance of a thrifty forest cover to protect the soil mantle and to maintain or improve hydrologic conditions; and control of human activity as well as wildlife populations and habitat.

While the principles of multiple-use management may be applied to any watershed, the resource uses and the management practices will need to be tailored and timed to fit individual conditions. This is one of the utmost needs concerning water and forest land management. Foresters involved in the administration of watersheds have a challenge to update management to meet requirements and demands of the people. Likewise, municipal managers have a responsibility to participate in the preparation and execution of mutually acceptable management plans. Since wants and needs of people change, these plans will need to be periodically reviewed and revised as needed.

It is apparent that demands for high quality water will be increasing over the entire Willamette Basin. Prevention of water contamination at its source is usually less costly than measures needed to remove or offset the damages from the pollutants.

F U T U R E   P R O B L E M S

Increasing population, with its concurrent increasing demand for water and food and greatly increasing demand for forest recreation, will cause some new forest water problems and intensify many existing ones. More demands on a limited, even decreasing, area of forest land, probably accompanied by stricter water quality standards, will necessitate more careful planning of forest land use, more intensive forest management, and multiple use of many forest areas now in single purpose management.

In Part II, many of the existing problems caused by forest disturbance from various sources are discussed in detail. Many of these will continue to be problems, even as new technology develops. Other problems, such as (1) need for a primary system of access roads and (2) lack of knowledge of detailed soil-plant-animal-water relationships, may be approaching solution by the years 1985 or 2020. However, many problems become more critical.

Some of the problems expected to become critical are primarily physical or biological, but many are economic, social, or institutional. Anticipated problems of forest management or forest land use are listed as Physical, Economic and Social, and Institutional.

PHYSICAL PROBLEMS

Increased Recreational Use of Forest Land

Use of Forest lands for recreation purposes will continue to expand and intensify by year 2020. This increased use will speed up the soil disturbance and water quality problems. The need for more coordination and direction of recreation uses with other forest uses by private and public land managers will become more complex. Private ownerships will move in a big way into summer home residence and private camping and picnicking facilities. Public land management will specialize in development of wilderness, special interest zones, recreation occupancy sites and landscape management zones.

Research and Inventory Needs

Many of the biological and physical facts necessary for sound decisions about joint management of timber, soil and water are not known or are imperfectly understood.

1. Water requirements of the various plant species are largely unknown.

2. Per-acre water use by various forest types, forest conditions, densities of stocking, and for various non-timber types are not adequately known.

3. No complete forest soil inventory is available; particularly needed are data for each soil type on erodibility,

compactibility, runoff and percolation, as well as capabilities for growth of various tree and forage species.

4. Effects of various plant species and animals on each other and on soil and water relations are very little known.

5. Information is needed on the relationship of forest cover to quantity and timing of runoff. The effects of varying the stocking and the species composition of a stand should be known as an aid in making sound land use and forest management decisions.

6. Knowledge is needed on the feasibility of fertilization and irrigation of forest stands.

7. The effects of chemical contamination of water, through either fertilization or controlling insects, diseases and mammal pests, are imperfectly known.

Streambank Management

Measures are needed to minimize undercutting of streambanks, which results in losses of land and trees and contributes to flood damage. If streams in forested areas are to provide optimum environment for fish, and the banks are to be used by fishermen and other recreationists, modifications in timber management may be necessary.

ECONOMIC AND SOCIAL PROBLEMS

Evaluation of Water

If a meaningful dollar value can be placed on water of known quality at each location, sounder forest land use and resource management decisions can be made, and cost allocations can be more accurate.

Evaluation of Social Contributions by Private Landowners

Where a private owner spends extra dollars, above the expenditures justified by production economics, for benefits that accrue to the public but not to the owner, the value of such contributions should be identified. The extra costs or reduced income of the private owner providing these benefits are properly social costs.

Public Education

Because of the increasingly complex interrelationships among the resources and uses, there will become an increasing need to inform the public of these relationships and the importance of cooperation for constructive resource management.

INSTITUTIONAL PROBLEMS

Future institutional problems concerning forest-water relationships in the Willamette Basin are likely to be associated with ownership rights, responsibilities and laws.

In order to protect water quality, quantity and timing of flows the public may require some constraints on management of private forest lands. However, unreasonable legal controls on forest land use should be avoided. There is need for continued and more effective watershed management education for landowners and managers. The combined efforts of the State Extension Service, State Forester, U. S. Forest Service, the two State Universities, forest industrial associations, the Society of American Foresters and other conservation groups will be needed to achieve the necessary appreciation by landowners and to secure attention to water quality problems in their use of forest lands.

Small forest ownerships are mostly situated in the margins of the valleys, at low elevations. The timber management and logging practices in these ownerships will have a combined effect on the timber supply and on the water quality and quantity. There may be need of public regulation of small forest ownerships beyond existing minimum practice and slash disposal laws, plus such pollution control laws as may apply to all forest lands.

ALTERNATIVE MEANS TO SATISFY DEMANDS

agriculture

Photo IV-1. Conservation land and water measures are needed to insure a continuing agricultural economy in the Willamette Basin. (SCS Photo 0-1460-4)

Needed land treatment and watershed protection measures can and are being accomplished in a number of ways. In this section, some of the management concepts that materially influence land use, water quality and quantity are briefly discussed. Each concept is treated as an entity--and as such represents an extreme condition. The actual proposals contain elements of each concept in varying degrees. These proposals are based on maintaining maximum amounts of individual freedom, yet conserving the land and water resources of the basin.

MANAGEMENT CONCEPTS

LAND USE ZONING

To achieve a chosen goal, we have come to accept the need to plan our environment. Planning is accepted despite an ingrained urge to decide individually how each plot of ground is to be used. Many social and technological changes are taking this power of decision away from individuals. Through comprehensive community, county and basin planning, an attempt is made to use land and water resources to maximize benefits for both the individual and society.

Land use planning is the establishment of "primary goals". It has many interacting segments, each with a series of ramifications. Selection of the primary goals depends on the extent or relative importance of any particular segment to all of the others. One of the means of assuring attainment of the goals is through zoning. Zoning, then, is only an implementation tool and is properly used in conjunction with an adopted comprehensive plan.

Assuming for the moment that conservation is the overriding desirable goal, a master plan would be developed whereby each area is used within its capabilities. The master plan would direct where roads and airports should be located--where urban and industrial areas should develop and how the timber and agricultural lands should be used. The plan would further dictate how and when timber lands should be harvested and specify the required patterns and timing of cultural operations occurring on the various agricultural lands. The land would then be zoned and thus restricted to the ideal uses.

Such a land zoning program would have significant economic and legal problems and ramifications as well as presenting administrative problems. The primary drawback is that conservation planning as outlined would be single purpose and not allow development of the resources to meet other human and economic needs. Zoning for conservation's sake is only part of an overall comprehensive plan.

Rural zoning for any purpose has met stiff resistance in many of the counties within the Willamette Basin. This probably has been because the concept of zoning has been presented before that of planning and without the involvement of local people. This climate of public opinion has changed significantly in the past few years, however. Educational programs and meetings with county commissions and interested citizens of rural counties have stressed the benefits of community planning. Currently all counties within the basin have zoning ordinances covering all or a part of the county; and all counties have planning commissions.

The general public is becoming more aware that although rural planning and zoning is administratively difficult, the alternative--unplanned and uncontrolled proliferation of growth--creates far greater economic, conservation and administrative problems. Land use zoning for conservation of land and water resources must be considered part of a comprehensive development plan but not an end unto itself.

LAND BANK CONCEPT

Under the Land Bank Concept, lands with severe erosion, flood or drainage problems would be retired from agricultural uses until needed at some point in the future. These lands could be used for recreation or wildlife habitat or placed in a non-crop status with permanent pasture or forest uses. The land bank would have to directly control the land throughout right purchase or long-term lease. This program should be on a State or National level and geared closely to changes in the Nation's need for food and fiber.

Some phases of a land bank program can be seen in the administration of the holdings of the Forest Service, Bureau of Land Management, State and county governments. Under these programs the governments actually own and manage lands in the public interest. Another phase of the land bank is the "Soil Bank" or crop adjustment programs administered by the Agricultural Stabilization and Conservation Service of USDA. Although the primary purpose of these programs is for adjustment of crop production, they also result in conserving the land resource. In this program farmers voluntarily "leased" their land to the government for a specified number of years.

Several problems become apparent in implementing a conservation land bank if done on a mandatory basis. Number one problem is the cost of gaining control of the land. Also, a loss of revenue to the communities would occur from lowered crop production and loss of a land tax base. In many cases, entire farms would need to be purchased in order to control a critical sediment source area.

In the Willamette Basin most of the conservation problems are not severe enough to warrent a specific land bank program. Adequate farm prices plus programs of education with technical assistance, plus public economic assistance when incomes are low, are getting most of the job done. The various modified programs as described above should be continued and even expanded in specific problem areas.

COST SHARING AND PRACTICE PAYMENTS

A program of economic incentives through subsidies, direct payments, or tax advantages could accomplish a needed land treatment program. This program is related to the land bank in some ways, but would reimburse land users for any practices that would help maintain soil stability and/or reduce rapid runoff. It would pay him not to raise some crops and would subsidize production of others.

This program is currently being used in a limited way through ASCS programs. It has proven effective in the past and could be made more effective in the future through increased Federal cost sharing and expanding the needed practice base. As a single alternative, it would be quite costly initially and have a continuing high cost for practice maintenance. As a supplement to the proposed plan, it has great potential.

LEGAL RESTRAINTS

Under this program the landowner would be held responsible or liable for erosion on his land and for its downstream effects. There would be monetary penalties for land abuse. The program might have features whereby a county, State or Federal agency would have the power to go on the land and remedy the land abuse problem and require the landowner to pay for it. This is similar to how some noxious weed control districts or fire control districts currently operate.

Features of this program may become increasingly important as social concern slowly shifts from individual to group problems. A wide spread program would be difficult to uniformly enforce, and individual rights to use land advantageously could be arbitrarily violated.

EDUCATIONAL PROGRAMS AND TECHNICAL ASSISTANCE

This program would be designed to make the public as well as the landowner aware and concerned that basin land and water resource uses are maximized for the long-term good of the nation.

Educational conservation study programs in elementary through college levels would be mandatory as part of the basic curriculum. Teachers would have special training in these fields. News media and public releases would create a public awareness of the present and future problems.

With public awareness achieved, accelerated programs of problem solutions could be accomplished. Technical assistance would be made available to get needed conservation measures on the ground.

The educational alternative is considered one of the best and has its roots very deep in most of the Federal and State agencies dealing with forestry and agriculture. It is a program that is picking up momentum as populations continue to expand geometrically and resources become increasingly more scarce. The history of such programs now operating in the basin indicate that it can only do part of the job.

RESEARCH

Closely allied with education, this alternative can only give guidance as to possible solutions to land measure problems. It is a vital link in the chain of conservation, but positive research results must be applied to be effective. Combinations of other alternatives are often necessary for actual application of these research findings.

Research is perhaps the most important of the six concepts mentioned. We don't know enough to be able to relate the technical "know how" we think we have to the economic, social and political realities. We talk about zoning as though it could take place outside of comprehensive planning. We treat planning as though it is a matter of blue printing our environment. We choose (or think we do) the kind of economic order we want, yet at the same time are puzzled because it prevents us from doing right by our natural resources. Therefore, research needs to go far beyond developing ways to stop erosion as such. It should help us to use land and water intelligently--all within the bounds of our economic systems.

The research alternative is considered to be a requisite to other programs and a detailed discussion of future research needs will be presented subsequently.

SPECIFIC RECOMMENDATIONS

Each of the six concepts was considered only partially effective in achieving needed watershed protection or land measures. All have political, legal or economic limitations. Certain elements of each concept are considered desirable, however, and their inclusion in varying degrees will be shown in the discussion of going programs to meet conservation needs.

Several specific recommendations are made and are discussed later in some detail. They are:

1. Going programs dealing specifically with agricultural land and water use and the conservation features thereof, should be continued and expanded to give respective agencies broader authority in line with the trend toward resource planning, zoning, and use of these resources for the public good. Broader authority should slowly evolve as needs become more pressing.

2. Accelerated land treatment needs resulting from the projected land use shifts for 1980, 2000 and 2020. These needs are shown specifically for 1980 and treated generally for 2000 and 2020.

3. Watershed project oriented land measure needs resulting from specific projects for flood control, irrigation, drainage and recreation. The need for associated accelerated land treatment practices should be considered as an integral part of planning.

4. Critical needs outside watershed areas. Small projects of spot work to meet urgent localized problems need to

be accomplished. These projects are usually beyond individual scope, yet are too small for the scope of the three main construction agencies. In some cases, they do not meet agency purposes, qualifications and current legal or administrative limitations. Many of these prospects would fall in the Resource Conservation and Development or Agricultural Conservation Payment pooling agreement size. These programs are discussed in the next section.

GOING PROGRAMS

A number of existing programs influence the landowner and his use of the land. Some deal directly with conservation problems and development of land and water resources. Others deal with agricultural production or problems directly but have a significant indirect effect on land measures application. The main going programs function primarily into three categories--informational, technical assistance and financial.

Basin research is constantly being done by Universities, Governmental agencies, and by private industry. Data are collected and evaluated from numerous angles. Research results are then made known to the public. Limited educational programs are available down through the county levels. These programs include school workshops, exhibits, and displays and other visual aids. Publications are written, advertisements made, and data disseminated through the news media. An outstanding example of applied research results is the basin grass seed industry. Thousands of acres of grasslands have had a significant effect in stabilizing the soils on rolling hill lands.

Landowners do not always recognize problems or see development opportunities. Even when they do, they may not know how to go about solving them. Several agencies have programs to help landowners to make right decisions and resolve problems. Trained technicians work directly with landowners in problem solution. Data used and work accomplished on the land usually are highly dependent on the informational and financial program categories.

Needed land measures or watershed protection practices may not be applied due to an initial high cost or little on-site short-term benefit. Many landowners have a more productive use for scarce capital. Government programs of actual cost sharing on approved practices for conservation purposes are available. Group projects for problem relief on land and water development may receive financial assistance in planning and construction.

Other valuable financial assistance comes through low-cost loans to rural landowners. Not only is the money available, but in many cases the loaning institutions will give valuable assistance in planning a good conservation program over the loan life.

AGENCY PROGRAMS

A brief discussion of the major going agricultural programs follows. These programs illustrate major types of assistance available. Additional agencies and institutions contribute to varying extents in getting conservation on the ground.

It is expected that the level of future needed watershed protection and land treatment measures can be accomplished through the going programs or accelerating going programs. There may need to be some broadening of scope and relaxation of current restrictions and concepts, however, as changes in demand occur.

A number of other programs are currently being considered by various legislation. Nearly all of the legislation could be incorporated under the various authorities currently in existence.

Agricultural Research Service

The Agricultural Research Service is the major scientific research agency of the Department of Agriculture. This service is charged with the responsibility for the conduct of fundamental and applied research in the physical, biological, engineering and agricultural sciences. Research and regulatory activities are organizationally grouped into four major areas effecting land use as follows:

1. The Utilization Research and Development activities are directed toward the discovery and development of new or improved uses for and methods of utilizing agricultural commodities of all types.

2. Farm Research is concerned with matters relating to farming practices and the production of agricultural commodities.

3. The Regulatory Programs are concerned with measures for preventing the introduction and controlling of the spread of animal and plant diseases and plant pests.

4. The Experiment Stations Divisions of ARS administer the Federal acts granting funds for the support of research conducted by State and territorial agricultural experiment stations.

Research needs to solve local soil and water conservation problems are submitted annually to ARS by the Extension and Soil Conservation Services. These needs are organized by categories and priority, and research is initiated and carried out as funds and resources are available. It is expected that these needs will increase significantly in the future as the complexities of scientific agriculture increase. These needs would be proportional to those of the other agencies concerned with agriculture.

Agricultural Stabilization and Conservation Service

The Agricultural Conservation Program is designed to provide means of sharing with farmers a part of the cost of carrying out essential conservation practices. Cost sharing is provided only on those practices that are satisfactorily performed.

The program is administered locally by elected Agricultural Stabilization and Conservation county and community farmer-committee men with assistance in technical matters of the Soil Conservation Service, Forest Service, Extension Service, and the State Board of Forestry. The program is tailored for local conditions by the county ASC committees, supervisors of the Soil and Water Conservation Districts, and cooperating Federal and State agencies.

Basic conservation land measures for which cost sharing is available in this basin are: seeding for protection or land use adjustment; liming; forest tree planting; planting trees and shrubs to prevent erosion; establishing sod waterways, diversions and terraces; streambank or shore protection and channel clearance; constructing open and closed drains; reorganizing irrigation systems; land leveling for irrigation; lining irrigation ditches; constructing dams, pits, or ponds for agricultural uses; seeding cover crops; developing springs and installing pipelines for livestock water; controlling competitive shrubs on pasture land; subsoiling; developing wildlife habitat; and installing beautification-conservation measures.

Special ACP pooling projects are designed to provide conservation benefits and improve the economic condition of farmers and the community in general. In this area some of these projects are planned or are underway, and some have been completed.

The Agricultural Stabilization and Conservation Service also administers the Soil Bank Program, which provides payments for retiring land from cultivation. In many respects this land retirement has greatly assisted in conserving the soil resource.

It is expected that the Agricultural Conservation Program will remain as a major source of direct financial aid to Willamette Basin farmers by sharing with them the cost of solving problems of conserving soil, water and wildlife resources.

The 1980 trend to more intensive farming and production of diversified crops will result in the need for more effective use of cropland. Conservation measures that make intensification possible will probably be the ones for which ACP cost sharing will be used to a greater extent. These measures include control of water--to avoid damage to farmlands; through stream channels and bank improvements; and improvements in the use and disposal of water through efficient irrigation and drainage systems. As in the past, emphasis will be placed on establishment and maintenance of protective cover of grass, legumes or trees where needed.

The pattern of ACP assistance may result in a greater sophistication in the planning, engineering and use of land treatment practices in the farming operation. This pattern will be directly influenced by large scale community and area projects for drainage or irrigation or both. For example, large areas of the basin are presently handicapped as to use because of lack of adequate drainage outlets.

An additional area of assistance could result from an acceleration or redirection of the soil bank or farmland diversion programs. These programs could be directed at solving conservation problems as well as excess production reductions.

Farmers Home Administration

The Farmers Home Administration makes soil and water loans accompanied by technical management assistance to owners or operators of farms and ranches to assist them in developing, conserving and making proper use of their land and water resources. Group loans are also availabl .

The agency's programs strengthen family farms and rural communities and reduce rural poverty. Credit extended by the agency supplements but does not compete with loans made by private and cooperative lenders. Most loans are made for operation, purchase and improvement of family-type farms.

Farm ownership loans are made to help farmers buy land, improve land and buildings and refinance debts. Loan funds may be used to pay the applicant's share of the cost of flood control dams and reservoirs, water supply reservoirs including municipal and industrial water storage, diversion dams, irrigation canals, drainage facilities, recreation facilities, easements and similar purposes.

Operating loans, that help farmers make better use of land and labor resources, are made for the purchase of equipment, feed, seed, fertilizer, livestock and other farming needs including family subsistence.

Emergency loans are made to eligible farmers in designated areas where natural disasters such as flood and droughts have brought about temporary need for credit not available from other sources.

Watershed loans are made to help eligible organizations meet their share of the costs of works of improvement that protect, develop and use water resources in small watersheds, and that are approved for operation by the Soil Conservation Service. Loan funds may be used to pay the applicant's share of the cost of flood control dams and reservoirs, water supply reservoirs, rural water supply distribution systems, diversion dams, irrigation canals, drainage facilities, recreation facilities, easements and similar purposes.

Soil and water conservation loans are made to eligible individual farm operators and owners to develop, conserve and make better use of their soil and water resources. A borrower's total indebtedness on the farm, including the loan being made, may not exceed $60,000.

Loans to rural groups for soil and water conservation and shifts in land use are also made to eligible groups of farmers and ranchers, to develop irrigation systems, drain farmland, and carry out soil conservation measures. Loans may also be made for shifts in land use to develop grazing areas and forest lands.

Water and waste disposal system loans and grants for the construction of rural community water and waste disposal systems are made to public bodies and nonprofit organizations. The group's total indebtedness for these loans together with any assistance in the form of a grant cannot exceed $4,000,000. Grants may be made, of not over 50 percent, to eligible groups for development costs.

Similar loans can be made for the development of rural recreation areas including facilities for swimming, golfing, boating, fishing and camping.

Resource conservation and development loans are available to public agencies and private nonprofit corporations for natural resource conservation and development including outdoor recreation facilities in designated areas. The projects can serve residents of open country and rural towns of not more than 5,500 population.

It is expected that the need for soil and water loans to individual farmers will increase as more Willamette Basin land is put under irrigation. It is also expected that cooperative drainage and sprinkler irrigation projects will become more desirable and that loans will be needed to assist in the development of these projects. The extent of the increase in need for loan funds is impossible to estimate because it depends to a great degree upon the condition of the private money market.

United States Forest Service

The Forest Service is charged with the responsibility for promoting the conservation and wise use of the country's forest and related range, water and other wildland natural resources--as basic factors in our national security and strength.

To meet this responsibility the Forest Service engages in three main lines of work: (1) management of the national forests; (2) cooperation with the State and private forest landowners in obtaining better forestry; and (3) forest and related range research, which are discussed in more detail in the Forestry section.

Federal Cooperative Extension Service

The Federal Cooperative Extension Service is an agency in the U. S. Department of Agriculture with designated responsibility for educational and informational activities. The Extension Service maintains offices in the county seats of Willamette Basin counties and is supported by the central staff, including subject matter specialists, located at OSU, facilities and personnel of the Agricultural Experiment Station, and all other departments and facilities at OSU.

Research results conducted by USDA agencies, OSU and other State, Federal and private research agencies located both in Oregon and elsewhere are made available to the local people. Significant subject matter, backed by research and modified by experience, form the base for combining demonstration and education programs.

County extension agents assume responsibility for educational and organizational activities in connection with a wide range of action programs sponsored by various agencies in the USDA and other Federal, State and county agencies. Traditionally, Willamette Basin extension agents have worked closely with local people in developing and projecting plans and programs intended to improve the local agriculture, resource conservation and development, and overall economy.

Willamette Valley extension agents have effectively aided in securing local support for projects relating to land and water resource development, such as irrigation, drainage and flood control. This includes aid in perfecting appropriate legal organizations to assume local financial responsibility for construction, operation and maintenance. Their offices will continue to aid in completing this necessary step between planning and application.

The job of continuing education and dissemination of research results will increase especially if portions of the needs listed in a later section are enacted. Rurbanization will result in basin lands being used increasingly by owners with little agriculture or forestry background. These owners will require a different type of information and need an expanded program to fill their needs.

Changes in agriculture--notable intensification--bring about new crop patterns and necessitate different cultural and marketing procedures. It is expected that the extension programs will continue to be closely allied with that of the other Federal agencies and will need to be expanded in relation to them.

Soil Conservation Service

The Soil Conservation Service is the Department of Agriculture agency primarily assigned to the technical operation phase of soil and water conservation. Its principal duties are soil survey; technical assistance to landowners, operators, organizations and communities through the local Soil and Water Conservation Districts; administration of the Watershed Protection and Flood Prevention Act (P. L. 566); and technical assistance to the Agricultural Stabilization and Conservation Service cost-share program.

Much of the technical assistance provided to landowners, operators and organizations for the conservation of soil and water resources in the basin is through the local Soil Conservation Service offices serving the separate Soil and Water Conservation Districts.

This technical assistance available through the Soil and Water Conservation Districts includes:

1. Soil surveys that provide an inventory of the soil resources to be used for conservation planning and application with individual groups and organizations. To provide soils information and interpretations to community planners.

2. Assist individual landowners, operators and organizations in the formulation of their conservation plan which delineates the needs of the land and the application of an action program to meet these needs.

3. Technical assistance in planning and applying conservation practices in the fields of engineering, agronomy,

geology, woodland, soils, biology, plant materials, recreation and water forecasting.

4. Helping groups of landowners, operators and organizations to plan and apply drainage and irrigation measures that cover more than one ownership.

5. Assisting local organizations develop and apply work plans under the Watershed Protection and Flood Prevention Act (P. L. 566) for the overall solution of flood and water management problems.

6. Assigned responsibility for leading the planning and for providing technical assistance to Resource Conservation and Development projects.

7. The service participates with other Federal and State agencies in making surveys and investigations of river basins and other watersheds and has overall responsibility for USDA participation in these activities.

8. It will encourage, assist and cooperate with local people, organizations, Federal, State and local agencies in broad resource area planning in the community, area or region.

9. Give technical assistance and guidance in the preparation of plans for the orderly and effective development of soil, water and related resources in proper relationships to the total social and economic needs.

10. Helps to assemble, screen and increase plant materials that have possible value in soil and water conservation. This work is done at plant materials centers, which are operated under cooperative agreements with the states in which they are located.

11. The service provides technical assistance on permanent type conservation practices to the County Agricultural Conservation program on their cost-share programs. Needs and feasibility are determined, design and layouts are made, and completed practices are checked for compliance with technical standards.

12. Cooperative snow survey and water forecasting are made on snow courses throughout the basin.

13. In addition, the service provides technical information and consultation to private engineers, architects, contractors and other agencies, organizations and individuals who need help in soil and water conservation problems.

COMMUNITY PLANNING

A significant step in meeting some of the land and water resource needs has been taken through the development of a community action approach to various problems. Several agencies or organizations may be involved.

Technical Action Panel

The technical action panel consists of personnel from the U. S. Department of Agriculture agencies serving their respective areas and appropriate representatives of the Federal, State and local agencies. The Farmers Home Administration serves as primary chairman of this panel.

At the local or county level, these panels function in a useful positive way, which is beneficial to the local community. They are in a position to be instrumental in influencing attitudes of the landowner, whether he is a farmer or a rurban dweller in the need of proper land use, agriculture zoning and proper concern for the soil resources.

Specific duties which the panels perform are:

1. More effectively extend services and benefits of Federal and State agencies to rural communities and to groups and individuals within such communities.

2. Provide information on technical and financial assistance and guidance for project development.

3. Assist rural individuals and groups with economic development plans, community projects, inventories and surveys.

4. Encourage and assist local leaders in rural development organizations and citizen committees for community resource development.

Soil and Water Conservation Districts

For a quarter of a century, the Soil and Water Conservation Districts in the Willamette Valley have carried out a program of conservation of soil, water and other natural resources. Individual landowners have installed conservation practices on their lands using soil capabilities and conservation plans as a guide.

SWCD's are legal subdivisions of the State of Oregon, organized and administered by local people to assist and encourage the conservation of the natural resources within their district. Nearly all of the Willamette Basin is now covered by sixteen Soil and Water Conservation Districts.

Local people seeking to create new opportunities through resource development find that the community is a resource which also needs to be developed. Their conservation goals include building an economic base in the countryside, one that has both utility and beauty.

Conservation District leaders are taking an active part in the water and related land resources development of the basin. SWCD's serve as sponsoring organizations for the many P. L. 566 watershed projects and also encourage and assist at the local level with many other water development programs.

In addition to conservation programs in their own district, voluntary associations of several SWCD's are now serving as the nucleus for area-wide resource development. The Upper Willamette RC&D Project is sponsored by six SWCD's and three counties. This successful project indicates that SWCD's are ready and qualified to cooperate with both urban and rural planning bodies, individuals and agencies interested in planning and guiding orderly development of natural resources.

ACCELERATED LAND TREATMENT NEEDS

Future technical assistance is expected to continue to be associated with practices of three main types: (1) annual--recurring; (2) semi-permanent; and (3) permanent. It is not possible to clearly define how much of the total conservation job is actually done, or more important, remains to be done, except at a fleeting point in time. This is largely due to the nature of the three practice types.

The recurring practice (type 1) may be illustrated as conservation cropping systems, cover cropping and proper irrigation water application. These practices, where needed, must be annaully applied to be effecitve. A significant portion of the technical time is necessary to maintain the current application rates. Additional time is required to assist other landowners who currently do not apply these land measures.

The semi-permanent practice (type 2) are those having a life of several years but which will eventually be replaced or improved upon. Examples are pasture and/or woodland plantings, contour orchard or berry plantings, and surface drainage practices. Once these practices are established, they normally suffice until the land use is changed.

Permanent land measures (type 3) are the only ones that can be accumulated over time. Farm ponds, spring development, internal drainage at optimum spacing, and drop structures are examples. Even these may change as land use is altered.

Some lands need only one type of land measure, while others require all three to be fully treated. Other land can be considered adequately treated with only one type of practice as long as it remains in its present use. Land measures should be dynamic and responsive to any change in use.

Table IV-1 illustrates the total needs for conservation in the basin by 1980. These needs do not include those resulting from project or critical need development. Accomplishments to date are shown and the job remaining quantified. Part of this remaining job plus maintenance of the existing accomplishment is next illustrated. Column 5--Unmet needs, are the figures of importance as is the proposal of additional technical time required to meet them.

Accelerated total land measure accomplishments are keyed to technical application time. Technical time required in the various subbasins is based on the job remaining and the expectation of achievable accomplishments. It is expected that from 30 to 50 percent of the remaining job is the practical limit that people are willing to apply under realistic conditions. Assuming that technical people were available when needed, the annual rate of new accomplishments are limited to a 3 to 5 percent "bite" of the remaining job. To obtain that net figure, staffing rates would need to increase 7 percent annually to allow for slippage due to ownership changes and changes in land use and methods of farming.

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About 22 percent of the remaining needs will be met through a continuation of the going programs. This expenditure ($17.4 million out of $78 million needed) should be accomplished by 1980. Most of the remaining $60+ million needs are not considered achievable goals due to landownership patterns, changes and restrictions. About $4.3 million is the projected accomplishment that could be obtained. This accelerated spending would beat the annual rate of $400,000, of which 5 to 15 percent would be for technical assistance and the remainder for application.

Accelerated land measures outside of proposed project areas and exclusive of critical need areas, have a lower priority than those just mentioned. They have less effect on the quantity and quality of water at any given location.

No attempt is made to estimate land measure assistance programs beyond 1980. This is because the many changes that will take place will result directly from project action and can best be estimated when specific project proposals are known.

EARLY ACTION WATERSHED PROJECT

The completion of multi-purpose projects in the Willamette Basin will permit intensification of land use especially for agriculture. The availability of water for irrigation, the reduction of flooding, improved drainage facilities, provisions for recreational use, and fish and wildlife enhancement will promote the more intensive use of all the lands within the project area. Project action will stimulate resource use and increase the need for trained technicians in order to apply a sound soil and water conservation program.

Each of the presently identified 26 early action projects of USDA has been located and the impact of land use change computed. Most of these projects have a major impact on the requirements for accelerated land measures. Proper land treatment is necessary before the project benefits can be fully realized. A number of Corps of Engineer and Bureau of Reclamation proposals could have an impact on future land treatment needs, but because of the normal "developmental period" the land use changes are not expected to create land measure demands until after 1980.

Table IV-2 summarizes the early action project impact on basin lands and the resulting accelerated land treatment needs. When these projects are built over $10 million of land measures will need to be applied. Approximately $1.0 to $1.5 million will be required for technical assistance and $8 to $9 million for installation costs. The bulk of the $10 million needs are one-time expenditures and will be spread over a period of years. Actual rates of application will depend on the pattern of the project development and will lag behind actual completion of project structural works of improvement. Proposed project areas are shown on Map IV-1.

Table IV-2

Estimated Accelerated Land Treatment Needs Due To Installation Of Anticipated 10 to 15 Year Projects of USDA

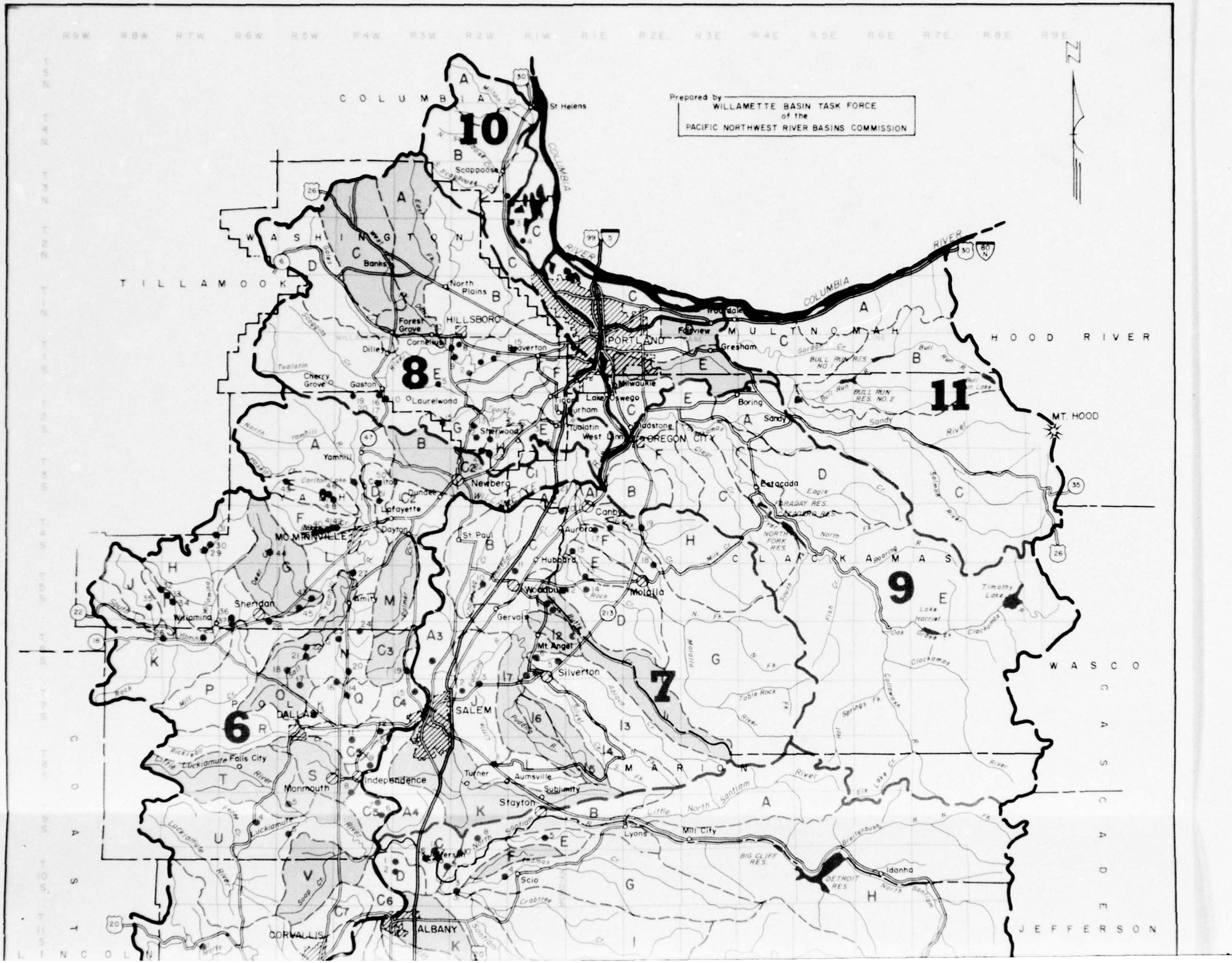
Watershed Name	Watershed Number	Size acres	Flood Plain Benefited	Acreage To Be Irrigated	Channel Improvement miles	Reservoir Storage ac. ft.	Reservoir Surface Area acres	Land Treatment Costs dollars
Camas Swale	1-B	28,800	2,700	1,430	-	22,400	1,070	196,000
Cloverdale	1-D	21,100	740	1,800	4.5	9,000	330	173,000
Subtotal		49,900	3,440	3,230	4.5	31,400	1,400	369,000
Rattlesnake Creek	2-C	7,500	550	800	3.5	-	-	106,900
Ferguson Creek	4-D	16,000	1,050	1,900	4.1	11,700	280	190,000
Bear Creek	4-E	14,790	1,760	1,000	7.5	10,700	240	196,000
Coyote-Spencer	4-F	67,000	2,500	2,000	-	20,500	730	288,000
Subtotal		97,790	5,310	4,900	11.6	42,900	1,250	674,000
San-Thomas	5-F	7,790	720	-	6.0	-	-	41,800
Grand Prairie	5-K	23,100	9,060	3,240	42.5	-	-	984,300
East Muddy Creek	5-O	97,190	-	7,000	-	-	-	1,140,000
Walton Slough	5-P	35,680	2,300	-	10.0	-	-	206,300
Subtotal		163,760	12,080	10,240	58.5	-	-	2,372,400
Chehalem Creek	6-B	36,360	780	1,000	9.0	4,700	210	240,000
Spring Valley Creek	$6\text{-}C_3$	13,160	-	1,700	-	4,800	200	252,000
Deer Creek	6-G	34,750	-	5,200	-	36,400	1,300	583,000
Palmer Creek	6-M	21,380	-	2,000	-	11,550	690	500,000
Salt Creek	6-O	33,310	1,650	4,400	11.0	17,900	820	475,000
Ash Creek	6-S	22,000	1,500	-	11.2	6,100	310	156,000
Little Luckiamute River	6-T	52,640	2,900	4,000	6.0	31,000	670	393,000
Soap Creek	6-V	33,720	610	1,200	3.5	3,600	210	246,800
West Muddy Creek	6-X	79,980	7,250	7,600	31.0	32,200	920	958,000
Subtotal		327,300	14,690	27,100	71.7	148,250	5,330	3,803,800
Butte Creek	$7\text{-}I_1$	54,170	-	5,200	-	21,300	490	700,000
Drift-Pudding	$7\text{-}I_5$	53,290	-	2,300	-	14,200	570	580,000
Mill Creek	7-K	84,070	3,220	-	22.0	29,850	1,350	506,000
Subtotal		191,530	3,220	7,500	22.0	65,350	2,410	1,786,000
East Fork Dairy Creek	8-A	51,940	1,900	2,500	6.0	18,000	550	331,000
West Fork Dairy Creek	8-C	50,190	3,400	3,000	6.0	14,220	290	447,000
Subtotal		102,130	5,300	5,500	12.0	32,220	840	778,000
Fairview Creek	10-D	15,600	140	-	3.0	-	-	45,000
Johnson Creek	10-E	28,800	-	-	-	5,350	450	83,000
Subtotal		44,400	140	-	3.0	5,350	450	128,000
Total Willamette Basin		984,310	44,730	59,270	186.8	325,470	11,680	10,018,100

EARLY ACTION SMALL GROUP ENTERPRISE

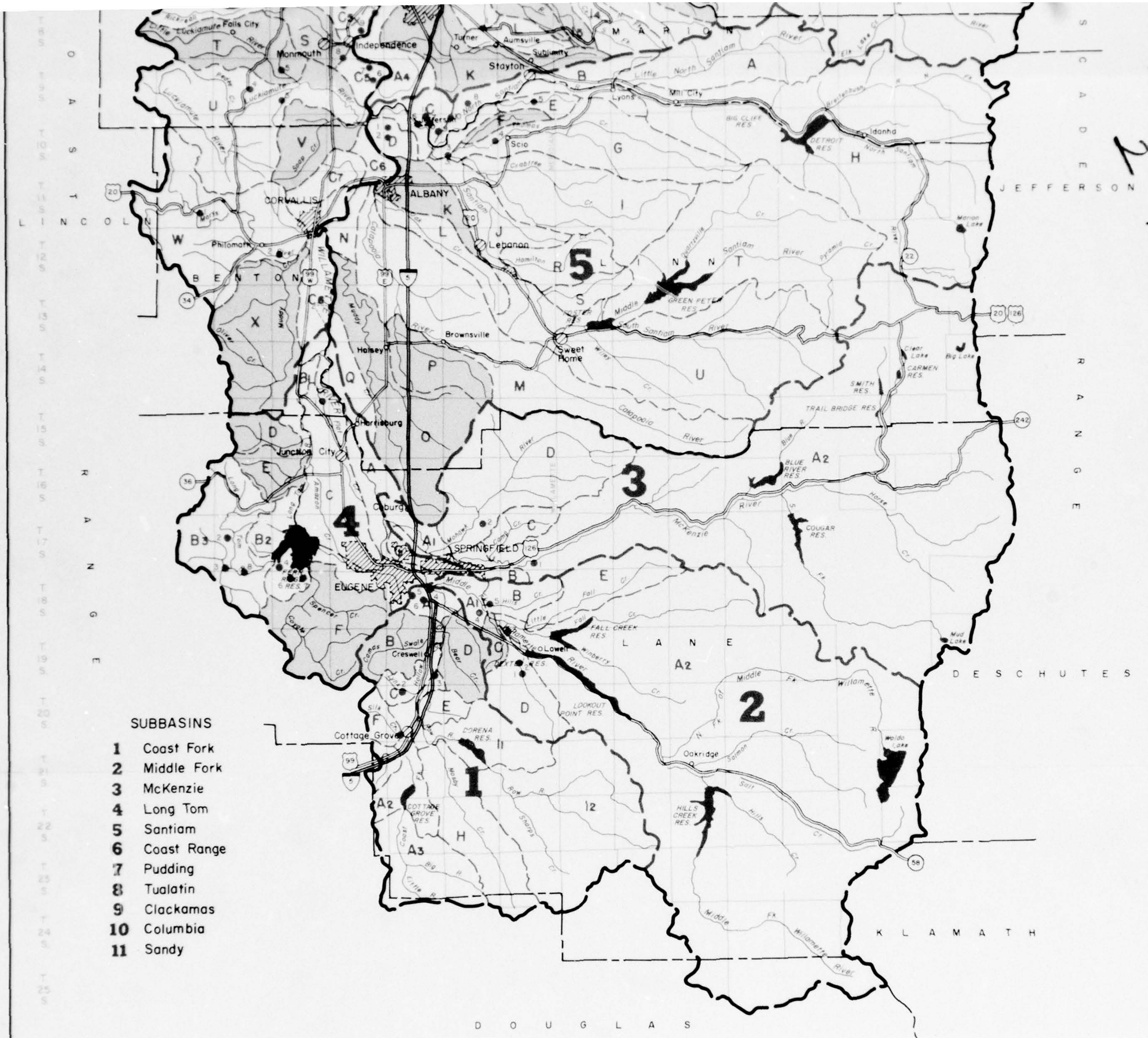
In addition to project development, a second type of critical land measure need is identified by location on Map IV-1. The program is an extension of individual land measures to areas larger than single ownerships. Small group irrigation and drainage project requirements are included as well as spot work for channel clearing and shaping, bank stabilization and dikes. These jobs are too small for consideration under normal watershed programs of the construction agencies. They do fit under the ASCS pooling type agreements or the RC&D program in those counties within the Upper Willamette Resource, Conservation and Development boundaries. A total of 133 specific jobs with an installed cost of $6,985,000 are identified by subbasin in Table IV-3. The jobs are summarized as follows:

Type of Job	Number	Average Size
Streambank, dike stabilization and construction	50	2.3 miles
Drainage improvements	48	610 acres
Irrigation development	25	285 acres

Application of the nearly 7 million dollars of needed land treatment over the next 10-12 years would represent a 105 percent increase in this activity level for the basin.



Prepared by
WILLAMETTE BASIN TASK FORCE
of the
PACIFIC NORTHWEST RIVER BASINS COMMISSION
COLUMBIA
TILLAMOOK
WASHINGTON
MULTNOMAH
HOOD RIVER
CLACKAMAS
MARION
WASCO
CASCADE
JEFFERSON
COAST
LINCOLN
St Helens
Scappoose
Banks
North Plains
HILLSBORO
Forest Grove
Cornelius
Dilley
Beaverton
PORTLAND
Troutdale
Fairview
Gresham
Milwaukie
Lake Oswego
Tigard
Tualatin
West Linn
Gladstone
OREGON CITY
Boring
Sandy
Estacada
Cherry Grove
Gaston
Laurelwood
Sherwood
Yamhill
Carlton
Newberg
Dundee
Lafayette
Dayton
McMINNVILLE
Sheridan
Willamina
Amity
Canby
Aurora
St. Paul
Hubbard
Woodburn
Molalla
Gervais
Mt. Angel
Silverton
SALEM
DALLAS
Falls City
Monmouth
Independence
Turner
Aumsville
Sublimity
Stayton
Lyons
Mill City
Idanha
Jefferson
Scio
CORVALLIS
ALBANY
MT. HOOD
BULL RUN RES. NO 1
BULL RUN RES. NO. 2
FARADAY RES.
NORTH FORK RES.
BIG CLIFF RES.
DETROIT RES.
Timothy Lake
Lake Harriet
COLUMBIA RIVER
10
11
8
9
7
6


SUBBASINS
1 Coast Fork
2 Middle Fork
3 McKenzie
4 Long Tom
5 Santiam
6 Coast Range
7 Pudding
8 Tualatin
9 Clackamas
10 Columbia
11 Sandy
LINCOLN
BENTON
LINN
LANE
MARION
JEFFERSON
DESCHUTES
KLAMATH
DOUGLAS
CORVALLIS
ALBANY
EUGENE
SPRINGFIELD
Lebanon
Sweet Home
Brownsville
Halsey
Harrisburg
Junction City
Coburg
Cottage Grove
Creswell
Oakridge
Lowell
Stayton
Independence
Monmouth
Falls City
Philomath
Scio
Lyons
Mill City
Idanha
Turner
Aumsville
Sublimity
DETROIT RES.
BIG CLIFF RES.
GREEN PETER RES.
FOSTER RES.
BLUE RIVER RES.
COUGAR RES.
FALL CREEK RES.
LOOKOUT POINT RES.
DEXTER RES.
HILLS CREEK RES.
DORENA RES.
COTTAGE GROVE RES.
TRAIL BRIDGE RES.
SMITH RES.
CARMEN RES.
Waldo Lake
Marion Lake
Clear Lake
Big Lake
Mud Lake
WILLAMETTE
McKenzie River
Calapooia River
North Santiam
South Santiam
Middle Fk Willamette River
2

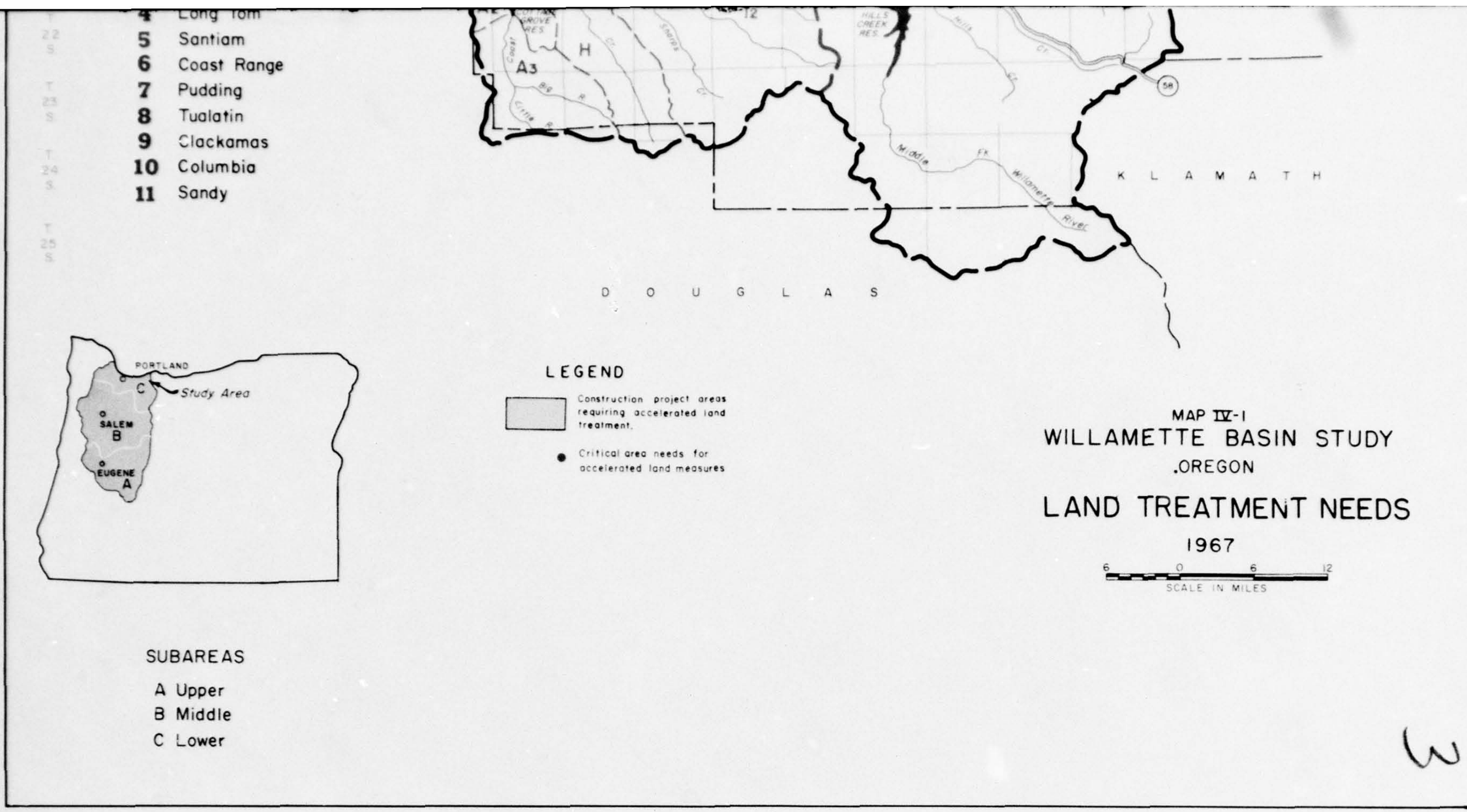


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Table IV-3

Early Action Small Group Enterprise Land Measure Needs

Map Numbers	Type	Unit	Size
Subbasin 1			
6	A	acres	46
4	C	feet	1,200
1	D	feet	2,600
2,5	E-D	feet	28,800
3	F	feet	1,200
Subbasin 2			
5	A	acres	30
2	C	feet	500
1,3	D-C	feet	1,700
4	E-D	feet	31,000
Subbasin 3			
1,2	C	feet	1,350
Subbasin 4			
1,8	A	acres	250
5	B	acres	300
3	E	feet	1,300
2,4,6,7	E-D	feet	18,200
Subbasin 5			
1,2,3,4,5,10	A	acres	4,200
6,7,8	B	acres	900
11	E	feet	10,400
9	E-D	feet	9,700

Map Numbers	Type	Unit	Size
Subbasin 6			
3,5,6,7,8,11,12,13,14,16,17,19,20,25,26,27,29,32,38,46,50	A	acres	9,855
4,18,21,22,23,24,33,35,39,51	B	acres	2,945
1,36,40,43,47	C	feet	11,600
30,48	D	feet	1,750
34,41,44,49,52	E	feet	62,700
2,9,10,15,28,31,37,42,45	F	feet	70,300
Subbasin 7			
1,2,10,11,16,17,18,21	A	acres	9,100
13,14,15	B	acres	800
4,5,6,7,8	C	feet	37,700
12,19	D	feet	98,800
20	D-C	feet	20,800
3,9	E	feet	33,800
Subbasin 8			
1,2,3,4,16	A	acres	5,450
5,6,7,8,9,17,21,23	B	acres	2,150
10,11,12,13,14,15,19	D	feet	111,200
20,22	E	feet	3,600
18	F	feet	5,200
Subbasin 9			
1	A	acres	300
Subbasin 10			
2,3,4	A	acres	385
1	C	feet	4,000

Summary

Type of Job	Number Jobs Required	Units	Size	Total Cost
A - Drainage	48	acres	29,620	$1,647,000
B - Irrigation	25	acres	7,095	2,554,000
C - Streambank Stabilization	15	feet	56,350	127,000
D - Channel Shaping	12	feet	214,350	643,000
D-C - Channel Stabilization and Shaping	3	feet	22,500	118,000
E - Channel Clearing	11	feet	111,800	112,000
E-D - Clearing and Shaping	8	feet	87,700	351,000
F - Dikes	11	feet	76,700	523,000
Total Construction Costs				$6,075,000
Total Installation Services				915,000
Total Cost				$6,985,000

RESEARCH NEEDS

Solutions to land treatment problems should be based on the best technological data available. Additional understanding of the existing problems and the ramifications and effectiveness of the solutions require more study. In the past, progressive application of improved technology based on research made it possible for the basin's agricultural industry to grow in value and importance without adding to its land area. Yields are substantially higher than they were forty years ago. These increases have occurred concurrently with improvement of soil cover conditions and greater soil stability.

Agricultural intensification is projected to continue. This is due to increasing demand for agricultural products, increasing production costs, the loss of agricultural land to other uses, and the desire for economic gain. Continuing research is necessary to open new avenues for further intensification and at the same time to minimize losses of soil and water resources.

No attempt is made to predict specific research need for the basin. This is because of the interrelation of research in a particular sector to many other areas. There are general subject areas, however, where a continuing research will be necessary to maintain agriculture as a major contribution of wealth in the basin. In each of the general areas, some more specific needs have been illustrated. Research should not be limited to these items and emphasis of research will need to change over time.

BASIC SOIL PROBLEMS

In over a half century of farming, crop removal and losses by erosion and leaching have drawn heavily on the native fertility of basin soils. Nutrient removal and the addition of fertilizer and soil amendments have altered the chemical makeup of many soils. There is evidence of the development of toxic materials through increasing soil acidity or other residual effects of heavy fertilization. Only continuing research can provide the answer to the compounding problems created by intensive treatments and use.

There is a need for information concerning the effects of specific cultural practices and cropping sequences on soil organic material and the soil microbial population. Studies are also needed on the effect of micro-organisms on the availability of nutrient elements and transformations in each of the major soil series on both irrigated and nonirrigated cropland. Crop production and crop residue development, soil structure improvement and maintenance and the fertility of the soil are closely and intricately related to soil microbiological phenomena.

Further basic research is needed on the nature and stability of surface soil structure. Soil structure maintenance and improvement is extremely important on many fine textured soils. It profoundly affects soil and water conservation and the agricultural use of land in general. Specifically, there is a need for better diagnostic procedures to characterize benchmark soils as to surface structure under specific systems of use, management and treatment. Alternative conservation cropping systems are needed to determine the effect of tillage, crop combinations, crop residues, and different kinds of fertilizer in accentuating or destroying favorable soil structure. Information is also needed on principles of creating and maintaining optimum conditions of soil structure.

Intensification can only mean heavier use of the soil, increased cultivation and increased traffic with the accompanying adverse effect on water penetration and movement, tilth and root penetration. Research is needed to develop procedures for minimizing compaction in soils for both agricultural and other uses.

EROSION CONTROL

To develop an effective erosion control program, it is necessary to estimate the effectiveness of soil and water management practices. Information is needed on the relative erodibility of different soils under different management practices as a basis for predicting potential sediment production.

Protected waterways are an essential part of soil and water conservation plans for most farms and ranches. These serve as outlets for terraces, diversions and farm ponds and are frequently needed in drainage, irrigation and water-spreading systems. Economic means are needed for controlling overfalls at the ends of waterways in areas when gullying is a problem and for controlling gullies in selected areas where the problem is acute.

Criteria are needed for delineating relative sources of sediment with respect to sheet, channel and gully erosion. Information is needed on sediment production of soils, or groups of soils with similar characteristics, for the assignment of factors expressing relative erodibility and for estimating the rates of erosion and sediment yield under various land uses and treatments.

SOIL MANAGEMENT

The conservation of crop and grass land for sustaining agricultural production is of paramount importance. New techniques are needed to improve the control of erosion; to improve soil structure and tilth, thus providing for the proper development of roots and for good soil, water, air and temperature conditions; and to maintain soil organic matter and fertility. Special problems occur when lower soil layers are exposed by land leveling, land smoothing, erosion, construction or mining.

Cropping Practices

With relatively low-priced chemical nitrogen and new crop and soil management practices available, it is important that crop sequence research be further expanded and intensified. New data are needed to evaluate these new measures, as compared with the use of grasses and legumes, from the standpoint of erosion control, crop production and maintenance of favorable physical conditions.

Investigations should include the position and length of time that grasses and legumes are needed in cropping systems and compared with the use of other cultural and management measures to achieve the desired soil stability. There is also a continuing need for more specific data on suitable alternative cropping and soil management practices on land devoted to intensive production of truck crops. Studies should include systems of management of residues, kinds and amounts of tillage; fertilizer and lime requirements and their effects on soil and water losses; drainage; soil structure; crop yield; and weed, insect and disease control.

Crop Residue Management

Specific data are needed for alternative systems of farming that make maximum use of all available crop residues produced by a wide variety of crops in the Willamette Basin. The ideal system is one in which the residues or mulch are so managed as to give maximum soil protection, maintain soil tilth, and at the same time maintain or increase yields.

Photo IV-2. Row cropland with rows being laid out on the contour, Columbia County. (SCS Photo 0-312-11)

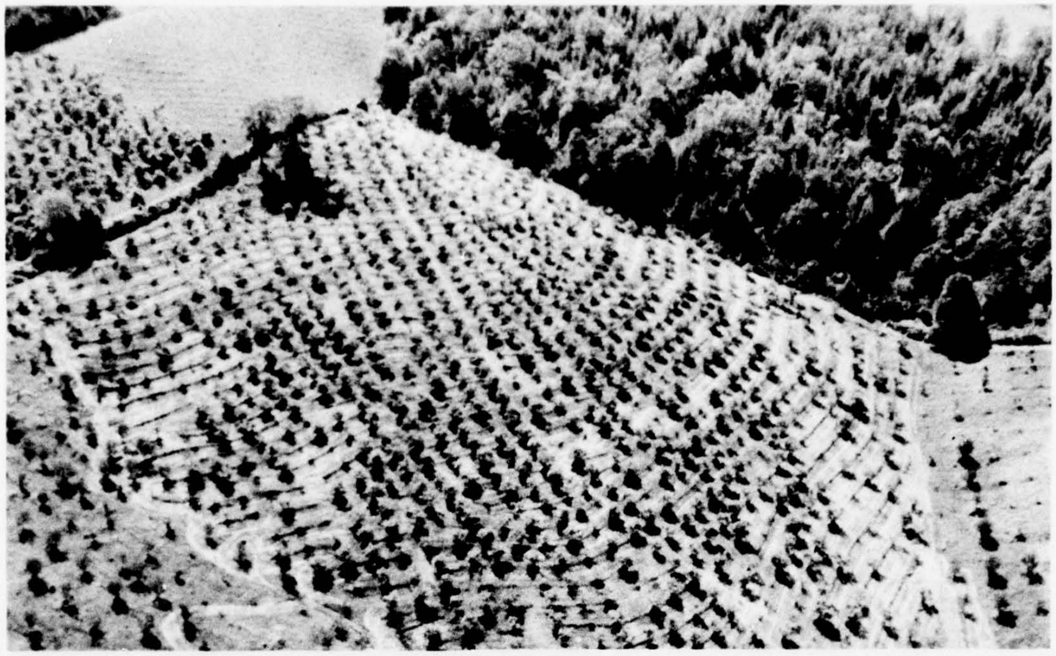


Photo IV-3. Steeper lands are well suited to orchards but must be planted and cultivated on the contour, Polk County.
(SCS Photo 0-1995-4)

Photo IV-4. Dual use of land provides crop income and hunting opportunities. Marion County. (SCS Photo 0-1492-6)

Photo IV-5. Most legume crops cannot be commercially grown without applications of lime every few years. (SCS Photo 0-15857)

The burning of grass seed aftermath growth and residue left following harvest is widespread in the Willamette Valley. This practice is harmful to wildlife, insects and soil organisms and destroys valuable organic matter needed for soil improvement and also contributes to the air pollution problem. However, it is considered necessary for the control of blind seed disease, sod webworm and nematode on grass seed fields.

There is need for some method of control other than burning. Alternative types of crop rotations need to be developed which would make it possible to return the grass seed residue to the land without danger of loss.

WATER MANAGEMENT

Irrigation

The competitive demand for water and a rapidly expanding irrigated acreage create the necessity to increase efficiency in the distribution and application of irrigation water. Acceptable efficiency can only be achieved with continued attention to soil, moisture, plant relationships and improved methods of application. Problems created from runoff and erosion will be aggravated when sizable acreages of sloping hill soils are placed under irrigation. The introduction of new crops and the development of new production techniques will require compensating changes in irrigation and water management practices.

Drainage

Recent drainage research has suggested that new methods of underdrainage, the use of plastic tubing placed at shallow depths, may reduce costs and improve the effectiveness of underdrainage of some wetter soils in the basin. Irrigation and other intensification of land use will also create a demand for drainage on land with only minor drainage restrictions. Additional information is needed to improve design, reduce installation cost and increase operation efficiency.

In an irrigated and humid area such as the Willamette Basin, survey methods and design criteria are needed for predicting the rate of flow from subsurface drains. Such rates should be related to soil characteristics and rates of drawdown. The most urgent need for this type of information is on soils underlain by stratified layers, for drains on irrigated lands and for interceptor drains.

Information on hydraulics of flow through ground and into tile under field conditions should be related to methods for designing subsurface drainage systems. Research should determine effects of deep-rooted crops, soil amendments and conservation rotations in influencing permeability of soils and effectiveness of drains. Methods of determining the effects of sand-gravel, fiberglass and other filter materials for drain tile are also needed.

Photo IV-6. Group drainage improvements enable local farmers to adequately drain their individual farms. (SCS Photo B-731-3)

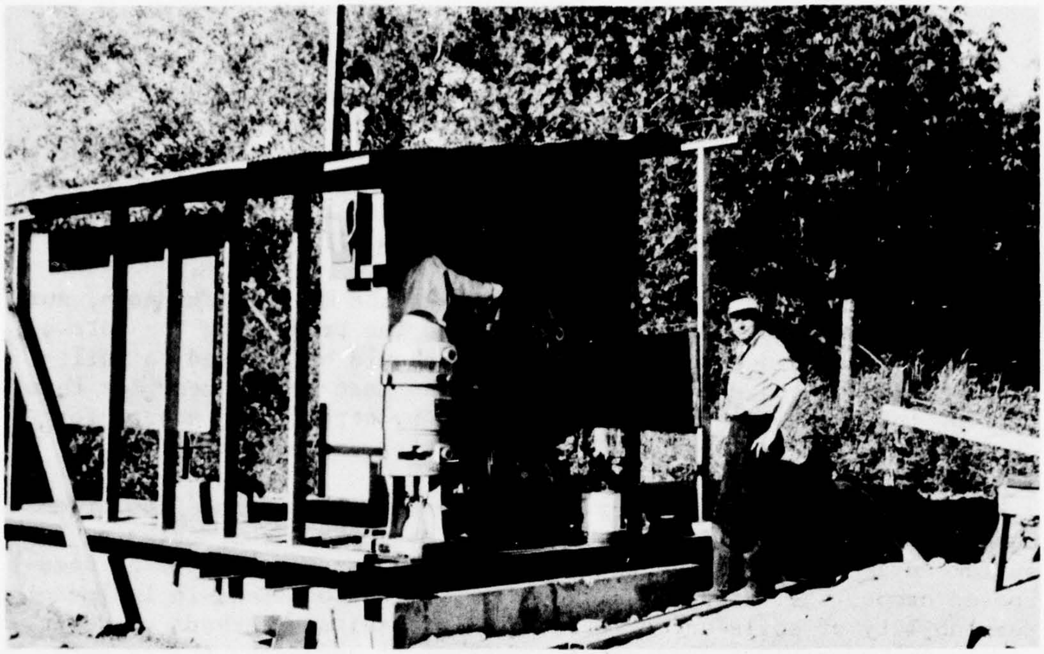


Photo IV-7. Kingston irrigation group pumping plant which irrigates several hundred acres. (SCS Photo 0-1046-8)

Photo IV-8. Conservation education beginning in the elementary grades will help insure future understanding of conservation principles. (SCS Photo 0-1242-3)

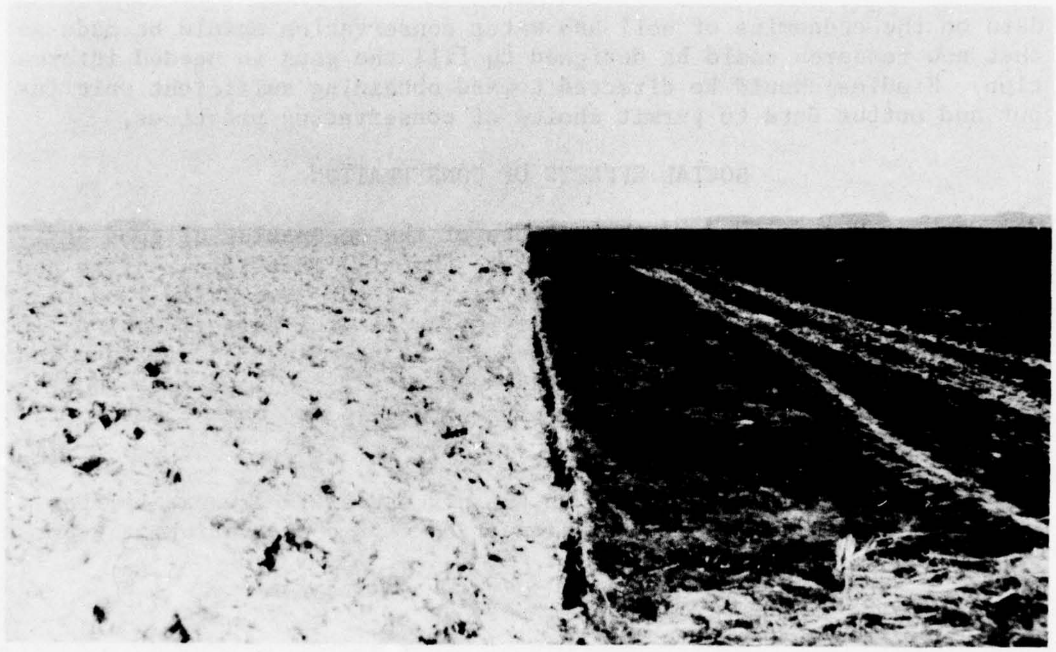


Photo IV-9. Crop residue utilization versus English ryegrass burning, Linn County. (SCS Photo 0-851-12)

Research should include development of procedures for determining need for subsurface drains and effectiveness of drains in control of ground-water tables. Research needed is on improved procedures for making and analyzing substratum surveys and other investigations to determine the size, depth and pattern of drains.

Research is needed on effects of excess water on grain, pasture, truck, forage and other principal crops. Information is needed on the length and duration of waterlogging and flooding tolerated as a basis for drainage design.

To date little attention has been given to research on the drainage of lands for non-agricultural uses. Suburban residential and industrial development have created unanswered problems, particularly in connection with waste disposal. Future development will intensify the problem.

ECONOMIC EFFECTS OF CONSERVATION

Specific research needs in economics are mainly concerned with estimating costs and returns of soil and water conservation measures. Such data are needed for formulating and evaluating alternative plans for individual farms and ranches. The economic impact on whole communities from widespread application of conservation measures on farms and ranches should be evaluated. A national inventory of presently available data on the economics of soil and water conservation should be made so that new research could be designed to fill the gaps in needed information. Studies should be directed toward obtaining sufficient unit input and output data to permit choice of conservation practices.

SOCIAL EFFECTS OF CONSERVATION

Research is needed on the effects of the occupation of good agricultural land by non-agricultural uses, that is, industrial, urban and rurban development, airports, highways, etc., thus resulting in permanent loss of productive agricultural resources (tax base reduction, in the case of highways). There is need for a determination of sound and orderly long-time procedures for the best use of the land resources, such as zoning, land capability approach to allocate most Class I, II, and III land to agriculture, etc.

Information is also needed on the effects of landownership, tenancy, and tenure of leases on the adoption of a conservation program.

forestry

Forest land uses in Willamette Basin will affect the water resource in the future. These uses will temporarily influence the quantity and timing of runoff until new plant growth restores the original stable soil and water balance. The main impact after land use until that land receives new cover is on the quality of water yield. Thus, the emphasis in this section is on water quality.

Water flows and the use of the forest lands are tied closely together and will, therefore, be emphasized in future forestry operations. Part III pointed out that the land base and water base are relatively fixed but that the dynamic demands on our forests for increased raw materials, goods and services create a serious conflict in water and land values. Thus, there is a basinwide need for increasing the level of watershed management in the future.

The needs for increased activity in watershed management are apparent, but some areas will need more or earlier attention than others. A proper program emphasis can be developed by identifying key water and land values, coordinating the two, and estimating their trends. Data in this part point out the location, quantity, and cost of numerous restoration opportunities where gullies, sheet erosion, channel debris, and excessive bank wasting exist. Fortunately, these specific problem areas and major water quality problems caused by poor forest land management are at an extremely low incidence basinwide.

Photo IV-10. Studies are being made of the economic feasibility of removing timber from steep slopes by balloon logging with very little disturbance to the soil and water resources. (Pacific N. W. Research and Exp. Station Photo)

AUTHORIZATIONS AND JUSTIFICATIONS

The forest watershed rehabilitation needs identified herein are in response to the second planning objective set forth in Senate Document 97 which set the policies and standards for comprehensive basin studies. This objective is to preserve the natural resources of the area by proper stewardship through (1) protection and rehabilitation of resources to insure availability for their best use when needed; (2) to maintain open space, green space and wild areas of rivers, lakes and mountains; and (3) to preserve areas of unique natural beauty, historical and scientific interest for the inspiration, education and enjoyment of the people.

The proposed forest land program will help provide at least three of the primary benefits set out in Senate Document 97. It will result in water quality control benefits by reducing water sedimentation, siltation and stream temperatures. It will reduce flood damage by removing forest debris from stream channels. It will result in land stabilization benefits by reducing soil erosion through protection of stream banks and establishing vegetative cover on hillsides and forest areas disturbed by resource use.

M E T H O D O L O G Y

Some system was necessary to identify alternatives. Public and private landowners were invited to meetings where they could identify problems, restoration opportunities, and suggest future watershed management practices in forest land use, development and management. State and Federal agencies represented in the study entered their data and views. The State farm forester contributed for small private forest landowners. Industrial forest owners and small private owners both had opportunity to contribute in local "County Conservation Needs Inventory" meetings held especially for this purpose in May and June of 1967.

Forest lands in the basin are in the control of many owners and agencies. The major ownership breakdown is approximately 1/2 public forests, 1/4 small private forests, and 1/4 industrial forests. Since the technical criteria are inprecise and goals vary by subbasin, each major ownership group represents a complexity inside a complexity. The opportunities to use socio-economic, legal, technical and educational alternatives in pursuit of watershed management objectives will vary greatly among the above groups.

Program emphasis depends largely on the available knowledge of general watershed problems. Where there is little understood about a problem, research should probably be the emphasis. Once causal relationships between use, benefits and ownerships are more clearly defined institutional controls and practices should be the dominant considerations. However, once a specific emergency problem has been encountered, restoration measures are usually needed to protect high values. Very broadly then, program and project alternatives are shown in Table IV-4. These are the framework considerations for each time period, and all will be used to a degree--some more than others--depending on specific needs and water developments in each subbasin.

Table IV-4
Basic Alternatives in Watershed Management

Alternatives	Forest Uses and Occurrences - Water Yield Relationships
Research	unknown
inventories	
soils	
vegetation	
climate	
water uses	
Institutional Control	unclear or undefined ownership responsibility
legislation	
education	
social	
economic	

Table IV-4 (cont'd)

Alternatives	Forest Uses and Occurrences - Water Yield Relationships
Practices	known or theorized
surveys and plans	
use design	
development of use	
use program	
use control	
education	
Restoration Measures	specialized solution needed
damage repair	
specific improvement	

An idealized schedule which suggests the broad use of these alternatives underlies the recommendation emphasis in Part IV (Table IV-5).

Table IV-5
Suggested Levels of Basic Watershed Management Activities

Basic Programs and Project Alternatives	Time Periods: Presently Occurring	1970-1980	1980-2000	2000-2020
Research	Low	High	Medium	Medium
Institutional Control	Low	Medium	High	Low
Practices	Medium	Medium	Medium	High
Restoration	Low	Medium	Low	Low

B A S I N W I D E   A L T E R N A T I V E S

Resource managers must face the fact that there is only a limited amount of land and water in the basin to fill the needs of a rapidly increasing population. Careless and abusive use of these resources now will leave us with impaired resources to meet accelerating needs in the future.

Rapidly expanding multiple use demands on forest watersheds clearly indicate that the public wants to both use and protect this important resource. On this basis, the alternative of decreasing existing watershed protection programs is not acceptable. Unless watershed management programs are strengthened by the various forest management ownerships, the public may soon demand such improvement.

Consideration of program alternatives is the first step in plan formulation. Often alternatives stand on their own. Political, social and economic considerations guide the proposals made. Inherent in this study is the awareness of the growing power of public opinion as it affects use of private resources, especially the large ownerships of forest land.

LAND USE CONTROLS

The Oregon State Sanitary Authority has set water quality criteria for Willamette River Basin waters. Measures for the enforcement of these water quality standards or their achievement by other means has not been fully implemented. Accelerating demands for high quality water emphasizes the need for the implementation of a number of external land use controls--zoning, public cost sharing, legal restraints, scenic or other limited land use easements, education and research. As is the case with pollution control, implementation may be slow. Land use zoning has not been readily accepted in rural areas, and legal restraints on land abuse are difficult to enforce. More effective state legislation is needed to strengthen the enforcement powers of the State Sanitary Authority in achieving the adopted high water quality standards. Along with this is the need for public education as to the need for high quality water and the cost to the public from water contamination. Research in the field of watershed management must also be given high priority.

Governmental designation of "Protection Forests" on private lands to insure scenic beauty, prevent erosion and protect water quality requires adequate compensation to the owner from losses resulting from the restricted use under this designation. The benefiting public would bear such costs through increased taxes.

Land Use Zoning

Forest lands with high-hazard, unstable soils should be identified and either designated as a non-cutting area or logged by special means such as balloon logging. Ideally, such lands should be managed extensively for recreation or wildlife uses. Some method to compensate private forest landowners will be needed to make this alternative practical.

Public Cost Sharing

Payments for specific practices need to be devised to reimburse forest landowners for the additional costs sustained to protect water quality for the general public. Rarely does the forest landowner benefit directly from the water coming off his land. Subsidies, direct payments, or tax credits are possible alternatives for improving water quality coming from these lands. It may be necessary for the county or the state to acquire scenic easements, open space easements, or other restrictive land use controls on private lands in order to protect the public interest.

Management Cooperation

Many of the problems of management of small private forests could be relieved through formation of an association of small owners which could employ a forester to provide forest management and timber marketing advice.

Legal Restraints

Monetary penalties could be assessed for forest land abuse resulting in erosion or stream siltation. This alternative may be difficult to achieve.

Education and Technical Assistance

This alternative would probably be of most benefit to the smaller forest landowners. Educational activities are practiced across the board by all conservation groups, but the State of Oregon Extension Service can best reach the small forest owner with its updated technical publication, tours and demonstration activities. Recreation, watershed coordination and urban forestry are becoming a much more significant slice out of the total forestry use activity. Therefore, agencies which give on-the-ground technical assistance (i.e., Soil Conservation Service, Extension Service, Farm Forestry Program) to small private forest owners must take a larger and accelerated role in resource development.

WATERSHED MANAGEMENT

Forest Fire Prevention, Presuppression and Control

There will be a continuing need for a forest fire control program. The many large forest fires that erupted in the summer of 1967 show the need for an improved fire control program; it is necessary to get more men to the fire sooner, before it gets out of control. The millions of dollars fire damage in 1967 alone would have paid for a stronger fire detection and control force. One practical alternative is to continue the present program, risking additional large fire losses. More funds for the fire prevention program in the basin would give watershed benefits through reduced fire losses.

The rapidly accelerating recreation use of the forest watershed also alerts management to the need for a more active fire prevention and presuppression program.

Timber Harvest

Land use decisions are made on the basis of the major value of the forest cover on the watershed. Use of forest cover for recreation, aesthetics, or watershed protection may have a higher value than use for production of wood fiber; however, the basin's economy is so dependent on the forest industry that there can be no quick shifts in forest land use without causing serious economic impact. This must be recognized in watershed planning.

Also, there is need for water quality criteria by specific location to guide timber harvest procedures for protection of the watershed. Such guidance is needed to justify additional road building, slash disposal, and land rehabilitation costs. Also, recognition of the value of water coming from forest land is urgently needed; a monetary yardstick for water quality would provide this.

The alternatives in timber harvest are to either ignore impact of the harevest operation on water quality or to sustain additional expense entailed in protection of water quality.

Recreation Use

Recreation use of forest watersheds may require provision for access, prevention of biological water contamination, and provision for facilities. Public opinion has influenced industrial forest managers to permit use of private lands without charge. This is an expense to the companies for road and equipment damage. Liability and monetary considerations minimize efforts to provide facilities to prevent water contamination. The forest manager must decide what level of recreation use can be permitted on the watershed.

Water

Management decisions must be made as to the need for control of water quality and quantity, manipulating the timing of water runoff, intensity of insect and disease control for site protection, as well as on-site use of water for irrigation of timber crops, recreation and wildlife.

Research

More research is needed as a basis for measuring monetary loss from impaired water quality and the physical impact of poor forest watershed management. Decisions must be made whether to accelerate research to give the needed data for a sounder watershed management program or to continue present "trial and error" approaches.

An accelerated development by the Pacific Northwest Range and Experiment Station of watershed research projects and an early start of a fish and wildlife habitat project would require an additional $160,000 annually starting in 1971. This would furnish about four additional scientist man years effort beyond the present level of $80,000 now. In addition, about $3 million is the capital required to construct the Forestry Sciences Laboratory1/ in Corvallis, Oregon. About $400,000 of this amount could be reasonably allocated to watershed management research activities in the basin and on the H. J. Andrews Experimental Forest at Blue River, Oregon.

Surveys and Plans

The need for identification and inventory of basic resources is a universal early step in conservation management. As pointed out in other sections this program is started or in some cases nearly completed for many forest lands in the basin.

The Forest Service has completed a reconnaissance inventory of soils on National Forest areas. Also, Standard National Cooperative Surveys have been completed on the Sandy Subbasin and on about 1/2 of the Clackamas Subbasin. The recommended program for the early action period 1971-1980 is to supplement the basic reconnaissance planning survey with sufficient soil management services for specific management problems on a project by project basis. This requires an acceleration of the present 1/2 soil scientist man year/year level to a one man year/year level in 1971-75, and to a 2 1/2 man year/year level in 1976-80. These soil management services, aside from their primary consulting nature to Forest Service resource management activities on a project basis will provide two other benefits: (1) mapping in certain areas will be refined and additional management interpretations will be added and (2) detailed soil surveys will be completed on areas where intensive management requires. The annual Forest Service program for National Forest lands in the early action period is:

Now	$10,000 per year
Early action period	
1971-75	$20,000 per year
1976-80	$50,000 per year

The Bureau of Land Management is presently completing an intensive soil survey in cooperation with the Soil Conservation Service of all its administered lands in subbasins 1, 2, 3, 4, 5 and 6 that are part of the Upper Willamette Resource Conservation and Development Project areas; BLM recommends completion of comprehensive soil surveys for all of its remaining lands outside of the project area (about 178,000 acres) for a cost of about $75,000 during the early action period 1971-1975.

The Soil Conservation Service with some contribution by private industry and local governments is surveying the soil on private forest

1/ *National Program of Research for Agriculture, October 1966.*

lands in the Upper Willamette Resource Conservation and Development Project area. The SCS recommends a 1/3 increase (about $35,000/year) in their manpower for the period 1971-80 in order to complete cooperative intensive soil surveys of forest lands in Columbia, Clackamas and Polk counties.

The need at the field level for adequate forest hydrology is widely accepted. Some private forest industries have already recognized this need and are practicing professional hydrologic practices in irrigation of seed orchards and Christmas tree plantations. As wood fiber crop rotations shorten, management intensity increases, and direct economic benefits become increasingly evident, progressive forest industries will accelerate their effects and expenditures in the hydrology field for this phase of forestry.

The Bureau of Land Management administered lands have no forest hydrology program at present. They are recommending a start of one man year/year ($20,000) at the state level for 1970-75, and an increase to two man years/year ($40,000) in the period 1976-80.

The Oregon State Department of Forestry has recommended an increase of the farm forestry program from a present level of five man years/year to eight man years/year in 1970-75 and to eleven man years/year in 1976-80. This increase is due in large part to the recognition of soil and water problems in present forest management and the predicted acceleration of small watershed projects involving state and private lands in the basin.

The Forest Service present hydrology program of two man years/year ($25,000) needs acceleration to three man years/year in 1970-75 ($40,000) and five man years/year ($65,000) in 1976-80. The principal emphasis in this acceleration is the need to design prescriptive practices into all land use operations in order to prevent or curtail severe water quality problems.

PROJECT IMPACTS

Certain public and private activites on the forest watershed have major impacts on the land and water resources, over which the forest owner or manager has little control. Some of these are the construction of reservoirs, electric transmission lines and public roads.

Reservoir construction on forest lands has a two-phase impact on the watershed. First, it changes the resource use--from timber production, wildlife habitat, anadromous fish spawning area and stream fishing recreation area to other uses. Second, it has an impact on the water itself due to the disturbance of soil associated with construction of the reservoir and access roads. Reservoir construction also forces the existing road systems within the reservoir area to be relocated on the generally unstable hillsides above.

Electric transmission line construction requires clearing the timber from rights of way through forest lands. This exposes the soil to rainfall impact and erosion. The requirement for long, straight rights-of-way rules out the possibility of following topographic contours, resulting in uphill and downhill construction. Temporary access roads for construction expose even more of the area to washing and gullying. Once built, these roads are used indiscriminately by hunters, even in wet weather, resulting in further damage.

Highways and roads take more and more acreage out of forest area every year. In achieving optimum grade levels at lowest construction cost, these roads are often built alongside streams and rivers. In some cases, the stream must be moved and an artificial channel established. The result of straightening the channel is to increase the stream gradient, often making the stream a mere sluiceway difficult for fish to navigate. In construction, large amounts of soil are allowed to enter the stream with harmful effects on downstream fish spawning areas. Also, streamside vegetation is removed, allowing the sun and radiation from the open areas to increase water temperatures, which may become harmful to fish life. The unprotected cutbanks and fills are exposed to rainfall washing and erosion, contributing to the water quality problem.

All these project impacts must be considered, then in developing programs for each of the subbasins within the Willamette Basin.

RECOMMENDATIONS

From a basinwide standpoint, the following watershed management measures are recommended:

1. Accomplish restoration measures in tributaries which have a high demand for water quality for recreation, fish and municipal water supply. The subbasins most in need are: 3 - McKenzie, 5 - Santiam and 11 - Sandy.

2. Complete soil inventories in all subbasins which are uncompleted. First priorities are Subbasins 1 - Coast Fork, 3 - McKenzie, 5 - Santiam, and 6 - Coast Range.

3. Accelerate research programs to identify the causal relationships between forest land uses and water yields.

4. Study need for tax incentives, legislation and/or zoning in order for private industry to accomplish adequate watershed management.

5. Develop access roads on public lands in undeveloped tributaries prior to public sales and logging. Subbasin priorities for this work are 5 - Santiam, 9 - Clackamas and 11 - Sandy.

6. Continue technical assistance programs to all small private forest landowners.

7. Intensify forestry education programs in all subbasins for litter control, vandalism, fire, insect and disease, all of which have a direct impact on water quality.

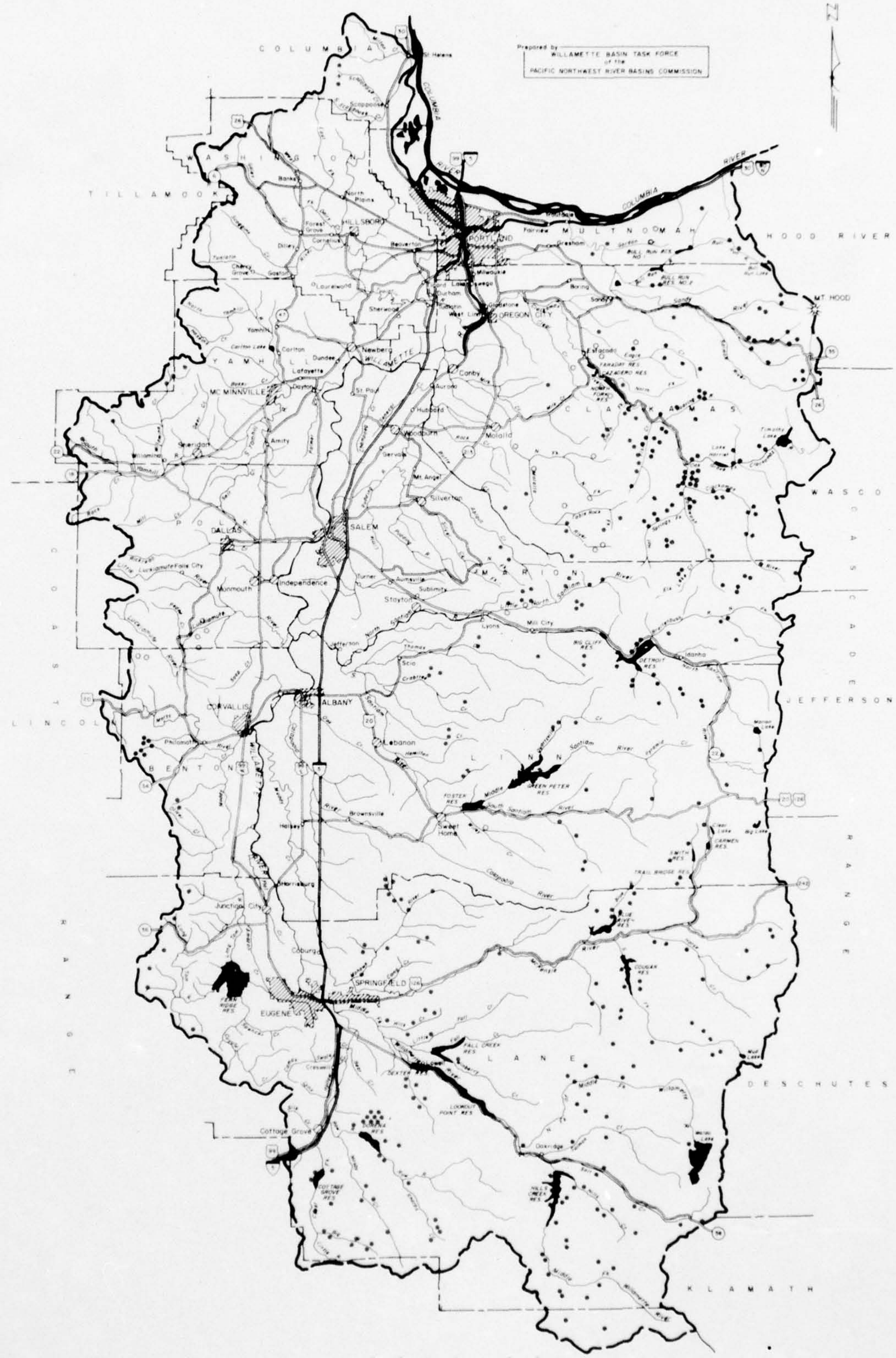
8. Maintain and improve inspection and control of watershed management practices at construction activities involving roads, water storage developments, power transmission corridors, water diversions and urban sprawl developments.

Specific restoration opportunities for the Willamette Basin are shown on Map IV-2 and summarized in Table IV-6. The priority of accomplishment is dependent on the development of land use programs and specific water development proposals by landowners in each subbasin. Specific practices, locations and ownership information are presented in the subbasin analyses in the following section. Original data showing restoration opportunities on large industrial holdings are incomplete due to lack of participation by private industrial representatives in the study. It is estimated that restoration opportunities and costs would be similar to those shown for lands administered by the Bureau of Land Management.

The alternatives include only watershed restoration opportunities that were known to exist in 1968. The stable condition of the watersheds relative to many watersheds in the Western United States, is due mostly to predominantly stable soils, prompt reestablishment of native vegetation and acceptable watershed management practices by many forest landowners as a standard practice in logging and road building and other forest uses.

Table IV-6
Soil and Water Restoration Opportunities
Willamette Basin, 1968

Types of Restoration	Units of Work and Costs by Ownerships					
	Public Domain & O&C Lands	National Forests	Private Woodlands	Industrial Forests	County, State, Local & Other	Total
Gully Stabilization						
miles	42.3	81.3	2.3	5.1	-	131.0
costs ($1,000)	47.8	81.6	2.3	5.1	-	136.8
Sheet Erosion Control						
acres	1,080	4,060	475	71	50	5,736
costs ($1,000)	182.0	203.2	27.1	3.6	3.0	418.9
Channel Debris Cleanup						
miles	31.2	175.2	5.4	.5	.8	213.1
costs ($1,000)	57.7	877.0	26.5	2.5	4.0	967.7
Channel Revetment						
miles	17.2	34.7	2.4	1.0	.7	56.2
costs ($1,000)	39.8	815.0	168.0	70.0	49.0	1,141.8
Road and Trail Restoration						
miles	70.9	90.0	58.0	1.5	.3	220.7
costs ($1,000)	100.5	90.6	44.5	2.0	.5	238.1
Total Costs ($1,000)	427.8	2,067.4	268.4	83.2	56.5	2,903.3



LEGEND

- • National Forests
- ∗ O and C and Public Domain
- ○ Private, State and Local

MAP IV-2
WILLAMETTE BASIN STUDY
OREGON

IDENTIFIED LOCATIONS OF SOIL AND WATER RESTORATION OPPORTUNITIES

1967

SCALE IN MILES

WBTF-O-1064-L

SUBBASIN ANALYSES

This section presents specific alternatives, by subbasin, for watershed management. In many cases, there are diverse alternatives among the tributaries within a subbasin. Since watershed management activity is complementary to other uses and must be responsive to other land and water use proposals, these analyses should be interpreted in terms of the plan formulation proposals.

SUBBASIN 1--COAST FORK

Conclusions and Recommendations

Remedial and protective measures are listed in the order of their priority:

1. Mosby Creek is a valuable anadromous fish spawning area and has recreation values. Watershed protection measures will be needed in "roading" and logging the large area of old-growth timber in the upper watershed. Special care will be needed to protect spawning areas from direct disturbance and siltation.

2. Row River has high recreation values. Also, there is a need to protect Dorena Reservoir. The upper watershed drains a large area of unstable soil. Special care and watershed protection measures will be needed in logging the large area of old-growth timber remaining.

3. Coast Fork Willamette River has high recreation value. There is also need to protect Cottage Grove Reservoir. Removal of log jams is needed to permit fish passage and reduce downstream flood damages.

4. Camas Swale Creek has recreation values. It needs watershed protective measures in "roading" and logging remaining old-growth timber. Protective measures are also needed on some logging roads and skid trails.

5. Gettings Creek has recreation value. Rehabilitation measures are needed on the upper watershed to reduce downstream sediment and debris deposition. Channel clearing is also needed.

6. Martin Creek has recreation value. Rehabilitation measures are needed to stop erosion on some logging roads and skid trails.

Opportunities for soil and water restoration in the Coast Fork Subbasin are included in Table IV-9 as a part of the Upper Subarea. Units of work costs for each type of restoration needed are presented.

Municipal water for Cottage Grove is taken from Laying Creek. Sediment caused by logging on the watershed occasionally plugs municipal treatment facilities.

SUBBASIN 2--MIDDLE FORK

Conclusions and Recommendations

Watershed management activities needed in Subbasin 2 are:

1. Middle Fork Willamette River is used extensively for recreation, fisheries and municipal water supply. Quality is generally adequate except for montmorillonite clays which are settling out of the Hill Creek Reservoir inflow. Watershed management programs should be formulated to deal with this problem.

2. Small private forests in the lower portions of the subbasin appear to be in generally good condition. Programs of technical assistance, including watershed management practices, should be continued at their present level.

3. An area in wilderness classification in the upper portion of the subbasin should present only limited problems to the soil and water resources. There is some risk of biological contamination. A wilderness recreation plan should provide for specific prevention measures.

4. Violent storms, unstable soils and the steepness of terrain occasionally cause serious flooding and silting. This is especially true in areas of recent construction developments. Restoration should be carried out in those streams presenting the most immediate hazard to the water quality--Salmon Creek and Middle Fork of the Willamette should receive the first attention.

5. Forest lands in private ownership should be soil-mapped to assist private landowners in watershed protection. Most of the National Forest lands have been mapped.

6. In areas of mixed ownership, cooperative projects are needed to protect watershed values.

Watershed impacts are shown in Table IV-7. Restoration opportunities and costs are included in Table IV-9 as a part of the Upper Subarea.

Until the year 2000 the continued harvest of old-growth timber with its corresponding access development will present the greatest hazard to soil and water management. After 2000 most of the timber stands should be under management with a majority of the main access roads in place.

Table IV-7

Watershed Impacts on Tributary Drainages, Middle Fork Subbasin

Tributary Area	Impoundments: Existing	Impoundments: Potential	Unstable Soil Areas 1/	Status of Access Development 4/	Special Water Requirements 2/	Other Factors 3/
Pleasant Hill	None		3	75-100	1,2,3	
Fall Creek	Fall Cr.		2	50-75	1,2,4	2
Winberry Cr.	Fall Cr.		2	25-50	1,2,3,4	2
North Fork Middle Fork	None	Upper N. Fk. Moolack Mt.	2	25-50	1,2	1,2
Salmon River	None		3	50-75	1,2,5,6	2
Minor trib. Middle Fork	Lookout Dexter		1	50-75	1,2,4	2
Salt Creek	None		2	0-25	1,2	1,2
Middle Fork Willamette R.	Hills Cr.	Campers Flat Mile 56	1	25-50	1,2,4	1,2
Hills Creek	None		3	75-100	1,2,3	
Rattlesnake Cr.	None		3	75-100	1,2	
Lost Creek	None		3	75-100	1,2,3	
Little Fall Creek	None		2	75-100	1,2,3	2

1/ *(1) many, (2) medium, (3) few*

2/ *(1) recreation, (2) resident fish, (3) anadromous fish, (4) impoundments, (5) municipal, (6) fish hatcheries*

3/ *(1) wilderness areas present, (2) large areas of old-growth timber*

4/ *Figures refer to percent of transportation, access completed.*

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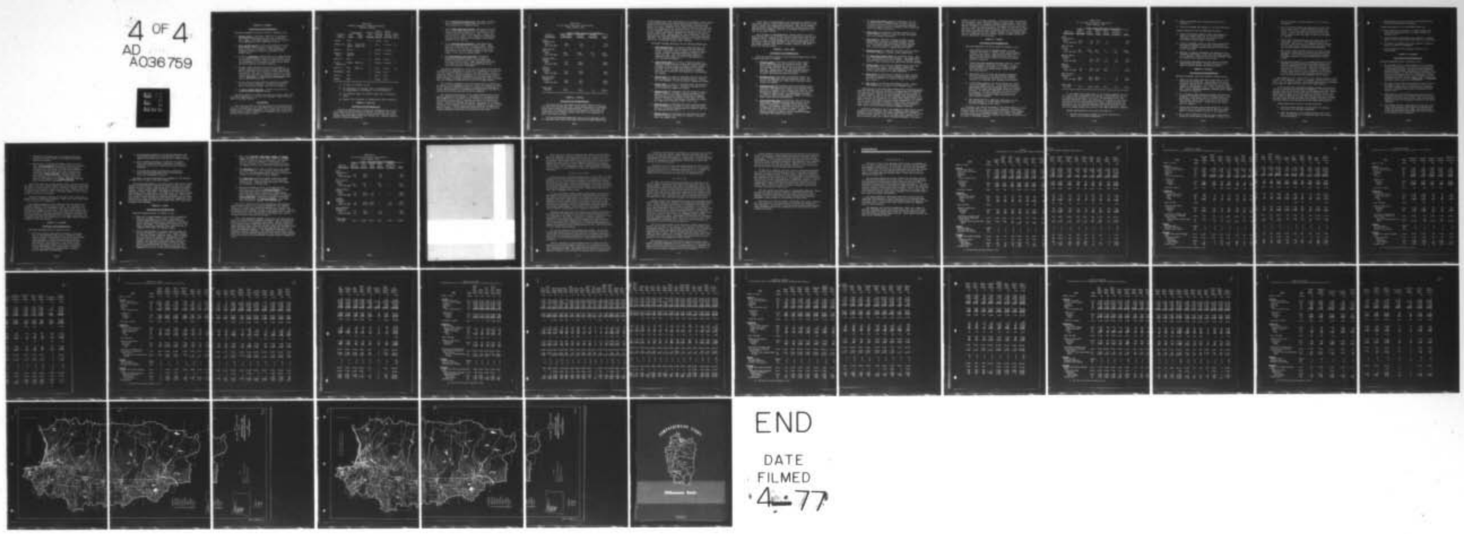

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SUBBASIN 3--McKENZIE

Conclusions and Recommendations

Watershed management activities needed in Subbasin 3 are:

1. McKenzie River is nationally known for its recreation and fishery resources and is the source of Eugene's water supply. Watershed management should be continued or strengthened to insure high quality water.

2. Small private forests in the lower portions of the subbasin appear to be in generally good condition. Programs of technical assistance, including watershed management practices, should be continued at their present level.

3. An area in wilderness classification in the upper portion of the subbasin should present only minor problems to the soil and water resources. There is some risk of biological contamination. A wilderness recreation plan should provide for specific prevention measures.

4. Violent storms, unstable soils and the steepness of terrain occasionally cause serious flooding and silting. This is especially true in areas of recent construction developments. Restoration should be carried out in those streams presenting the most immediate hazard to the water quality--Blue River and South Fork of the McKenzie should receive the first attention.

5. Forest lands in private ownership should be soil-mapped to assist private landowners in watershed protection. Most of the National Forest lands have been mapped.

6. In areas of mixed ownership, cooperative projects are needed to protect watershed values.

Watershed impacts on tributary drainages are shown in Table IV-8. Restoration opportunities and costs are included in Table IV-9 as a part of the Upper Subarea.

Alternatives

Until the year 2000, the continued harvest of old-growth timber with its corresponding access development will present the greatest hazard to soil and water management. After 2000, most of the timber stands should be under sustained yield management with a majority of the main access roads in place.

Table IV-8
Watershed Impacts on Tributary Drainages, McKenzie Subbasin

Tributary Area	Impoundments Existing	Impoundments Potential	Unstable Soil Areas 1/	Status of Access Development 4/	Special Water Requirements 2/	Other Factors 3/
Coburg	None		3	75-100	1,2,3	
McKenzie R.	Smith Carmen	Foley Ridge Twisty Cr.	3	0-25	1,2,3,4,5	1,2
Blue R.	Blue R.		1	75-100	1,2,3,4,5	2
McKenzie, Minor	Leaburg Gate Cr.		3	25-50	1,2,3,4,5	
Quartz Cr.	None		3	25-50	1,2,3,5	2
So. Fk. McKenzie R.	Cougar	Rebel Cr.	1	75-100	1,2,3,4,5	2
Horse Cr.	None	Horse Cr.	2	0-25	1,2,3,5	1,2
Willakenzie	None		2	75-100	1,2,3	
Camp Cr.	None		3	50-75	1,2,3	
Mohawk	None		3	75-100	1,2,3	

1/ *(1) many, (2) medium, (3) few*

2/ *(1) recreation, (2) resident fish, (3) anadromous fish, (4) impoundments, (5) municipal, (6) fish hatcheries*

3/ *(1) wilderness area, (2) contains large area of old-growth timber*

4/ *Figures refer to percent of transportation system completed.*

SUBBASIN 4--LONG TOM

Conclusions and Recommendations

Protective measures will be needed over widespread areas to solve the problems of fire protection and suburban encroachment into forest zones. Fire protection continues to be an essential need and its importance mounts as timber stands reach sawlog size. Measures needed in specific tributary drainages are:

1. In the Harrisburg watershed area every effort should be made to preserve the natural state and beauty of the strip bordering the Willamette River.

2. In the Middle Long Tom watershed, some areas on the west shore of Fern Ridge Reservoir can be enhanced by landscaping and planting shade trees. Also, there is very little erosion of forest lands now, but if proper precautions are not taken in the clearing and roadbuilding associated with subdivision development, some sediment movement can be expected.

3. In the Ferguson Creek watershed, a few ranchers are striving to make pasture out of forest lands. These areas are in greatest need of rehabilitation. Erosion from roads is at a minimum now because of little logging activity, but when logging resumes on the steep slopes, it will pose an erosion hazard.

4. The Coyote-Spencer Creek watershed is currently threatened by suburban sprawl. Its proximity to Eugene and good access roads have encouraged people to settle on forest land. Proper precautions will need to be taken in the clearing and roadbuilding associated with subdivision development.

The program opportunities in the 10-15 year period until 1980 are a continuation of adequate fire protection, an emphasis on erosion control with increased harvest of timber on the steep slopes, steps to lessen the impact of suburban expansion into the forest zone, and consideration of water storage impoundments to alleviate summer season water shortages. Restoration measures needed and their costs, by ownership, are included in Table IV-9 as a part of the Upper Subarea.

The scientific management and conservation practices promoted by the Bureau of Land Management should be a course for industry to follow. As soil and water resources get greater recognition and knowledge of forest practices which will safeguard them become known, then each succeeding crop should be harvested by better standards.

The original authorization of Fern Ridge Reservoir was for flood control, navigation and irrigation. Recreation was incidental--now great emphasis is on recreation. This reservoir can be enhanced for recreation by landscaping, by improving the forest setting near the lake, by reducing the sediment carried into the lake by the tributary streams, and by improving the fish habitat. Management of the surrounding forest land to achieve these objectives should be considered as a matter of policy. Like consideration should be given for other water storage impoundments which may be constructed in the future.

Table IV-9
Soil and Water Restoration Opportunities
Upper Subarea, 1968

Types of Restoration	Public Domain & O&C Lands	National Forests	Private Woodlands	Total
	Units of Work and Costs by Ownerships			
Gully Stabilization				
miles	26.5	9.7	-	36.2
costs ($1,000)	31.7	10.0	-	41.7
Sheet Erosion Control				
acres	895	2,422	150	3,467
costs ($1,000)	151.7	121.0	7.5	280.2
Channel Debris Cleanup				
miles	30.2	105.4	-	135.6
costs ($1,000)	53.7	528.0	-	581.7
Channel Revetment				
miles	16.5	22.0	-	38.5
costs ($1,000)	33.5	12.0	-	45.5
Road and Trail Restoration				
miles	50.0	33.2	-	83.2
costs ($1,000)	59.9	45.0	-	104.9
Total Costs ($1,000)	330.5	716.0	7.5	1,054.0

SUBBASIN 5--SANTIAM

Conclusions and Recommendations

The Forest Service has completed some medium-intensity soil surveys but still has much work left. These surveys need to be completed on all forest lands in the Santiam Subbasin. At $0.40 per acre, this survey will cost nearly $0.5 million to accomplish. This should be given priority for completion before 1980, due to the importance of water flows from this area.

The critical watershed management areas are the remaining stands of old-growth timber where heavy road building and timber harvest will soon be taking place, with considerable soil disturbance. Heavy stands of merchantable timber are found on Thomas Creek, Rock Creek, headwaters of the North Santiam, Little North Santiam, Crabtree Creek, Quartzville Creek, headwaters of the Middle Santiam and South Santiam Rivers, and headwaters of the Calapooia River. By the year 2000, most of the old-growth timber will have been cut and the access roads completed. Smaller and lighter equipment will be used to harvest the second-growth timber, causing much less soil disturbance. Thus, the critical forest watershed management periods are from 1965-1980 and 1980-2000. The implementation of land measures is urgently needed to protect the increasingly valuable water resource.

Watershed treatment priorities for the Santiam Subbasin are:

1. North Santiam River is a source of municipal water for Salem and Mill City, and has fishery and recreational values. Tributary stream clearance is needed to remove channel blockage and reduce downstream deposition of debris and logs. Also, the high erosion hazard in headwater areas requires protective land measures in road building and logging.

2. South Santiam River is a source of municipal water for Albany and Lebanon and has fishery and recreation values. Tributary stream clearance is needed to remove channel blockages and reduce downstream deposition of debris and logs. Also, the high erosion hazard in headwater areas requires protective land measures in road building and logging.

3. Abiqua Creek is a source of municipal water for Silverton and has anadromous fish and recreation values. Protective land measures in road building and logging are needed.

4. Silver Creek is a source of municipal water for Silverton and has recreation values. Protective land measures in road building and logging are needed.

5. Crabtree Creek has anadromous fish and recreation values. Channel clearance is needed to remove blockage to fish migration and to reduce downstream deposition damages. Road rehabilitation is needed to reduce gully and sheet erosion. Protective land measures are needed in roading and logging the old-growth timber in this area.

6. Hamilton Creek has anadromous fish and recreation values. Road rehabilitation is needed to reduce gully and sheet erosion. Protective land measures are needed on some old log landings and skid roads.

7. McDowell Creek has anadromous fish and recreation values. Protective measures are needed on a number of old skid roads and logging roads.

Forest lands in Santiam Subbasin are deteriorating from gully erosion, sheet erosion, stream channel debris blockage, excessive road and channel erosion, and unstabilized land slumps. The cost to rehabilitate and protect these deteriorating lands and streams comes to about $296,000 for the subbasin. This cost is included in Table IV-10 as a part of the Middle Subarea.

Most of Bureau of Land Management's problem areas lie on Little North Santiam River and on Thomas, Crabtree, Quartzville, Hamilton and McDowell Creeks. Problems on small private forest lands occur in the foothills of lower stream drainage areas. High erosion hazard areas are found on the following drainages: North and South Santiam Rivers; and Jordan, Crabtree, Mill, Beaver, Onehorse, Hamilton, Oak, Butte, Warren and Courtney Creeks.

SUBBASIN 6--COAST RANGE

Conclusions and Recommendations

Priorities should be given to the following drainage areas because of downstream water use demands:

1. Rickreall Creek is the source of Dallas' water supply and has anadromous fish and recreation values. Old-growth timber remaining for harvest is in an unstable soil watershed and will require special protective measures. Eroding spur roads, skid roads and log landings need remedial action. Clearing stream channels of debris and protecting banks are needed.

2. Willamina Creek is the source of Willamina's water supply and has anadromous fish and recreation values. Protective land measures are needed where old-growth timber remains for harvest.

3. Luckiamute River has anadromous fish and recreation values. Protective land measures are needed in the unstable watershed where old-growth timber remains to be harvested. Land measures are needed to correct considerable gully erosion on abandoned logging roads. Upstream channel clearance is needed to reduce severe downstream damage from erosion, debris deposition and sedimentation.

4. Little Luckiamute River has anadromous fish and recreation values. Protective measures are needed on the unstable watershed where old-growth timber remains for harvest. Land measures are needed to correct gullying on abandoned roads and seeding is needed to reduce sheet and rill erosion on road cuts and fills. Upstream channel clearance is needed to reduce downstream damage from debris and sediment deposition.

5. The Upper South Yamhill River has anadromous fish and recreation values. Timber harvest is taking place on an unstable watershed, which needs protective measures. Tributary channel clearing is needed to reduce downstream debris and sediment deposition.

6. Agency Creek has anadromous fish and recreation values. Stream channel clearing is needed to reduce downstream debris and sediment deposition.

7. Mill Creek has anadromous fish and recreation values. Stream channel clearance is needed to reduce stream blockage and downstream deposition of debris and sediment. Watershed treatment is needed on some logged areas and particularly on logging and skid roads.

8. Gooseneck Creek has anadromous fish and recreation values. Watershed treatment is needed on some logged areas.

9. The Upper North Yamhill River has recreation values. However, the watershed soils are unstable. Some logged areas need revegetation and livestock control. Treatment is also needed to reduce erosion on old skid trails and log landings.

10. Panther Creek is the source of Carlton's water supply and has recreation values. Stream channel clearance is needed to remove debris and land treatment is needed to restrain water runoff on the upper watershed.

11. Baker Creek has recreation and fisheries values. Stream clearance is needed to reduce blockage and remove debris. Watershed revegetation is needed to reduce the rate of water runoff.

12. Deer Creek has recreation and downstream values. Watershed revegetation is needed to hold unstable soils.

Some portions of the Coast Range Subbasin have watershed management problems requiring protective measures. Problem areas and rehabilitation costs for this subbasin are included in Table IV-10 as a part of the Middle Subarea. Most of the land treatment costs inventoried are on public lands, because most of the remaining old-growth timber is on these lands and soil disturbance will result from "roading" and harvest. Because of the large number of private forest landowners, it is difficult to obtain an accurate inventory of their forest land problems. Also, there is reluctance on the part of private forest industry to admit any but the most obvious watershed management problems.

Willamette Industries, Inc. is an example of a major private forest landowner in this subbasin. They have an advanced timber management program giving good attention to needed land measures to stabilize soils and protect water quality. Some of the other large companies in the area are doing a poor job of forest watershed management. The area of greatest concern is the Big Luckiamute, Little Luckiamute and Rickreall Creek headwaters where old growth stands of timber remain. Road building and logging will be changing watershed characteristics in this area and have an impact on water quality to the degree that protective measures are used. The same alternatives will exist to about the year 2000 when most of the mature timber on private lands will be harvested and the forest lands will be fully roaded. Harvest of second growth timber will be accomplished with more flexible lighter equipment which will create a minimum of soil disturbance.

SUBBASIN 7--PUDDING

Conclusions and Recommendations

Watershed management activities needed in Subbasin 7 are:

1. Some congestion from old logging remains in stream channels; the floods of 1964-65 cleared stream channels of much of this debris. Some erosion problems exist on small ownerships where woodland has been converted to grazing or field crops; technical assistance programs should be continued.

2. Present watershed management programs related to irrigation seem adequate and should be continued. In the Pudding Subbasin, 50 percent of the summer streamflow and 45 percent of the ground water is used for low flow and irrigation.

3. The present level of forest and watershed management should be maintained in the Molalla River drainage. It is nearly 90 percent forested, and the stream is important for anadromous fish spawning and recreation.

4. In the Pudding Subbasin, the major problems are inundation and streambank erosion. In the 1970-1980 period, restoration and preventive programs should be initiated. Milk, Gribble, Butte and Rock Creeks should have highest priority. By the period 1980-2020, the lower parts of the subbasin in private ownership may incur soil and water problems as forested areas are harvested and rural housing increases.

5. Soil mapping should be completed, particularly in the Molalla drainage, to permit better recreation and watershed management in the future.

In general, the forested watershed in the Pudding Subbasin is much better protected than in most of the other subbasins. Restoration, treatment needs and other measures required are rather minor compared to those needed in the Clackamas Subbasin, for example. Watershed restoration opportunities for this subbasin are included in Table IV-10 as a part of the Middle Subarea.

Table IV-10
Soil and Water Restoration Opportunities
Middle Subarea, 1968

Types of Restoration	Public Domain & O&C Lands	National Forests	Private Woodlands	Industrial Forests	County, State, Local & Other	Total
	Units of Work and Costs by Ownerships					
Gully Stabilization						
miles	13.8	3.2	2.3	.1		19.4
costs ($1,000)	14.1	3.2	2.3	.1		19.7
Sheet Erosion Control						
acres	70	1,522	325	11	50	1,978
costs ($1,000)	20.8	76.1	19.6	.6	3.0	120.1
Channel Debris Clearance						
miles	-	8.4	4.9	.5	.8	14.6
costs ($1,000)	-	42.0	24.5	2.5	4.0	73.0
Channel Revetment						
miles	.4	1.0	.4	1.0	-	2.8
costs ($1,000)	3.8	70.0	28.0	70.0	-	171.8
Road and Trail Restoration						
miles	19.4	18.9	58.0	-	.3	96.6
costs ($1,000)	38.0	27.0	44.5	-	.5	110.0
Total Costs ($1,000)	76.7	218.3	118.9	73.2	7.5	494.6

In the higher country where most of the streams originate, the forest cover is well established. The importance of watershed protection is recognized and generally reflected in the management plans. The principal ownerships, public and industrial, are careful in road layout and construction to avoid unstable soil areas. Logging practices are designed to fit the terrain and minimize erosion; exposed mineral soil and cutover areas are quickly stabilized with grass and trees. These costs are usually written off as part of the timber operational expenses.

Program opportunities in the period 1970-1980 are:

1. Continue the present programs for private ownerships in forest, soil and water management.

2. Adopt new measures that encourage multiple uses of woodlands.

3. Intensify programs and measures in critical tributaries.

Program opportunities in the 1980-2020 period are:

1. Change the existing program or adopt new measures to assure good forest practices on the small private woodlands. These lands will have many acres of second-growth timber ready for harvest.

2. Incentive programs, similar to the present Agricultural Conservation Program, or even legal controls may be necessary to maintain vegetative cover on cutover small private woodlands.

3. Measures to preserve streambanks and channels will be necessary, particularly in the lower and middle sections of the subbasin. More utilization of the hardwoods along the streams can be expected in the future.

4. Some housing developments will take place on forested lands during this period. Measures will have to be taken to prevent erosion and stream pollution.

SUBBASIN 8--TUALATIN

Conclusions and Recommendations

Watershed management activities needed in Subbasin 8 are:

1. Nearly all the forest lands have a good cover of coniferous trees and hardwoods. Some acreage in the upper watershed, part of the old Tillamook Burn, has not been completely rehabilitated. Very little old-growth timber remains in the subbasin, mostly in the Turner Creek drainage. Present watershed management programs appear adequate and should be continued.

2. It is essential that technical assistance and incentive programs be continued for private woodland owners. Over 80 percent of the forest land is in private ownership. Small owners control nearly 70 percent of this and industrial firms 30 percent. Forest lands cover nearly half the subbasin.

3. Forest practices that would permit Douglas fir to gain dominance over less desirable species should be encouraged to increase financial returns to the landowners.

4. By the period 1980-2020, timber on small private ownerships will become generally merchantable. Measures will

then be necessary to insure protection to the affected watersheds.

5. A fire protection problem has developed in recent years from a large influx of recreationists during the fire season. Most of the people are from the nearby urban centers. Present fire prevention measures by the protection agencies have been equal to the need and should be continued.

6. Considerable housing development has taken place on forested areas, especially in the McKay and Fanno Creek drainages. This activity will probably increase throughout the study period. Measures will be necessary to assure watershed protection and pollution abatement.

7. Some stream channel problems exist in the small private ownerships, particularly in the Dairy and Chicken Creek drainages. In the 1970-80 period restoration measures should be initiated to correct problem areas in these streams.

8. The facilities planned for the Scoggins Reservoir and the McKay-Rock Creek watershed projects should provide substantial opportunities to meet recreation demands projected for the 1970-80 period. Additional projects with recreational facilities will be needed in the 1980-2020 period. These facilities will concentrate recreationists in areas where there is better control over their activities, and better watershed management should result.

The watershed in the forested area of the Tualatin Subbasin is generally in good condition. Needs for treatment, restoration of critical areas, etc., are rather nominal. Restoration opportunities by ownership are included in Table IV-11 as a part of the Lower Subarea.

At the present time, watershed management programs are being carried out by the public and industrial landowners. In the past, these practices were not followed, and some of the logging scars still present problems, particularly in the upper Gales and Scoggins Creeks. The forest lands in small private ownership have good cover for the most part and are in young age classes; there has been very little logging. In recent years, housing development has probably presented more of a watershed problem in the forested area than timber harvesting has.

Program opportunities in the 1970-1980 period are:

1. Continue present programs, including ACP cost-sharing for forest, soil and water management.

2. Adopt new measures that encourage multiple uses of forests, particularly in the tributaries where water storage will be developed.

3. Adopt measures to correct erosion and stream pollution resulting from homesite development.

Program opportunities in the 1980-2020 period are:

1. Modify programs as necessary to assure watershed protection and vegetative cover, as timber reaches merchantable size.

2. Further homesite development can be expected. Measures enacted in the previous period will have to be continued.

3. The market for hardwoods will have improved, requiring measures to protect streambanks.

4. Continue measures that encourage "multiple use" of forest lands.

SUBBASIN 9--CLACKAMAS

Conclusions and Recommendations

Watershed management needs in Subbasin 9 are:

1. The Clackamas River is used extensively for recreation, fisheries and municipal water supply; its water quality is considered excellent. Present watershed management programs appear adequate and should be continued to protect this quality. In the 1970-80 period restoration and preventive maintenance should be accomplished in those tributaries constituting the greatest immediate hazard to Clackamas River water quality; Eagle Creek and South Fork tributaries should have the first priority.

2. The small private lands are generally in good condition and appear to have little disturbed area. Technical assistance programs which include watershed management practices on private lands should be continued at the present level.

3. Lands along the lower tributaries which are in private ownership represent little relative hazard now, but will probably pose a more serious risk to the soil and water resource as they are intensively harvested in the period 1980-2020.

4. Soil mapping should be completed for the private forest lands in the mountain areas between Mt. Hood National Forest and the agricultural lands. This would permit better watershed protection during the forecast periods by the private forest landowners.

5. Landowners on drainages with intermingled ownerships should collectively organize and accomplish watershed management programs.

6. The priority of restoration measures should be as follows: between 1970-80, upper Eagle Creek (fish hatchery), South Fork Clackamas River (municipal water supply), Collawash River (old growth, unstable areas) and lower Clackamas River (municipal water supply, recreation, fisheries); between 1980-2000, middle Clackamas River (old growth, fishery potential, unstable areas), and upper Clackamas River (old growth, fishery potential, reservoir development); and between 2000-2020, Oak Grove Fork Clackamas River (old-growth, recreation).

Some forest areas now contain gulleys, sheet erosion, stream channel debris, excessive road and channel erosion and unstabilized slumps. The costs to restore specific areas to hydrologic normality total over $1 million in the subbasin, mostly on public lands. These costs are included in Table IV-11 as a part of the Lower Subarea. Data for most private lands are not available.

Watershed management programs are presently being carried out on public lands and industrial ownerships. Their costs are usually borne as part of the cost of operation.

The program opportunities will depend on the time period, the tributary involved, and the priority of work. The old-growth areas within the subbasin are a significant indicator of where heavy road building and logging will take place. The special water quality demands and the unstable areas are two other significant variables which must be correlated. From the standpoint of converting old growth to new growth, the upper watershed will pose the highest risks from 1970 to 2000; by 2000, the age distribution of all timber stands within the subbasin will be more uniform.

SUBBASIN 10--COLUMBIA

Conclusions and Recommendations

Watershed management needs in Subbasin 10 are:

1. The forest area is almost wholly confined to the slopes west of the Willmaette River and the industrial forest area is limited to the uplands in the Milton and Scappoose Creek drainages. A thriving young-growth stand has developed with the removal of the old growth and with more intensive fire protection in the last 20 years. As the young growth matures for harvest, the engineering and maintenance of the access roads to avoid excessive soil movement and sedimentation to streams will be important considerations.

2. Fire protection continues to be the most important need in the undeveloped City of Portland Forest Park, in the unburned slash areas and in the extensive immature stands.

3. Before suburban development extends into the forest zone, steps should be taken to minimize its impact on production of wood fiber, aesthetics and soil and water resources.

4. An educational program supplemented by legislative action should be initiated to keep forest roadside strips and streambanks attractive.

Watershed restoration opportunities in Subbasin 10 are included in Table IV-11 as a part of the Lower Subarea.

The program opportunities in the period until 1980 involve intensifying the fire protection to protect the greater values and to insure against the greater risks. Some zoning will be necessary to preserve aesthetic values, provide orderly development, and insure the forest industry a supply of wood fiber. The impact of urbanization will be much greater on the steep slopes of the West Hills, so careful planning will be needed to protect the soil and water resources. Forest Park will become a greater attraction, requiring facilities such as a water supply system. Also, the need for water during the summer will probably require development of some water storage sites in the Milton and Scappoose Creek drainages.

SUBBASIN 11--SANDY

Conclusions and Recommendations

Watershed management needs in Subbasin 11 are:

1. There will be great demand to use the land in Sandy Subbasin for occupancies of all types. The nearness of Portland means that people will be seeking recreation retreat and will need recreation facilities in the nearby forest environment. The population of Portland will continue to expect clear municipal water, which may not be compatible with future recreational demand.

2. The Bull Run Watershed is currently used for timber production and harvest, in addition to its primary purpose of supplying Portland's municipal water. This secondary use is conducted only insofar as contamination of municipal water sources is prevented. Economic and social pressures will eventually force other uses, such as recreation, onto municipal watersheds, requiring further efforts to prevent manmade pollution. It is not likely that recreation use in the Bull Run Watershed will be demanded by the public in the short-term planning period.

3. Most of the Bull Run, upper Sandy, Zigzag, and Salmon River tributaries are forest lands in public ownership. Access is generally poor to nonexistent. Fire prevention and control are adequate for the present, but rapidly increasing use of this area indicates the need for higher levels of fire protection in the near future.

4. The Sandy River flood plain is highly prized for summer cabin and homesites. The tendency to build expensive facilities and improvements within this area occasionally results in severe flood and debris damages.

5. The Sandy River and minor Columbia tributaries support anadromous fish runs of steelhead, silver salmon and chinook salmon. Spawning areas need protection during any disturbance of nearby lands.

6. Restoration measures, listed in the order of their priority, are as follows: between 1970-1980, Bull Run River (municipal water supply), upper Sandy River (municipal water supply, fisheries, occupancies) and minor Columbia River tributaries (recreation, fisheries); between 1980-2000, Salmon River (reservoir development, road construction); and between 2000-2020, lower Sandy River (recreation, logging, road construction).

The cost to totally restore existing gullies, sheet erosion, stream channel debris, etc. is nearly $400,000 for the subbasin. Table IV-11 includes the restoration opportunities, by types and ownerships for this subbasin as a part of the Lower Subarea. Most of the opportunities listed are on public lands because this is where most of the large-scale use of forest land is now taking place and will continue to occur in the next 10-15 years.

Public land management programs in the 10-15 year period are expected to continue in the important tributaries, such as the Bull Run whose main value is for municipal water supply. Smaller tributaries such as Beaver Creek, Salmon River and parts of the upper Sandy also supply municipal water. From the present to 2000, the old growth areas within the upper watersheds, such as the Sandy and Bull Run will receive land management emphasis. The Salmon River drainage will undoubtedly be heavily developed in the 1985-2000 period because timber stands will then be reaching merchantable size; special land treatments for erosion control and stream channel clearance should be emphasized there.

Table IV-11

Soil and Water Restoration Opportunities
Lower Subarea, 1968

Types of Restoration	Public Domain & O&C Lands	National Forests	Private Woodlands	Industrial Forests	County, State, Local & Other	Total
	Units of Work and Costs by Ownerships					
Gully Stabilization						
miles	2.0	68.4	-	5.0	-	75.4
costs ($1,000)	2.0	68.4	-	5.0	-	75.4
Sheet Erosion Control						
acres	115	116	-	60	-	291
costs ($1,000)	9.5	6.1	-	3.0	-	18.6
Channel Debris Cleanup						
miles	1.0	61.4	.5	-	-	62.9
costs ($1,000)	4.0	307.0	2.0	-	-	313.0
Channel Revetment						
miles	.3	11.9	2.0	-	.7	14.9
costs ($1,000)	2.5	733.0	140.0	-	49.0	924.5
Road and Trail Restoration						
miles	1.5	37.9	-	1.5	-	40.9
costs ($1,000)	2.6	18.6	-	2.0	-	23.2
Total Costs ($1,000)	20.6	1,133.1	142.0	10.0	49.0	1,354.7

Man's use of the forest and agricultural lands of the Willamette Basin has undergone a striking change in the last century and a half. The early immigrants found magnificent stands of coniferous trees in the uplands, and oak-grassland cover in the lower valleys and foothills. During those early years, as men struggled to develop the land for farming and settlement, the forests were considered more a liability than an asset. As a consequence, pioneer clearing methods and farming practices began to cause problems as land uses changed with increasing population.

A G R I C U L T U R E

Agricultural use of Willamette Basin began in about 1810. By 1850 farming was increasing rapidly, with grain, hay, and pasture being the principal crops. As agriculture continued to expand during the next half-century, lands with various limitations were developed. Flooding and poor drainage began to restrict development in the lowlands; and in the foothills erosion was accelerated as steeper slopes were cultivated. A valley-wide orchard boom on the foothill lands, which began about 1910, left a permanent erosive scar.

In the early 1930's a major cropping change began to take place--development of the grass-seed industry. This arrested the trend of soil depletion and erosion losses in the foothills, because of the permanent grass sod. Additionally, the grass-seed crops proved better adapted to the wet lowlands than the previously grown cereal crops. Concurrently, significant irrigation development commenced, and the food processing industry started. Irrigation has required drainage and flood control improvements. Flood-plain scour and erosion remain serious problems in areas where row cropping is practiced.

Watershed protection and land treatment requirements are based on the capability and limitations of the soils and, more important--the use being made of the land. In the basin, a total of 2.8 million acres are suitable for cultivation. Erosion is a limiting problem on 1,385,000 acres of these lands, and unfavorable soil conditions limit the use of an additional 437,000 acres. Excessive wetness directly affects 807,000 acres and indirectly affects 500,000 intermingled acres. Farmers have adapted to these limitations fairly well, and the problems are local rather than basinwide.

As land use changes, land treatment needs change. The two most significant changes in land use projected for the basin by 2020 are (1) the shift of 750,000 acres from dryland to irrigated agriculture, and (2) the loss of nearly 400,000 acres of prime agricultural lands to urban uses. As these shifts take place, land treatment needs will accelerate.

Specific estimates of land treatment needs are shown for 1980. Based on the projected changes in land use, it is estimated that the land measures application under going programs would require a 22 percent acceleration by 1980. This amounts to an estimated $4-1/4 million ($300,000 annually) over and above the present level of expenditures.

A separate land treatment requirement is associated with the USDA early-action projects, which combine structural and land treatment measures in small watershed projects. The 26 small watershed projects recommended for early development by the Department of Agriculture will require an expenditure of approximately $59 million, of which $10 million is for land treatment.

In addition to the accelerated going programs and early-action small watershed projects, there are critical needs for land measures involving small groups of landowners (generally 2 to 6 in number) in specific locations. A total of 133 jobs, costing an estimated $6,985,000, are included in the early-action recommendations.

FORESTRY

By 1900, the forests had become valuable for lumber and so the need to protect the forests from natural catastrophe and man's abuse became evident. During the early part of the twentieth century, fire control measures were initated and basic attitudes toward forest land use improved. Currently, about five million acres--two-thirds of the basin's land area--are forested; these lands are about equally divided between public and private ownership. The forests are storehouses for man's material needs. Moreover, the forest cover conserves the soil and water and is the principal environment for outdoor recreation.

Demands on the forest and woodland resource are increasing greatly, and the non-renewable soil resource is becoming more endangered accordingly. Every year more than 500 miles of permanent forest roads are built and about 50,000 acres of timber are harvested. In addition, dams, power-transmission corridors, and campgrounds are being developed. Natural disasters--fire, flood, and storms--persist. Collectively, these factors disturb the forests and inhibit the natural conservation processes. About 2.5 million tons of suspended sediment emanate annually from forest lands. Approximately 43,000 acres are considered critical sediment-producing areas, mostly due to misuse by man. Watershed management investments by all classes of forest ownership are estimated to be at least $12 million per year.

The total forest acreage is not expected to change significnatly between now and 2020. Uses, however, will continue to intensify and become more competitive. As an example, recreational uses and municipal and industrial water requirements from forest lands are currently doubling every 10 years. The relationship between present use and its impact on future productivity of forest lands is not well known. The new tempo of use will require an equally accelerated effort to curb erosion of soil and degradation of water quality.

The downstream water quality benefits which would result from prudent watershed management practices on industrial forest lands are often insufficient motivation for acceptable practices. Moreover, the owners of small tracts of forest land need help and encouragement in vital areas of watershed management and rurban forestry.

Forest research is the first priority for the early action period. Little is known about certain aspects of accelerated erosion, detection of mass soil movements, fish and wildlife habitat, and water quality requirements. It is distinctly possible that practices such as timber harvesting along streams and widespread slash burning are not compatible with other forest soil and water values. Research on the effects of certain forest uses on fish and wildlife habitat is also non-existent. The present forest research program should be doubled.

In addition to research, the next 50 years of watershed management will involve several interrelated activities, principally restoration measures, land use practices, and soil surveys. Restoration measures are currently needed in order to return forest lands to full production and readiness to serve future needs. An expenditure of about $3 million would restore the most disturbed areas to hydrologic normality. Over a 10-year period, this investment would provide for 130 miles of gully restoration, 5,700 acres of sheet-erosion control, about 21 miles of channel debris cleanup, 56 miles of channel revetment, and 220 miles of forest road and trail restoration.

The land use practices which must be accomplished with every forest use activity require continual emphasis. The State Farm Forestry Program of technical assistance must be doubled within five years to keep pace with the rurban forestry needs oriented around watershed management, urban recreation, and building of small ponds.

More basic soil data are needed. Preliminary soil surveys indicate that 10-15 percent of all forest soils in the basin are unstable if used improperly. At present, 1.3 million acres of public and industrial forest ownerships have no soil inventory of any type on which to base planning activities.

ADDENDUM A

During the course of the Willamette Basin Study, considerable effort was made to specifically identify major problem areas and resource developmental opportunities. To facilitate the study, the Willamette was separated into 126 tributary watersheds based on hydrologic boundaries. Major land uses were tabulated and data collected on flood plains, irrigated areas and drainage needs. These initial data are tabulated in Table A-1.

The watershed tabulations clearly indicate the different amounts of problems and potentials in the many areas. The 126 tributary areas were reviewed and 73 watersheds having a definite physical need or potential were selected for more detailed study; see Map A-1. The next sort was to define project areas that have physical needs and solutions--economic feasibility--and active public support. Many of the 73 met the first two criteria, but lacked the local interest at this time. This sort resulted in early action project proposals for 26 watersheds which have major land measure requirements.

The group enterprise land measure needs were selected from the remaining 100 tributaries. Many of them were in the watershed areas sorted out first because the needs and opportunities were important but on a small scale. In most cases these jobs will meet the immediate needs of that tributary.

One important fact should be emphasized. There are a number of potential watershed projects beyond the selected 26 early action ones. As local interest develops many of these may become equally as important and could even replace some of the 26. Local support would be the major factor changing priority.

Table A-1

Reconnaissance Data on Tributary Areas Studied, Willamette

Item	Unit	Goshen $1\text{-}A_1$	Coast Fork Will. $1\text{-}A_2$	Coast Fork Will. $1\text{-}A_3$	Camas Swale 1-B	Lynx Hollow 1-C	Clover-dale 1-D	Getting Creek 1-E
Number of farms	Number	60	70	30	90	50	70	50
Land Use:								
Forest land grazed	Acres	2,675	4,600	3,300	950	1,500	2,540	2,220
Forest land not grazed	do.	1,700	22,400	43,900	18,350	4,965	13,280	7,580
Cropland	do.	3,705	1,910	1,150	4,030	1,570	2,770	1,570
Rangeland	do.	1,720	1,470	550	4,030	2,885	2,110	100
Other	do.	890	2,650	300	1,440	800	430	150
Total watershed area	do.	10,690	33,030	49,200	28,800	11,720	21,130	11,620
Cropland use:								
Dryland	Acres	2,805	1,460	880	3,650	1,260	1,770	1,270
Irrigated	do.	900	450	270	380	310	1,000	300
Total	do.	3,705	1,910	1,150	4,030	1,570	2,770	1,570
Potential cropland	Acres	620	500	30	2,000	1,470	2,500	3,200
Irrigation:								
Water source								
Pumped from streams	Acres	750	450	260	380	230	990	300
Pumped from wells	do.	150	0	10	0	80	10	0
Other	do.	0	0	0	0	0	0	0
Total	do.	900	450	270	380	310	1,000	300
Water shortage	Acres	--	--	--	--	200	200	30
Method of application:								
Sprinkling	Acres	900	450	240	380	310	1,000	300
Flooding	do.	0	0	30	0	0	0	0
Total	do.	900	450	270	380	310	1,000	300
Potentially irrigable land (not presently irrigated)	Acres	1,700	2,050	920	1,850	690	1,800	3,620
Water source								
Natural flows & ground water	Acres	1,700	2,050	773	0	0	0	0
Other	do.	0	0	147	1,850	690	1,800	3,620
Storage:								
Existing ponds	Number	3	2	2	4	1	3	1
Existing reservoirs	do.	1	1	0	1	0	1	0
Possible sites studied	do.	0	0	1	4	1	1	0
Drainage:								
Arable land needing drainage	Acres	500	105	130	4,000	400	1,670	240
Needs								
Improved surface	Acres	380	0	130	300	400	1,950	100
Subsurface								
Open drains	Acres	160	50	130	3,590	400	0	160
Closed drains	do.	220	55	115	410	0	1,670	240
Flooded areas	do.	0	100	0	1,700	0	570	151

1/ 1963 data with portions updated to 1967.

2

le A-1
Areas Studied, Willamette River Basin 1/

Lynx Hollow 1-C	Clover-dale 1-D	Gettings Creek 1-E	Silk Creek 1-F	Martin Creek 1-G	Mosby Creek 1-H	Row River 1-I_1	Row River 1-I_2	Total Subbasin 1
50	70	50	50	40	40	30	20	600
1,500	2,540	2,220	2,560	2,290	3,500	2,240	1,000	29,375
4,965	13,280	7,580	6,679	5,360	58,658	32,060	136,850	351,782
1,570	2,770	1,570	800	800	830	620	400	20,155
2,885	2,110	100	--	--	--	770	100	13,735
800	430	150	311	220	342	2,480	350	10,363
11,720	21,130	11,620	10,350	8,670	63,330	38,170	138,700	425,410
1,260	1,770	1,270	680	760	520	290	260	15,605
310	1,000	300	120	40	310	330	140	4,550
1,570	2,770	1,570	800	800	830	620	400	20,155
1,470	2,500	3,200	750	600	1,160	1,550	880	15,260
230	990	300	70	40	300	330	140	4,240
80	10	0	50	0	10	0	0	310
0	0	0	0	0	0	0	0	0
310	1,000	300	120	40	310	330	140	4,550
200	200	30	20	--	10	40	--	500
310	1,000	300	120	40	310	330	140	4,520
0	0	0	0	0	0	0	0	30
310	1,000	300	120	40	310	330	140	4,550
690	1,800	3,620	950	1,510	880	1,760	720	18,450
0	0	0	0	0	259	420	0	5,202
690	1,800	3,620	950	1,510	621	1,340	720	13,248
1	3	1	2	1	1	2	2	24
0	1	0	1	0	1	1	2	9
1	1	0	2	3	1	0	0	13
400	1,670	240	300	460	60	110	0	7,975
400	1,950	100	300	50	60	0	0	3,670
400	0	160	150	230	0	0	0	4,870
0	1,670	240	150	230	0	110	0	3,200
0	570	151	101	66	20	0	0	2,708

Table A-1 (cont'd)

Reconnaissance Data on Tributary Areas Studied, Willamette River Basin 1/

Item	Unit	Pleasant Hill 2-A1	Middle Fork Will. 2-A2	Hills Creek 2-B	Rattle-snake 2-C	Lost Creek 2-D	Little Fall Creek 2-E	Tota[l] Subba[sin] 2
Number of farms	Number	100	65	50	50	70	30	3[illegible]
Land Use:								
Forest land grazed	Acres	1,000	1,000	600	433	2,200	10,000	15,2[illegible]
Forest land not grazed	do.	2,200	547,086	13,370	5,117	31,820	29,935	629,52[illegible]
Cropland	do.	3,381	1,400	500	1,125	420	275	7,10[illegible]
Rangeland	do.	700	--	--	450	370	--	1,52[illegible]
Other	do.	639	210,574	550	365	490	280	212,89[illegible]
Total watershed area	do.	7,920	760,060	15,020	7,490	35,300	40,490	866,28[illegible]
Cropland use								
Dryland	Acres	2,081	1,270	460	925	270	95	5,10[illegible]
Irrigated	do.	1,300	130	40	200	150	180	2,00[illegible]
Total	do.	3,381	1,400	500	1,125	420	275	7,10[illegible]
Potential cropland	Acres	500	700	600	1,500	2,000	400	5,70[illegible]
Irrigation:								
Water source								
Pumped from streams	Acres	800	130	40	200	140	180	1,49[illegible]
Pumped from wells	do.	500	0	0	0	10	0	51[illegible]
Other	do.	0	0	0	0	0	0	[illegible]
Total	do.	1,300	130	40	200	150	180	2,00[illegible]
Water shortage	Acres	--	--	--	--	--	--	-[illegible]
Method of application								
Sprinkling	Acres	1,300	130	40	200	150	180	2,00[illegible]
Flooding	do.	0	0	0	0	0	0	[illegible]
Total	do.	1,300	130	40	200	150	180	2,00[illegible]
Potentially irrigable land (not presently irrigated)	Acres	200	370	60	1,020	1,850	350	3,85[illegible]
Water source								
Natural flows & ground water	do.	200	370	60	0	0	350	98[illegible]
Other	do.	0	0	0	1,020	1,850	0	2,87[illegible]
Storage:								
Existing ponds	Number	2	0	1	0	1	0	[illegible]
Existing reservoirs	do.	0	0	1	1	0	0	[illegible]
Possible sites studied	do.	0	0	0	0	0	1	[illegible]
Drainage:								
Arable land needing drainage	Acres	2,000	1,200	200	1,180	300	100	4,98[illegible]
Needs								
Improved surface	Acres	1,100	1,200	100	590	0	60	3,05[illegible]
Subsurface								
Open drains	Acres	0	0	125	0	100	60	28[illegible]
Closed drains	do.	600	0	75	1,180	200	40	2,09[illegible]
Flooded areas	do.	300	0	29	50	81	10	47[illegible]

1/ *1963 data with portions updated to 1967.*

2

Lost Creek 2-D	Little Fall Creek 2-E	Total Subbasin 2	Coburg 3-A1	Mc-Kenzie 3-A2	Willa-kenzie 3-B	Camp Creek 3-C	Mohawk 3-D	Total Subbasin 3
70	30	365	60	140	20	30	200	450
2,200	10,000	15,233	800	5,440	1,000	5,200	1,000	13,440
31,820	29,935	629,528	4,194	461,160	3,030	9,350	107,890	585,624
420	275	7,101	5,215	3,524	600	1,840	2,910	14,089
370	--	1,520	--	--	800	--	3,200	4,000
490	280	212,898	1,691	234,176	3,700	350	2,000	241,917
35,300	40,490	866,280	11,900	704,300	9,130	16,740	117,000	859,070
270	95	5,101	3,115	1,324	500	1,440	1,660	8,039
150	180	2,000	2,100	2,200	100	400	1,250	6,050
420	275	7,101	5,215	3,524	600	1,840	2,910	14,089
2,000	400	5,700	700	900	0	1,000	2,800	5,400
140	180	1,490	350	1,600	40	400	1,200	3,590
10	0	510	1,750	600	60	0	50	2,460
0	0	0	0	0	0	0	0	0
150	180	2,000	2,100	2,200	100	400	1,250	6,050
--	--	--	--	200	10	20	0	230
150	180	2,000	2,100	2,200	100	400	1,250	6,050
0	0	0	0	0	0	0	0	0
150	180	2,000	2,100	2,200	100	400	1,250	6,050
1,850	350	3,850	700	1,200	400	500	2,750	5,550
0	350	980	700	1,200	400	0	2,750	5,050
1,850	0	2,870	0	0	0	500	0	500
1	0	4	1	5	1	2	2	11
0	0	2	1	3	0	2	1	7
0	1	1	0	0	0	1	10	11
300	100	4,980	1,400	1,200	300	500	1,500	4,900
0	60	3,050	400	0	0	0	300	700
100	60	285	1,000	1,200	200	0	600	3,000
200	40	2,095	0	0	100	500	600	1,200
81	10	470	500	100	0	72	400	1,072

Table A-1 (cont'd)

Reconnaissance Data on Tributary Areas Studied, Willamette River Basin 1/

Item	Unit	Harrisburg 4-A	Long Tom 4-B1	Long Tom 4-B2	Long Tom 4-B3	Amazon-Flat Creek 4-C	Fe C
Number of farms	Number	440	65	180	180	550	
Land Use:							
Forest land grazed	Acres	4,000	1,200	3,500	22,540	1,500	
Forest land not grazed	do.	6,750	1,660	5,000	32,900	1,660	
Cropland	do.	30,130	5,700	4,100	5,300	54,000	
Rangeland	do.	3,300	2,400	6,850	3,000	1,600	
Other	do.	12,520	740	13,750	1,260	6,080	
Total	do.	56,700	11,700	33,200	65,000	64,840	1
Cropland use							
Dryland	Acres	22,630	3,300	3,790	4,760	49,000	
Irrigated	do.	7,500	2,400	310	540	5,000	
Total	do.	30,130	5,700	4,100	5,300	54,000	
Potential cropland	Acres	600	500	700	8,000	--	
Irrigation:							
Water source							
Pumped from streams	Acres	1,400	1,400	280	500	500	
Pumped from wells	do.	6,100	1,000	30	10	4,500	
Other	do.	0	0	0	30	0	
Total	do.	7,500	2,400	310	540	5,000	
Water shortage	Acres	--	300	--	60	--	
Method of application							
Sprinkling	Acres	7,500	2,350	310	540	5,000	
Flooding	do.	0	50	0	0	0	
Total	do.	7,500	2,400	310	540	5,000	
Potentially irrigable land (not presently irrigated)	Acres	12,500	300	7,090	5,220	35,000	
Water source							
Natural flows & ground water	Acres	0	78	0	146	0	
Other	do.	12,500	222	7,090	5,074	35,000	
Storage:							
Existing ponds	Number	4	3	8	6	3	
Existing reservoirs	do.	0	0	3	7	0	
Possible sites studied	do.	0	0	3	13	0	
Drainage:							
Arable land needing drainage	Acres	8,500	2,000	800	5,000	9,500	
Needs							
Improved surface	Acres	5,000	1,500	200	700	7,600	
Subsurface							
Open drains	Acres	4,000	1,000	--	5,000	--	
Closed drains	do.	3,000	1,000	800	2,000	6,000	
Flooded areas	do.	2,000	800	100	3,600	10,000	

1/ 1963 Data with portions updated to 1967.

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Tom B3	Amazon-Flat Creek 4-C	Ferguson Creek 4-D	Bear Creek 4-E	Coyote-Spencer 4-F	Willakenzie 4-G	Total Subbasin 4
180	550	53	70	160	20	1,718
540	1,500	1,950	4,016	33,000	--	71,706
900	1,660	5,410	4,264	19,260	760	77,664
300	54,000	3,360	2,958	5,360	2,820	113,728
000	1,600	4,960	3,256	3,350	--	28,716
260	6,080	320	296	6,030	4,020	45,016
000	64,840	16,000	14,790	67,000	7,600	336,830
760	49,000	3,230	2,158	4,660	2,470	95,998
540	5,000	130	800	700	350	17,730
300	54,000	3,360	2,958	5,360	2,820	113,728
000	--	1,500	500	--	--	11,800
500	500	130	610	600	300	5,720
10	4,500	0	40	10	50	11,740
30	0	0	150	90	0	270
540	5,000	130	800	700	350	17,730
60	--	--	40	--	20	420
540	5,000	130	730	680	350	17,590
0	0	0	70	20	0	140
540	5,000	130	800	700	350	17,730
220	35,000	2,570	2,200	2,100	0	66,980
146	0	0	200	0	0	424
074	35,000	2,570	2,000	2,100	0	66,556
6	3	2	4	10	1	41
7	0	0	0	4	0	14
13	0	3	3	18	0	40
,000	9,500	4,000	4,000	5,000	2,000	40,800
700	7,600	4,000	3,500	4,000	900	27,400
,000	--	2,500	1,500	4,000	2,000	20,000
,000	6,000	4,000	2,500	3,500	0	22,800
,600	10,000	610	1,040	2,520	700	21,370

Table A-1 (cont'd)

Reconnaissance Data on Tributary Areas Studied, Willamette River Basin 1/

Item	Unit	Little North Santiam 5-A	Lower North Santiam 5-B	Main-stem Santiam 5-C	Millersburg-Dever 5-D	Bear Branch 5-E	San-Thomas 5-F	Thom Cree 5-G
Number of farms	Number	10	530	141	70	40	25	1
Land Use:								
Forest land grazed	Acres	2,500	5,080	1,400	1,000	640	375	8,0
Forest land not grazed	do.	69,630	6,840	600	400	420	93	48,8
Cropland	do.	1,260	30,210	15,230	9,890	6,570	6,075	17,0
Rangeland	do.	90	5,400	1,100	0	1,500	1,012	7,0
Other	do.	130	4,340	740	400	100	235	2,0
Total watershed area	do.	73,610	51,870	19,070	11,690	9,230	7,790	82,8
Cropland use								
Dryland	Acres	1,060	15,000	9,200	7,890	6,070	5,775	15,0
Irrigated	do.	200	15,210	6,030	2,000	500	300	2,0
Total	do.	1,260	30,210	15,230	9,890	6,570	6,075	17,0
Potential cropland	Acres	2,500	4,700	1,000	0	1,600	0	2,5
Irrigation:								
Water source								
Direct stream diversion	Acres	0	0	1,700	0	0	0	
Pumped from streams	do.	100	6,960	2,600	1,200	400	100	
Pumped from wells	do.	50	8,250	1,730	800	100	200	1,8
Other	do.	50	0	0	0	0	0	1
Total	do.	200	15,210	6,030	2,000	500	300	2,
Water shortage	Acres	0	0	0	100	0	50	
Method of application								
Sprinkling	Acres	200	15,210	6,030	2,000	500	300	2,
Flooding	do.	0	0	0	0	0	0	
Total	do.	200	15,210	6,030	2,000	500	300	2,
Potentially irrigable land (not presently irrigated)	Acres	2,500	19,000	10,200	7,800	6,000	4,700	17,
Water source								
Natural flows & ground water	Acres	2,500	11,000	8,200	7,800	0	0	1,
Storage	do.	0	8,000	2,000	0	6,000	4,700	16,
Storage:								
Existing ponds	Number	4	5	4	4	4	4	
Existing reservoirs	do.	1	1	0	0	0	0	
Possible sites studied	do.	0	0	0	0	1	1	
Drainage:								
Arable land needing drainage	Acres	0	6,000	7,000	7,000	2,000	5,000	13,
Needs								
Improved surface drainage	Acres	0	2,000	5,500	0	0	0	1,
Subsurface drainage								
Open drains	Acres	0	1,000	3,500	0	0	0	
Closed drains	do.	0	5,000	3,500	7,000	2,000	5,000	13,
Flooded areas	do.	20	2,100	2,700	600	0	600	1,

1/ *1963 data with portions updated to 1967.*

2

Bear Branch 5-E	San-Thomas 5-F	Thomas Creek 5-G	Upper North Santiam 5-H	Crab-tree Creek 5-I	South Santiam 5-J	Grand Prairie 5-K	Oak Creek 5-L	Cala-pooia River 5-M	Willa-mette River 5-N
40	25	140	25	145	235	205	150	450	100
640	375	8,000	5,430	11,500	5,200	1,000	4,560	15,000	1,500
420	93	48,840	308,630	64,300	13,960	0	2,000	91,000	2,000
6,570	6,075	17,000	1,370	18,000	33,920	15,520	13,000	57,600	5,890
1,500	1,012	7,000	2,400	2,500	8,000	800	2,000	5,200	1,200
100	235	2,000	21,300	1,500	5,150	12,000	1,000	10,000	1,300
9,230	7,790	82,840	339,130	97,800	66,230	29,320	22,560	178,800	11,890
6,070	5,775	15,000	1,170	15,900	31,620	14,820	12,000	52,600	4,390
500	300	2,000	200	2,100	2,300	700	1,000	5,000	1,500
6,570	6,075	17,000	1,370	18,000	33,920	15,520	13,000	57,600	5,890
1,600	0	2,500	2,000	10,000	1,700	500	2,000	10,000	2,000
0	0	0	0	1,500	0	0	0	0	0
400	100	0	150	450	850	0	0	2,300	350
100	200	1,820	0	100	1,450	700	900	2,400	1,000
0	0	180	50	50	0	0	100	300	150
500	300	2,000	200	2,100	2,300	700	1,000	5,000	1,500
0	50	0	0	200	0	100	100	100	100
500	300	2,000	200	900	2,300	700	1,000	5,000	1,500
0	0	0	0	1,200	0	0	0	0	0
500	300	2,000	200	2,100	2,300	700	1,000	5,000	1,500
6,000	4,700	17,000	3,000	24,000	31,000	16,300	13,000	60,000	4,000
0	0	1,000	3,000	2,000	3,000	0	2,400	10,000	3,600
6,000	4,700	16,000	0	22,000	28,000	16,300	10,600	50,000	400
4	4	21	4	6	12	11	4	15	6
0	0	4	1	0	0	0	3	0	4
1	1	2	0	3	2	0	1	3	0
2,000	5,000	13,000	1,000	16,000	13,000	18,000	7,000	30,000	1,000
0	0	1,200	0	2,000	0	0	3,000	20,000	750
0	0	0	0	0	0	0	2,000	5,000	300
2,000	5,000	13,000	1,000	16,000	13,000	18,000	2,000	5,000	700
0	600	1,000	0	4,470	11,000	5,250	1,990	16,000	3,000

East Muddy 5-O	Walton Slough 5-P	Lake Creek 5-Q	Hamil-ton Creek 5-R	Mc-Dowell Creek 5-S	Middle Santiam 5-T	Upper South Santiam 5-U	Total Subbasin 5
319	140	70	110	15	5	50	2,975
1,600	11,000	2,000	5,000	2,700	0	5,000	90,485
33,400	2,910	2,000	16,200	10,270	182,460	172,000	1,027,953
51,090	19,610	9,790	4,000	1,820	50	3,310	321,205
6,400	1,080	1,000	3,000	800	150	2,000	52,632
4,700	1,080	1,000	100	200	1,050	1,000	69,325
97,190	35,680	15,790	28,300	15,790	183,710	183,310	1,561,600
47,830	18,410	9,290	3,600	1,700	20	3,100	276,445
3,260	1,200	500	400	120	30	210	44,760
51,090	19,610	9,790	4,000	1,820	50	3,310	321,205
5,000	2,000	2,000	4,000	100	0	1,000	54,600
0	0	0	0	0	0	150	3,350
500	0	250	350	120	30	60	16,770
1,360	100	250	0	0	0	0	21,210
1,400	1,100	0	50	0	0	0	3,370
3,260	1,200	500	400	120	30	210	44,760
0	0	50	0	0	0	0	800
2,760	1,120	500	400	120	30	210	42,980
500	80	0	0	0	0	0	1,780
3,260	1,200	500	400	120	30	210	44,760
46,740	13,800	9,000	5,000	1,000	0	2,000	296,040
37,340	1,000	4,000	200	300	0	1,800	99,140
9,400	12,800	5,000	4,800	700	0	200	196,900
8	0	5	2	2	0	4	125
1	1	0	0	0	0	0	16
1	1	0	1	1	0	1	18
40,000	9,000	5,000	2,000	500	0	1,000	183,500
20,000	5,000	3,000	1,800	0	0	0	64,250
5,000	2,000	1,000	0	0	0	600	20,400
15,000	2,000	1,000	2,000	500	0	400	112,100
3,560	1,335	0	0	0	0	50	53,675

Table A-1 (cont'd)

Reconnaissance Data on Tributary Areas Studied, Willamette River Basin 1/

Item	Unit	North Yam-hill River 6-A	Che-halem 6-B	Wil-son-ville 6-C_1	Main-stem Yam-hill 6-C_2	Spring Valley 6-C_3
Number of farms	Number	400	152	230	420	110
Land Use:						
Forest land grazed	Acres	17,550	8,500	3,200	1,720	3,020
Forest land not grazed	do.	36,600	9,700	3,040	4,020	2,500
Cropland	do.	19,320	12,700	12,470	26,800	6,580
Rangeland	do.	2,000	3,280	1,530	2,120	660
Other	do.	3,080	2,180	1,390	3,620	400
Total watershed area	do.	78,550	36,360	21,630	38,280	13,160
Cropland use						
Dryland	Acres	18,160	12,520	11,950	21,880	5,880
Irrigated	do.	1,160	180	520	4,920	700
Total	do.	19,320	12,700	12,470	26,800	6,580
Potential cropland	Acres	0	0	750	1,200	1,000
Irrigation:						
Water source						
Direct stream diversion	Acres	0	0	0	0	0
Pumped from streams	do.	1,160	45	250	3,050	630
Pumped from wells	do.	0	75	200	1,820	70
Other	do.	0	60	70	50	0
Total	do.	1,160	180	520	4,920	700
Water shortage	Acres	100	50	0	0	0
Method of application						
Sprinkling	Acres	1,160	175	520	4,920	700
Flooding	do.	0	5	0	0	0
		1,160	180	520	4,920	700
Potentially irrigable land (not presently irrigated)	Acres	15,000	8,520	11,000	23,000	5,800
Water source						
Natural flows&groundwater	do.	1,000	200	3,000	23,000	3,000
Storage	do.	14,000	8,320	8,000	0	2,800
Storage:						
Existing ponds	Number	6	7	0	6	6
Existing reservoirs	do.	3	5	0	3	3
Possible sites studied	do.	5	0	1	0	1
Drainage:						
Arable land needing drainage	Acres	9,000	5,000	1,000	7,000	3,000
Needs						
Improved surface drainage	Acres	200	3,000	1,000	3,000	0
Subsurface drainage						
Open drains	Acres	300	2,000	0	500	0
Closed drains	do.	8,700	3,000	1,000	6,500	3,000
Flooded areas	do.	800	580	700	7,000	403

1/ 1963 data with portions updated to 1967.

West Salem 6-C4	Inde-pen-dence 6-C5	Benton County 6-C6	Bowers Slough 6-C7	Hawn Creek 6-D	Pan-ther Creek 6-E	Baker Creek 6-F	Deer Creek 6-G	Willa-mina Creek 6-H	Cos-per Creek 6-I	Agency Creek 6-J	Upper South Yam-hill 6-K	South Yam-hill River 6-L	Palmer Creek 6-M	Ash Swale 6-N
200	50	255	35	45	75	90	130	205	14	50	30	260	149	95
1,080	1,150	4,900	1,100	1,200	1,700	1,600	8,700	2,000	1,000	500	4,530	8,150	1,800	2,630
3,130	390	3,600	7,000	0	12,610	8,380	12,500	45,860	2,930	12,460	55,380	2,160	1,900	400
7,030	12,050	19,600	5,700	6,740	3,000	4,580	11,490	3,190	2,000	1,500	5,220	38,330	14,300	19,810
480	0	650	1,370	300	1,000	2,000	1,360	480	360	2,000	800	4,550	2,580	3,310
3,910	810	10,110	2,100	400	200	300	700	700	80	200	1,720	7,460	800	790
15,630	14,400	38,860	17,270	8,640	18,510	16,860	34,750	52,230	6,370	16,660	67,650	60,650	21,380	26,940
5,730	6,200	15,300	5,400	6,440	2,730	4,100	10,770	2,640	2,000	1,480	5,020	35,850	12,300	19,750
1,300	5,850	4,300	300	300	270	480	720	550	0	20	200	2,480	2,000	60
7,[illegible]30	12,050	19,600	5,700	6,740	3,000	4,580	11,490	3,190	2,000	1,500	5,220	38,330	14,300	19,810
0	0	4,000	500	100	0	200	0	0	0	150	0	0	200	500
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	1,500	1,000	50	180	250	280	720	550	0	20	200	2,220	1,490	10
1,200	4,350	3,300	150	60	15	180	0	0	0	0	0	80	500	0
50	0	0	100	60	5	20	0	0	0	0	0	180	10	50
1,300	5,850	4,300	300	300	270	480	720	550	0	20	200	2,480	2,000	60
0	0	0	0	50	50	500	0	0	0	0	50	100	100	30
1,300	5,850	4,300	300	300	270	475	720	550	0	20	200	2,480	2,000	60
0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
1,300	5,850	4,300	300	300	270	480	720	550	0	20	200	2,480	2,000	60
4,000	6,000	19,000	5,000	5,500	2,500	3,500	6,200	1,500	1,320	1,500	4,500	35,030	10,500	17,500
1,000	6,000	7,000	2,300	200	50	100	1,000	500	100	100	0	250	750	50
3,000	0	12,000	2,700	5,300	2,450	3,400	5,200	1,000	1,220	1,400	4,500	34,780	9,750	17,450
7	0	0	10	5	4	2	3	3	0	0	3	14	6	4
4	0	0	1	1	0	2	0	0	0	0	0	5	1	0
0	0	0	0	0	1	2	6	4	1	1	1	3	1	2
300	1,000	5,000	700	2,000	2,000	3,000	4,000	2,000	0	2,000	2,000	15,000	4,000	6,000
0	0	5,000	600	100	100	400	1,600	100	0	300	0	1,000	700	0
0	0	1,000	300	100	150	600	200	100	0	300	500	700	150	0
300	1,000	4,000	400	1,900	1,850	2,400	3,800	1,900	0	1,700	1,500	14,300	3,850	6,000
1,300	7,000	9,500	959	222	869	516	800	61	40	46	345	9,241	780	808

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per uth - ll -K	South Yam-hill River 6-L	Palmer Creek 6-M	Ash Swale 6-N	Salt Creek 6-O	Mill Creek 6-P	Mud Slough 6-Q	Rick-reall Creek 6-R	Ash Creek 6-S	Little Lucki-amute 6-T	Lucki-amute River 6-U	Soap Creek 6-V	Marys River 6-W	West Muddy Creek 6-X	Total Subbasin 6
30	260	149	95	135	110	40	100	100	50	160	75	160	200	4,125
,530	8,150	1,800	2,630	4,010	1,020	1,380	2,060	2,300	3,130	8,890	4,990	11,000	9,940	124,750
,380	2,160	1,900	400	4,100	27,140	0	21,790	1,000	40,030	78,440	12,190	78,000	34,790	522,040
,220	38,330	14,300	19,810	21,580	5,090	15,790	14,390	14,300	5,260	18,870	13,840	13,780	26,370	381,680
800	4,550	2,580	3,310	2,880	0	1,980	0	2,200	2,630	5,000	1,350	5,300	2,490	54,660
,720	7,460	800	790	740	680	590	2,880	2,200	1,590	2,700	1,350	5,000	6,390	65,070
,650	60,650	21,380	26,940	33,310	33,930	19,740	41,120	22,000	52,640	113,900	33,720	113,080	79,980	1,148,200
,020	35,850	12,300	19,750	21,480	4,930	15,720	13,790	14,150	4,160	17,950	13,830	12,700	24,770	349,580
200	2,480	2,000	60	100	160	70	600	150	1,100	920	10	1,080	1,600	32,100
,220	38,330	14,300	19,810	21,580	5,090	15,790	14,390	14,300	5,260	18,870	13,840	13,780	26,370	381,680
0	0	200	500	1,000	500	0	500	500	500	1,500	3,500	2,000	3,000	21,600
0	0	0	0	0	0	0	0	0	0	120	0	0	0	120
200	2,220	1,490	10	58	160	0	600	150	1,100	800	10	1,020	1,550	19,103
0	80	500	0	0	0	0	0	0	0	0	0	60	50	12,110
0	180	10	50	42	0	70	0	0	0	0	0	0	0	767
200	2,480	2,000	60	100	160	70	600	150	1,100	920	10	1,080	1,600	32,100
50	100	100	30	100	600	20	100	0	50	50	50	700	300	3,000
200	2,480	2,000	60	100	160	70	500	150	1,100	800	10	1,080	1,600	31,870
0	0	0	0	0	0	0	100	0	0	120	0	0	0	230
200	2,480	2,000	60	100	160	70	600	150	1,100	920	10	1,080	1,600	32,100
,500	35,030	10,500	17,500	18,900	4,000	13,000	13,000	5,850	4,500	17,000	3,690	10,000	17,400	294,210
0	250	750	50	100	0	0	0	3,550	0	0	0	500	760	54,510
,500	34,780	9,750	17,450	18,800	4,000	13,000	13,000	2,300	4,500	17,000	3,690	9,500	16,640	239,700
3	14	6	4	8	0	2	0	2	6	36	2	20	25	187
0	5	1	0	5	0	1	1	1	0	7	0	12	2	57
1	3	1	2	2	0	0	1	2	0	7	2	4	4	51
,000	15,000	4,000	6,000	9,800	2,000	9,000	2,000	6,400	3,000	7,000	10,000	1,000	27,200	151,400
0	1,000	700	0	0	0	0	0	0	0	100	1,000	500	6,000	24,700
500	700	150	0	3,300	500	1,000	0	900	0	400	4,000	700	5,440	23,140
,500	14,300	3,850	6,000	6,500	1,500	8,000	2,000	5,500	3,000	6,600	6,000	300	21,760	128,260
345	9,241	780	808	1,800	732	826	871	906	1,844	6,000	1,467	1,800	4,205	62,421

Table A-1 (cont'd)
Reconnaissance Data on Tributary Areas Studied, Willamette River Basin 1/

Item	Unit	Canby 7-A1	Butte-ville 7-A2	North Salem 7-A3	South Salem 7-A4	Champoeg Creek 7-B	Lower Pudding River 7-C	Rock Creek 7-D
Number of farms	Number	30	100	230	230	140	270	180
Land Use:								
Forest land grazed	Acres	200	1,000	2,030	4,130	550	1,800	7,000
Forest land not grazed	do.	160	1,500	3,850	5,840	4,300	5,000	5,800
Cropland	do.	2,200	6,600	27,300	14,000	22,520	24,060	21,870
Rangeland	do.	180	720	0	3,260	1,050	1,850	4,000
Other	do.	580	770	8,350	1,000	1,260	2,600	2,010
Total watershed area	do.	3,320	10,590	41,530	28,230	29,680	35,310	40,680
Cropland use								
Dryland	Acres	1,400	5,750	21,300	10,350	18,520	20,560	21,070
Irrigated	do.	800	850	6,000	3,650	4,000	3,500	800
Total	do.	2,200	6,600	27,300	14,000	22,520	24,060	21,870
Potential cropland	Acres	150	850	1,700	1,000	1,800	1,530	3,100
Irrigation:								
Water source								
Direct stream diversion	Acres	0	0	0	0	0	0	0
Pumped from streams	do.	350	375	2,000	1,750	400	500	500
Pumped from wells	do.	450	475	4,000	1,800	3,600	2,800	200
Other	do.	0	0	0	100	0	200	100
Total	do.	800	850	6,000	3,650	4,000	3,500	800
Water shortage	Acres	0	0	0	0	100	0	100
Method of application								
Sprinkling	Acres	800	850	6,000	3,650	4,000	3,500	800
Flooding	do.	0	0	0	0	0	0	0
Total		800	850	6,000	3,650	4,000	3,500	800
Potentially irrigable land (not presently irrigated)	Acres	1,100	6,000	23,000	11,000	19,000	20,000	20,000
Water source								
Natural flows & ground water	do.	1,100	4,650	20,000	8,000	3,000	1,250	4,850
Storage	do.	0	1,350	3,000	3,000	16,000	18,750	15,150
Storage:								
Existing ponds	Number	0	0	0	9	0	3	21
Existing reservoirs	do.	0	0	0	1	0	0	8
Possible sites studied	do.	0	0	0	0	0	0	3
Drainage:								
Arable land needing drainage	Acres	400	2,500	7,000	4,000	9,000	9,000	7,000
Needs								
Improved surface drainage	Acres	200	2,000	6,800	4,000	7,000	7,000	0
Subsurface drainage								
Open drains	Acres	0	1,400	3,000	2,000	2,000	2,000	1,000
Closed drains	do.	400	1,100	4,000	2,000	7,000	7,000	6,000
Flooded areas	do.	150	200	2,000	4,500	300	600	669

1/ *1963 data with portions updated to 1967.*

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Lower Pudding River 7-C	Rock Creek 7-D	Bear Creek 7-E	Gribble Creek 7-F	Molalla Creek 7-G	Mill Creek 7-H	Butte Creek 7-I1	Zollner Creek 7-I2	Abiqua Creek 7-I3
270	180	180	160	350	500	240	100	105
1,800	7,000	1,100	600	1,120	23,000	5,710	1,000	1,760
5,000	5,800	1,220	500	131,810	22,460	23,630	3,200	36,000
24,060	21,870	8,810	8,280	15,170	15,330	12,010	5,160	13,000
1,850	4,000	1,050	650	1,340	3,000	1,640	420	1,330
2,600	2,010	900	560	1,220	2,000	1,220	180	420
35,310	40,680	13,080	10,590	150,660	65,790	44,210	9,960	52,510
20,560	21,070	8,460	7,780	12,600	13,480	7,963	610	10,890
3,500	800	350	500	2,570	1,850	4,047	4,550	2,110
24,060	21,870	8,810	8,280	15,170	15,330	12,010	5,160	13,000
1,530	3,100	800	650	500	4,300	1,700	1,000	8,000
0	0	0	0	0	0	0	0	990
500	500	100	250	1,500	1,000	2,347	510	220
2,800	200	150	150	745	550	1,093	3,017	600
200	100	100	100	325	300	607	1,023	300
3,500	800	350	500	2,570	1,850	4,047	4,550	2,110
0	100	50	250	600	400	400	100	600
3,500	800	350	500	2,570	1,850	4,047	4,550	2,110
0	0	0	0	0	0	0	0	0
3,500	800	350	500	2,570	1,850	4,047	4,550	2,110
20,000	20,000	8,200	6,000	12,500	17,500	3,313	4,550	18,000
1,250	4,850	1,200	2,000	2,500	1,200	245	0	0
18,750	15,150	7,000	4,000	10,000	16,300	3,068	4,550	18,000
3	21	0	0	0	0	12	2	41
0	8	0	0	0	0	1	2	9
0	3	2	0	1	3	3	1	1
9,000	7,000	3,000	2,000	1,500	8,000	4,000	5,000	5,000
7,000	0	0	0	0	1,100	4,000	0	3,000
2,000	1,000	700	500	0	0	1,000	0	2,000
7,000	6,000	2,300	1,500	1,500	8,000	3,000	5,000	3,000
600	669	214	233	2,000	544	842	220	447

Silver Creek 7-I4	Drift Creek 7-I5	Beaver Creek 7-I6	Pudding River 7-I7	Little Pudding River 7-J	Mill Creek 7-K	Beaver Creek 7-L	Total Subbasin 7
105	105	30	480	195	675	300	4,705
4,900	1,000	200	3,000	1,000	7,000	2,050	70,150
18,000	7,500	300	5,140	1,500	5,000	2,800	285,510
3,670	5,820	3,930	34,910	31,740	40,400	13,540	330,320
410	770	420	3,550	0	600	950	27,190
8,100	1,100	130	3,600	2,000	11,130	600	49,730
35,080	16,190	4,980	50,200	36,240	64,130	19,940	762,900
3,370	5,220	3,530	31,410	26,740	36,100	12,940	280,043
300	600	400	3,500	5,000	4,300	600	50,277
3,670	5,820	3,930	34,910	31,740	40,400	13,540	330,320
1,000	1,000	200	2,000	1,000	1,000	950	34,230
0	0	0	0	0	0	0	990
150	300	400	500	2,000	1,720	80	16,952
100	150	0	2,500	2,500	645	350	25,875
50	150	0	500	500	1,935	170	6,460
300	600	400	3,500	5,000	4,300	600	50,277
20	30	20	100	300	400	200	3,670
300	600	400	3,500	5,000	4,130	580	50,087
0	0	0	0	0	170	20	190
300	600	400	3,500	5,000	4,300	600	50,277
4,000	1,040	2,600	21,860	20,000	15,100	4,800	239,563
0	0	520	0	2,000	1,030	180	53,725
4,000	1,040	2,080	21,860	18,000	14,070	4,620	185,838
20	10	5	0	4	20	8	155
3	4	2	0	1	1	0	32
3	4	2	3	1	6	0	33
1,000	800	800	11,000	6,000	15,000	3,000	105,000
1,000	800	800	0	2,000	5,000	1,000	45,700
100	100	500	0	1,000	6,000	1,000	24,300
900	700	300	11,000	5,000	9,000	2,000	80,700
130	318	100	250	1,708	1,710	0	17,135

Table A-1 (cont'd)

Reconnaissance Data on Tributary Areas Studied, Willamette River Basin 1/

Item	Unit	East Fork Dairy 8-A	McKay Creek 8-B	West Fork Dairy 8-C	Gales Creek 8-D	Tualatin River 8-E	Fanno Creek 8-F	Baker Creek 8-G	Chick Cree 8-H
Number of farms	Number	378	435	250	215	2,740	30	145	10
Land Use:									
Forest land grazed	Acres	1,800	3,500	1,500	1,200	9,300	1,250	2,000	1,50
Forest land not grazed	do.	25,720	20,490	32,190	36,920	77,110	2,820	5,620	1,32
Cropland	do.	20,780	27,600	13,500	7,600	65,740	4,240	5,900	6,10
Rangeland	do.	1,040	3,150	1,500	500	9,990	400	400	50
Other	do.	2,600	7,200	1,500	1,000	26,910	14,090	900	62
Total watershed area	do.	51,940	61,940	50,190	47,220	189,050	22,800	14,820	10,04
Cropland use									
Dryland	Acres	17,580	27,100	12,300	6,100	57,340	3,990	5,500	5,65
Irrigated	do.	3,200	500	1,200	1,500	8,400	250	400	45
Total	do.	20,780	27,600	13,500	7,600	65,740	4,240	5,900	6,10
Potential cropland	Acres	3,000	3,000	3,000	1,500	8,100	500	1,000	1,00
Irrigation:									
Water source									
Pumped from streams	Acres	2,750	500	1,050	1,475	6,950	200	250	37
Pumped from wells	do.	200	0	0	0	650	50	100	0
Other	do.	250	0	150	25	800	0	50	7
Total	do.	3,200	500	1,200	1,500	8,400	250	400	450
Water shortage	Acres	2,250	500	1,600	1,500	5,125	200	300	450
Method of application									
Sprinkling	Acres	3,200	500	1,200	1,500	7,550	250	400	450
Flooding	do.	0	0	0	0	850	0	0	0
Total	do.	3,200	500	1,200	1,500	8,400	250	400	450
Potentially irrigable land (not presently irrigated)	Acres	14,800	18,000	8.800	8,000	57.100	1,000	2,500	3.000
Water source									
Natural flows & ground water	do.	2,000	100	100	100	700	100	100	100
Other	do.	12,800	17,900	8,700	7,900	56,400	900	2,400	2,900
Storage:									
Existing ponds	Number	8	5	8	2	23	0	4	4
Existing reservoirs	do.	2	4	8	0	17	0	1	1
Possible sites studied	do.	2	3	5	1	2	1	2	1
Drainage:									
Arable land needing drainage	Acres	4,500	4,500	2,200	2,000	21,000	500	700	1,500
Needs									
Improved surface	Acres	1,000	1,000	500	500	4,000	0	0	0
Subsurface									
Open drains	Acres	1,000	1,000	500	500	4,000	100	100	200
Closed drains	do.	3,500	3,500	1,700	1,500	17,000	400	600	1,300
Flooded areas	do.	1,102	2,030	1,960	1,896	8,400	272	155	115

1/ *1963 data with portions updated to 1967.*

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Fanno Creek 8-F	Baker Creek 8-G	Chicken Creek 8-H	Total Subbasin 8	Deep Creek 9-A	Beaver Creek 9-B	Clear Creek 9-C	Eagle Creek 9-D	Clacka-mas River 9-E	Aber-nethy Creek 9-F	Total Subbasin 9
30	145	107	4,300	700	100	130	200	225	150	1,505
1,250	2,000	1,500	22,050	1,500	2,200	4,000	1,200	2,000	1,600	12,500
2,820	5,620	1,320	202,190	12,950	1,800	28,230	45,770	444,250	11,130	544,130
4,240	5,900	6,100	151,460	9,500	9,920	11,500	6,700	12,000	5,500	55,120
400	400	500	17,480	4,150	6,100	1,800	2,400	3,400	2,500	20,350
14,090	900	620	54,820	2,000	500	500	1,000	14,200	3,000	21,200
22,800	14,820	10,040	448,000	30,100	20,520	46,030	57,070	475,850	23,730	653,300
3,990	5,500	5,650	135,560	8,300	9,420	11,100	6,630	11,500	5,300	52,250
250	400	450	15,900	1,200	500	400	70	500	200	2,870
4,240	5,900	6,100	151,460	9,500	9,920	11,500	6,700	12,000	5,500	55,120
500	1,000	1,000	21,100	1,000	200	1,000	1,500	1,500	1,000	6,200
200	250	375	13,550	200	200	200	0	300	100	1,000
50	100	0	1,000	700	150	150	70	150	50	1,270
0	50	75	1,350	300	150	50	0	50	50	600
250	400	450	15,900	1,200	500	400	70	500	200	2,870
200	300	450	11,925	400	200	100	0	0	50	750
250	400	450	15,050	1,200	500	400	70	500	200	2,870
0	0	0	850	0	0	0	0	0	0	0
250	400	450	15,900	1,200	500	400	70	500	200	2,870
1,000	2,500	3,000	113,200	7,000	500	500	2,000	4,500	500	15,000
100	100	100	3,300	6,500	100	400	2,000	4,450	300	13,750
900	2,400	2,900	109,900	500	400	100	0	50	200	1,250
0	4	4	54	27	15	25	1	4	12	84
0	1	1	33	0	5	0	0	3	4	12
1	2	1	17	2	3	2	1	0	1	9
500	700	1,500	36,900	6,000	400	300	500	5,600	0	12,800
0	0	0	7,000	1,000	0	0	0	2,500	0	3,500
100	100	200	7,400	0	0	0	0	600	0	600
400	600	1,300	29,500	6,000	400	300	500	5,000	0	12,200
272	155	115	15,930	100	100	116	0	300	121	737

Table A-1 (cont'd)
Reconnaissance Data on Tributary Areas Studied, Willamette River Basin 1/

Item	Unit	Milton Creek 10-A	Scappoose Creek 10-B	Portland 10-C	Fairview 10-D	Johnson Creek 10-E
Number of farms	Number	80	270	570	200	350
Land Use:						
Forest land grazed	Acres	1,100	2,800	1,500	560	1,300
Forest land not grazed	do.	16,400	42,850	14,350	1,000	3,900
Cropland	do.	3,000	4,900	26,020	7,020	6,800
Rangeland	do.	600	950	4,900	2,020	2,800
Other	do.	1,000	900	108,430	5,000	14,000
Total watershed area	do.	22,100	52,400	155,200	15,600	28,800
Cropland use						
Dryland	Acres	2,800	4,400	20,210	2,000	4,600
Irrigated	do.	200	500	5,810	5,020	2,200
Total	do.	3,000	4,900	26,020	7,020	6,800
Potential cropland	Acres	1,000	2,500	6,100	1,600	1,300
Irrigation:						
Water source						
Pumped from streams	Acres	150	350	5,730	3,000	400
Pumped from wells	do.	0	50	80	1,600	1,400
Other	do.	50	100	0	420	400
Total	do.	200	500	5,810	5,020	2,200
Water shortage	Acres	150	300	100	0	700
Method of application						
Sprinkling	Acres	200	450	5,510	5,020	2,200
Flooding	do.	0	50	300	0	0
Total	do.	200	500	5,810	5,020	2,200
Potentially irrigable land (not presently irrigated)	Acres	1,200	5,000	15,200	3,600	1,000
Water source						
Natural flows & ground water	Acres	200	2,200	15,000	3,600	500
Other	do.	1,000	2,800	200	0	500
Storage:						
Existing ponds	Number	1	10	12	5	15
Existing reservoirs	do.	1	3	1	2	1
Possible sites studied	do.	3	3	1	0	2
Drainage:						
Arable land needing drainage	Acres	900	3,000	6,200	5,000	6,000
Needs						
Improved surface	Acres	0	0	1,400	0	0
Subsurface						
Open drains	Acres	0	1,000	1,100	0	0
Closed drains	do.	900	2,000	5,100	5,000	6,000
Flooded areas	do.	65	92	7,100	114	1,500

1/ 1963 data with portions updated to 1967.

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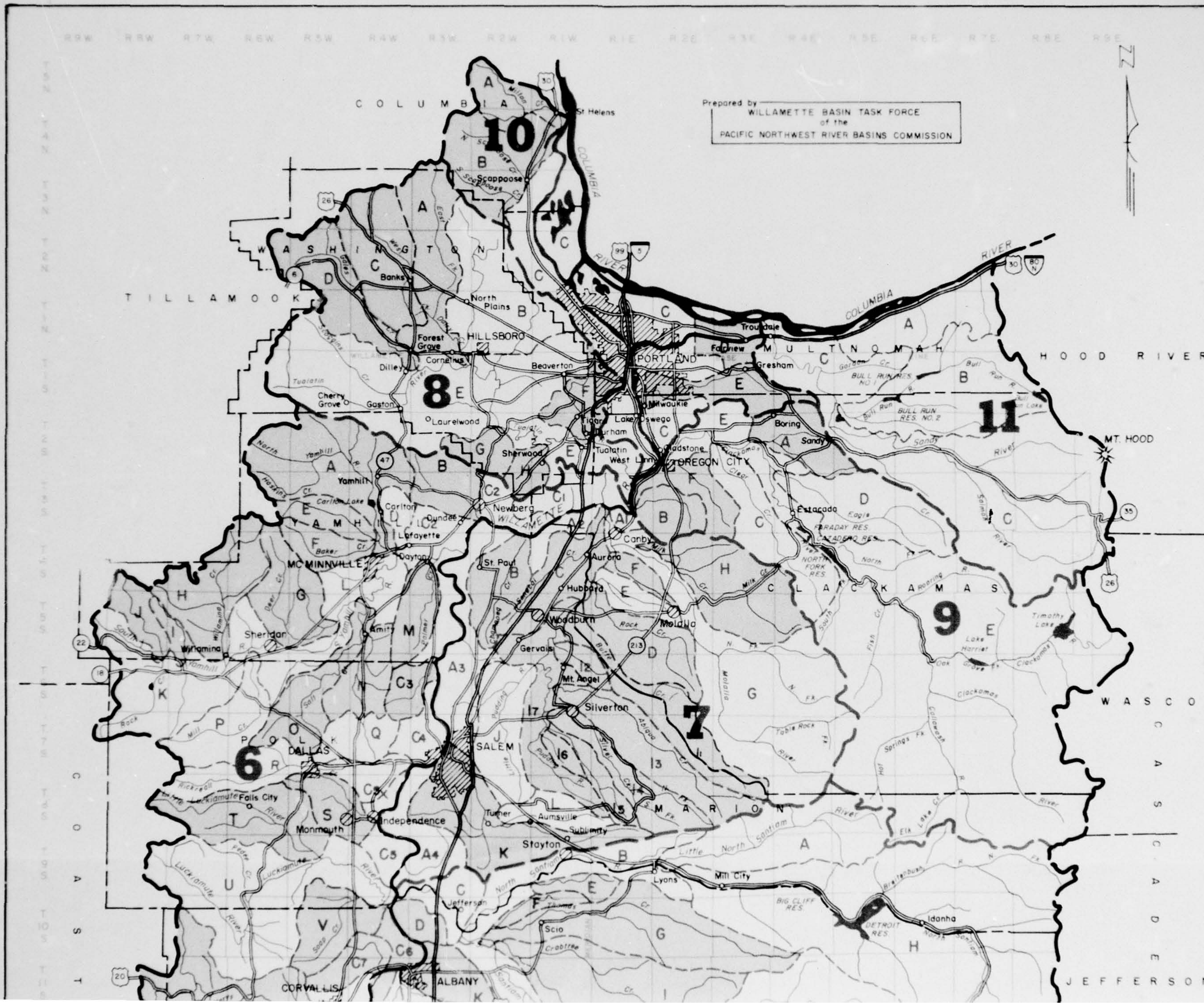
Fairview 10-D	Johnson Creek 10-E	Total Subbasin 10	Bonneville 11-A	Bull Run River 11-B	Sandy River 11-C	Total Subbasin 11
200	350	1,470	20	17	350	387
560	1,300	7,260	1,200	0	9,800	11,000
1,000	3,900	78,500	39,570	86,790	193,200	319,560
7,020	6,800	47,740	400	450	12,730	13,580
2,020	2,800	11,270	1,800	160	4,300	6,260
5,000	14,000	129,330	4,000	2,000	17,000	23,000
15,600	28,800	274,100	46,970	89,400	237,030	373,400
2,000	4,600	34,010	360	410	10,430	11,200
5,020	2,200	13,730	40	40	2,300	2,380
7,020	6,800	47,740	400	450	12,730	13,580
1,600	1,300	12,500	500	400	4,000	4,900
3,000	400	9,630	40	40	500	580
1,600	1,400	3,130	0	0	1,300	1,300
420	400	970	0	0	500	500
5,020	2,200	13,730	40	40	2,300	2,380
0	700	1,250	0	0	0	0
5,020	2,200	13,380	40	40	2,300	2,380
0	0	350	0	0	0	0
5,020	2,200	13,730	40	40	2,300	2,380
3,600	1,000	26,000	100	0	2,000	2,100
3,600	500	21,500	100	0	1,500	1,600
0	500	4,500	0	0	500	500
5	15	43	0	2	10	12
2	1	8	0	3	3	6
0	2	9	0	0	3	3
5,000	6,000	21,100	0	0	10,000	10,000
0	0	1,400	0	0	0	0
0	0	2,100	0	0	0	0
5,000	6,000	19,000	0	0	10,000	10,000
114	1,500	8,871	600	0	2,000	2,600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HOOD RIVER
CLACKAMAS
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WASCO
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COAST
PORTLAND
SALEM
HILLSBORO
OREGON CITY
MC MINNVILLE
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CORVALLIS
ALBANY
MT. HOOD
St. Helens
Scappoose
Banks
North Plains
Forest Grove
Cornelius
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Cherry Grove
Gaston
Laurelwood
Tigard
Lake Oswego
Durham
Milwaukie
Gladstone
Tualatin
West Linn
Sherwood
Yamhill
Carlton
Newberg
Dundee
Lafayette
Dayton
Troutdale
Fairview
Gresham
Boring
Sandy
Estacada
Canby
Aurora
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Hubbard
Woodburn
Molalla
Gervais
Mt. Angel
Silverton
Sheridan
Willamina
Amity
Falls City
Monmouth
Independence
Turner
Aumsville
Sublimity
Stayton
Lyons
Mill City
Idanha
Jefferson
Scio
COLUMBIA RIVER
WILLAMETTE
BULL RUN RES. NO. 1
BULL RUN RES. NO. 2
FARADAY RES.
NORTH FORK RES.
BIG CLIFF RES.
DETROIT RES.
Timothy Lake
Lake Harriet
10
8
11
9
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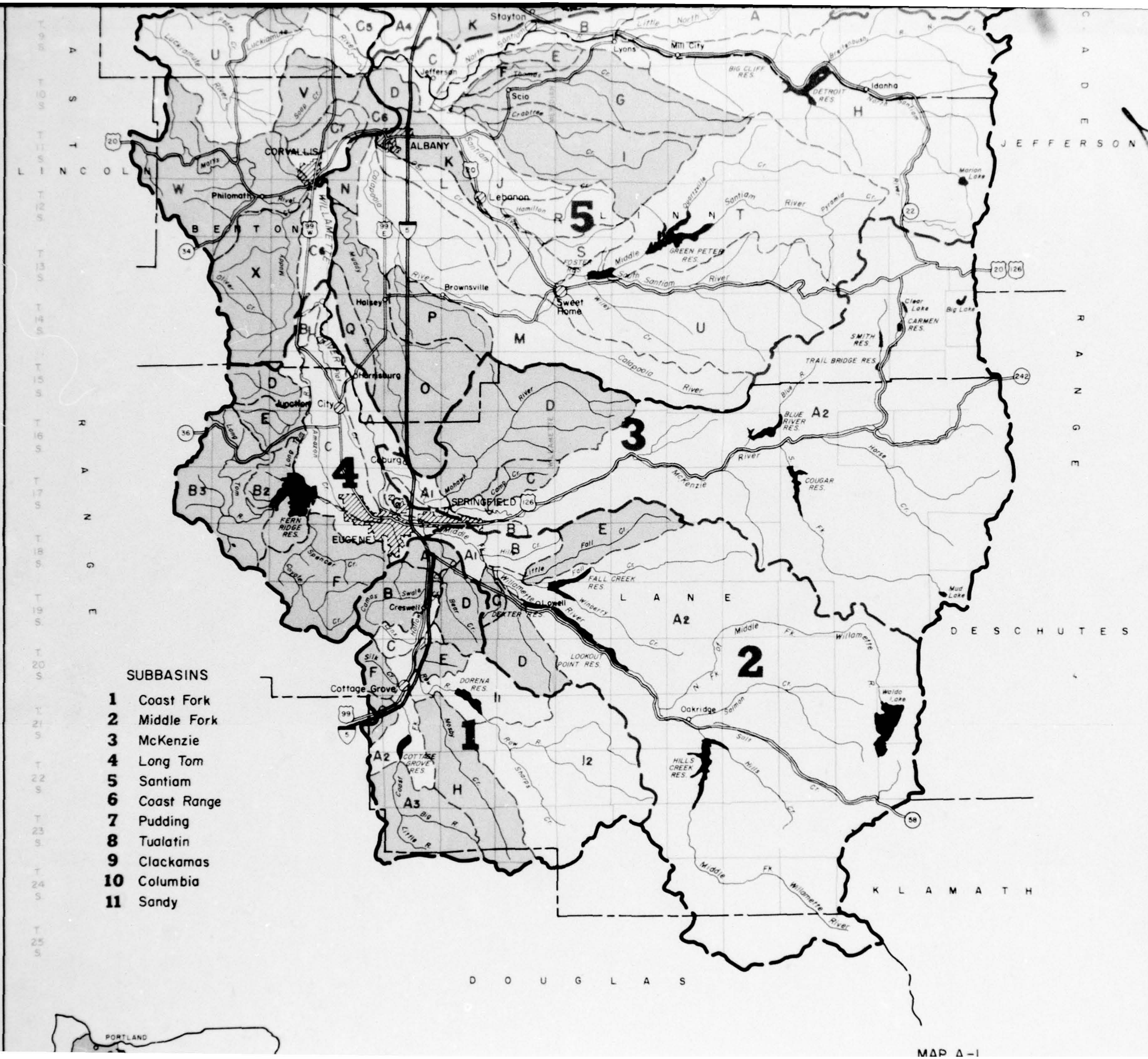
6


SUBBASINS
1 Coast Fork
2 Middle Fork
3 McKenzie
4 Long Tom
5 Santiam
6 Coast Range
7 Pudding
8 Tualatin
9 Clackamas
10 Columbia
11 Sandy
LINCOLN
BENTON
LINN
LANE
DOUGLAS
KLAMATH
DESCHUTES
JEFFERSON
CASCADE RANGE
COAST RANGE
CORVALLIS
ALBANY
EUGENE
SPRINGFIELD
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Lyons
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Jefferson
Scio
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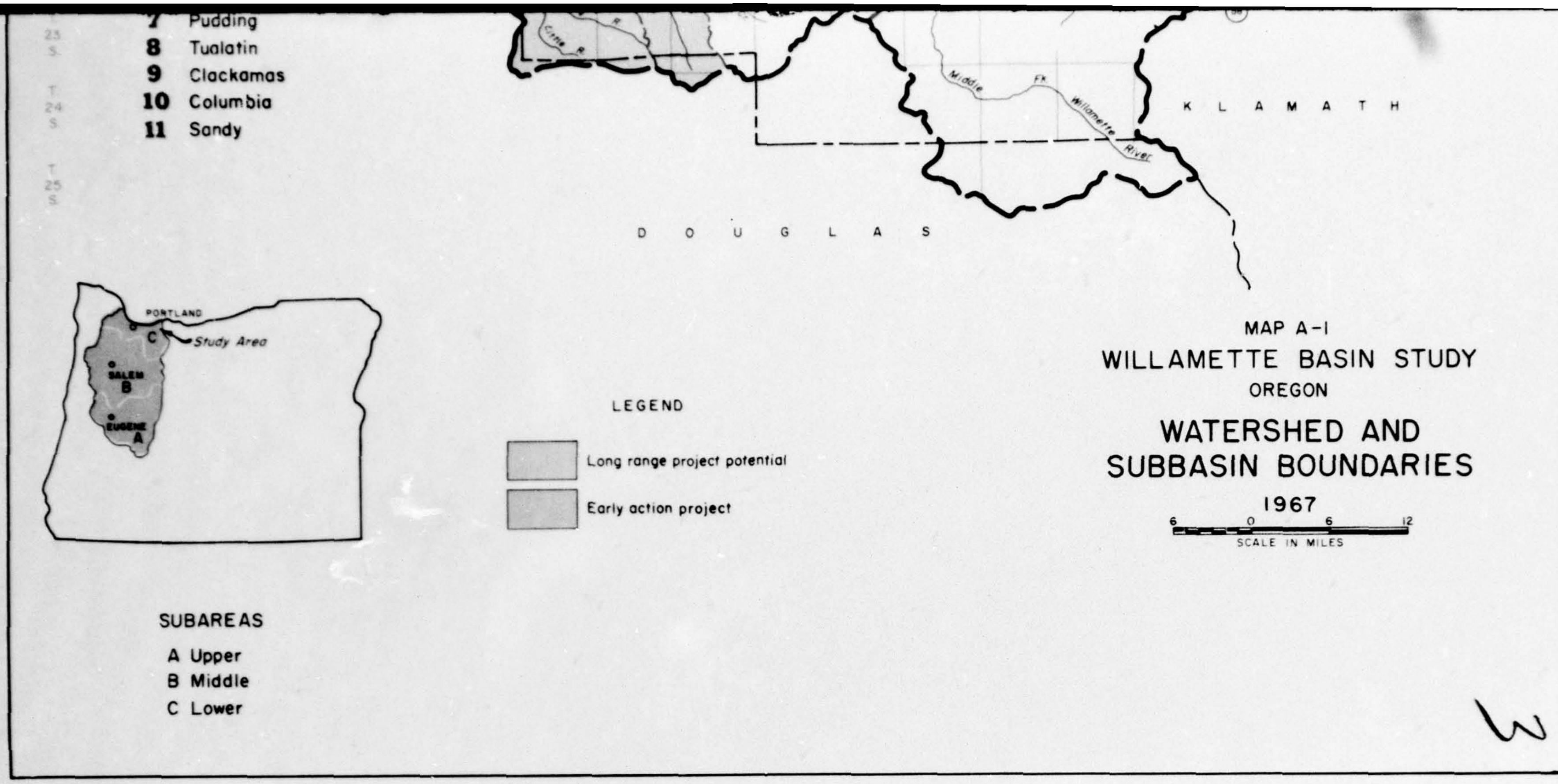
Philomath
Brownsville
Halsey
Sweet Home
Harrisburg
Junction City
Coburg
Creswell
Cottage Grove
Lowell
Oakridge
PORTLAND
DETROIT RES.
BIG CLIFF RES.
GREEN PETER RES.
FOSTER RES.
SMITH RES.
CARMEN RES.
TRAIL BRIDGE RES.
BLUE RIVER RES.
COUGAR RES.
FALL CREEK RES.
DEXTER RES.
LOOKOUT POINT RES.
DORENA RES.
COTTAGE GROVE RES.
HILLS CREEK RES.
FERN RIDGE RES.
Waldo Lake
Marion Lake
Clear Lake
Big Lake
Mud Lake
WILLAMETTE RIVER
McKenzie River
Calapooia River
Santiam River
South Santiam River
Middle Fk. Willamette River
MAP A-1



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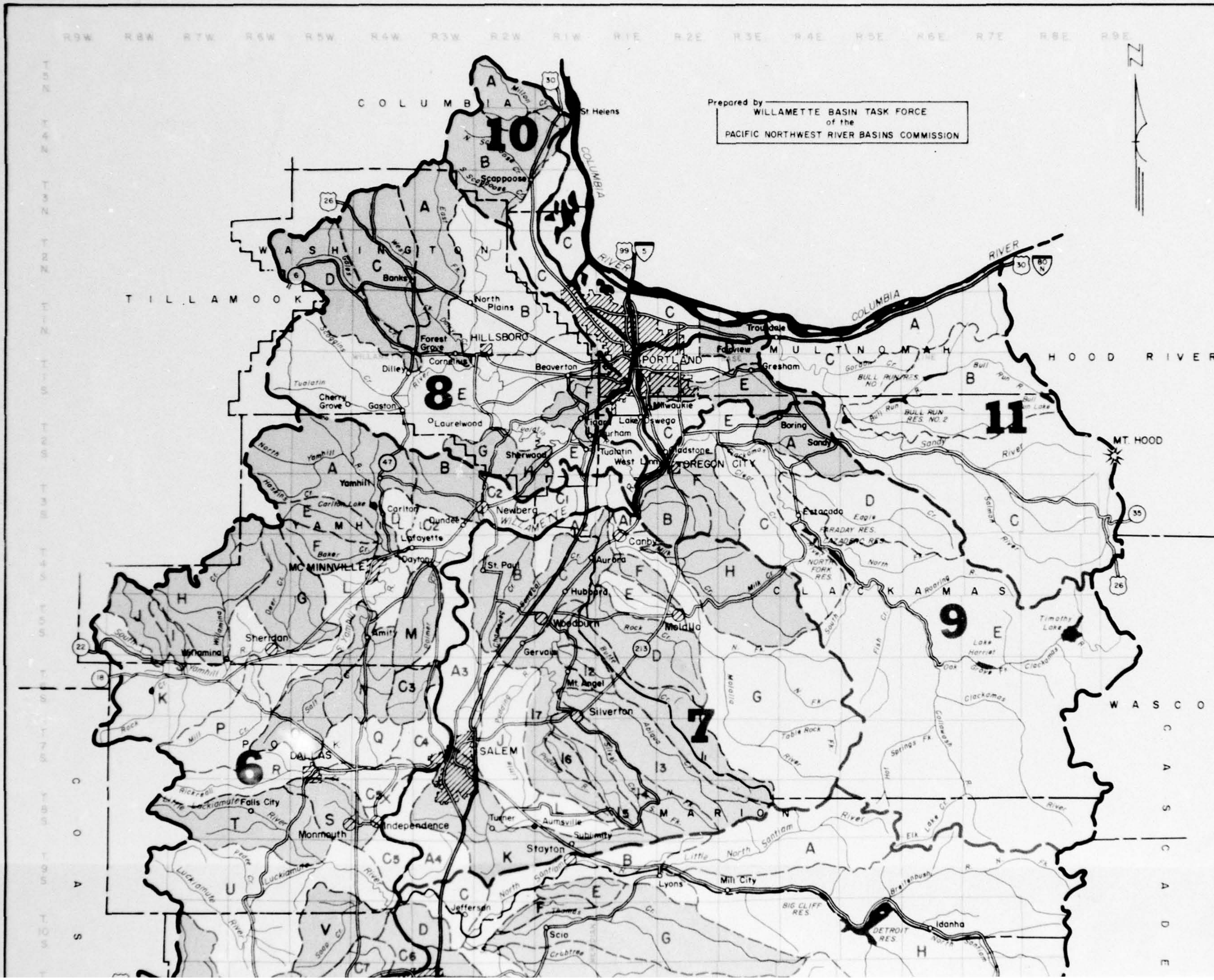

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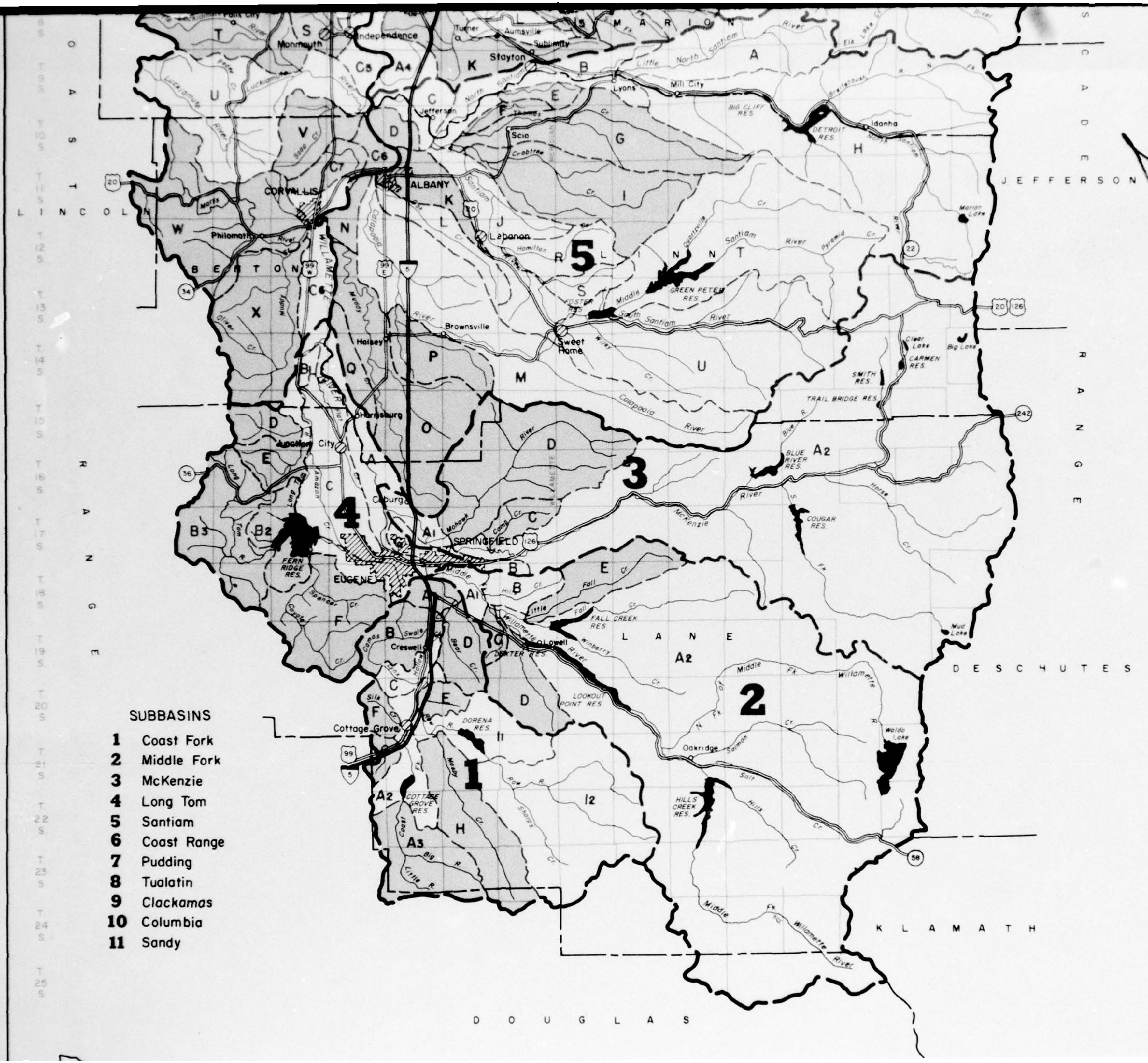

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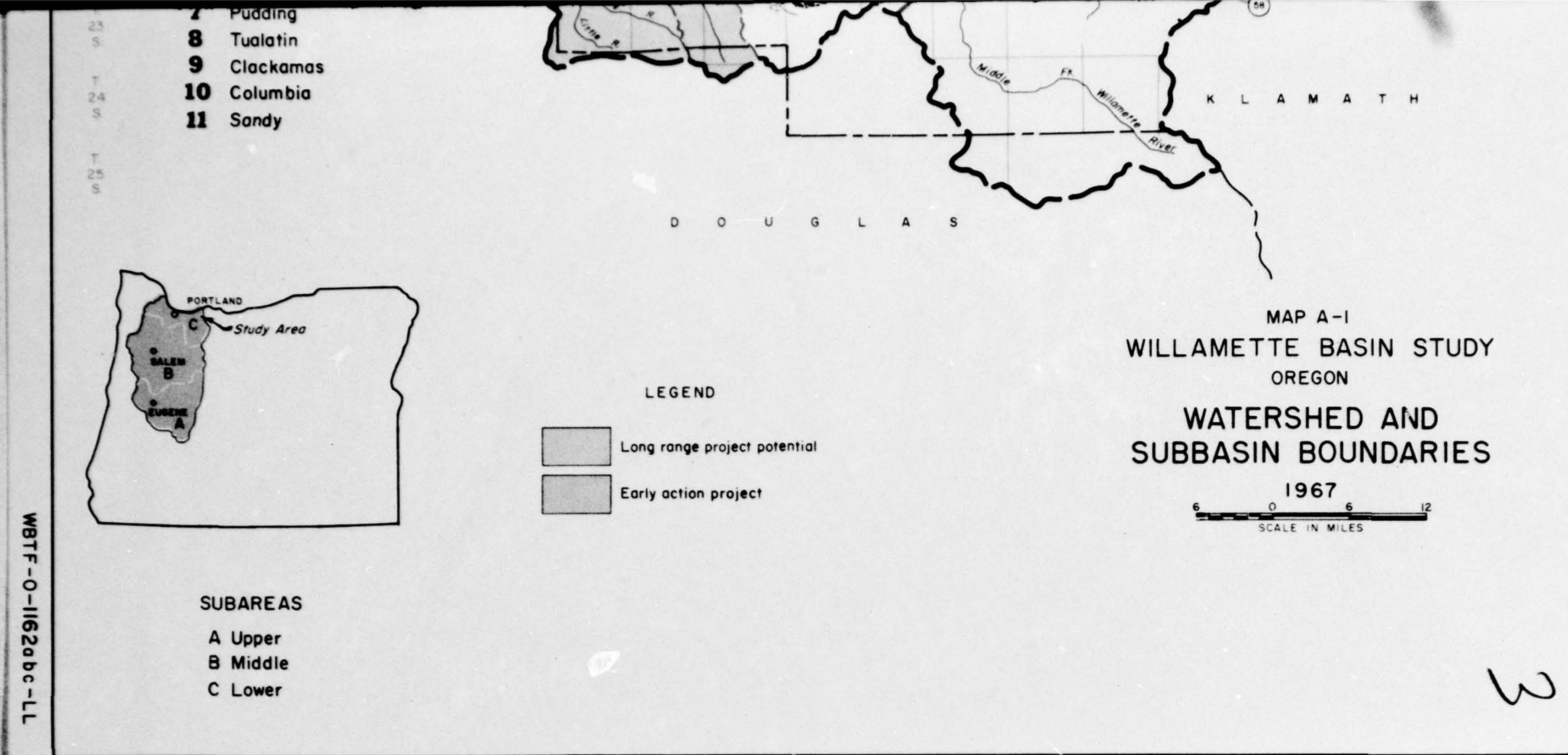
Green Peter Res.
Blue River Res.
Cougar Res.
Fall Creek Res.
Lookout Point Res.
Dexter Res.
Dorena Res.
Cottage Grove Res.
Hills Creek Res.
Fern Ridge Res.
Waldo Lake

2



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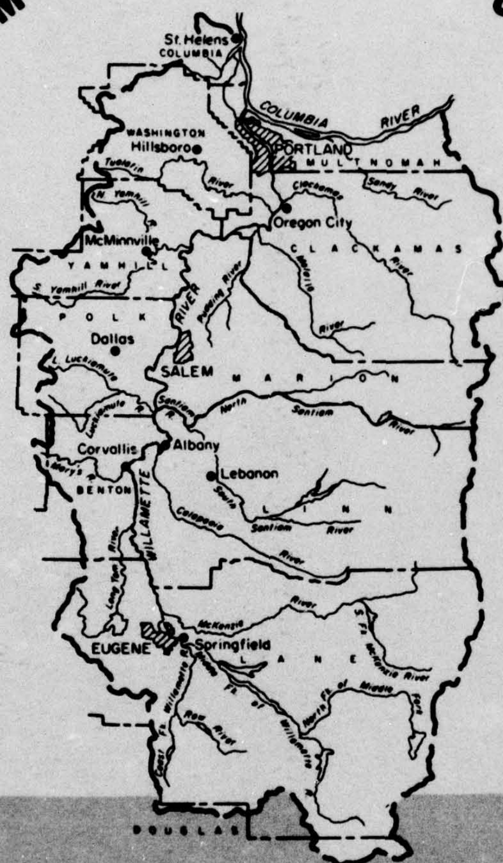
COMPREHENSIVE STUDY



Willamette Basin

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