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Title: HIGHLIGHTS IN THE CHANGING RESOURCE PERCEPTION AND LAND USE OF THE WILLAMETTE RIVER FLOOD PLAIN, ALBANY-CORVALLIS AREA

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Richard M. Highsmith, Jr.

Taking advantage of a favorable physical system but also risking the hazards of flooding, man has long occupied flood plain land. He has attempted to adjust rivers to his needs in order to reduce flood loss, but the rising cost of flood protection accompanied by an increase in flood damage potential warrants that a course of human adjustment be undertaken on occupied flood plains.

The flood plain of the Willamette River between Albany and Corvallis, Oregon provides an opportunity to study the resource use of a flood plain in a relatively youthful stage of economic development, having the physical assets and limitations of most flood plains. By studying the physical system and changing resource utilization of this flood plain, an evaluation has been made of the present and possible future use of its resource base.

Land use has evolved from a primitive stage of hunting, fishing, and gathering to intensive agricultural endeavors with some residential and commercial development. Resource utilization during the same period has changed from a dependence on the flora and fauna for food and clothing to a dependence on the soil and climate, flood protection, markets, labor, and so forth. The change has been towards a more intensive, higher valued use of the land with more sophisticated land management practices.

A relatively satisfactory arrangement of land use presently exists on the Albany-Corvallis flood plain; however, present land use practices in the study area reflect a rational use of flood subjected land primarily because the pressures of industrial and commercial development have not yet been heavily felt. Residential expansion, however, has taken place at an alarming rate.

Many of the human adjustments suggested by Gilbert White in his flood plain studies at the University of Chicago are applicable to a future course of orderly occupance for the Albany-Corvallis flood plain. One of the more applicable local forms of adjustment is the directing of flood plain use which involves land elevation, land use regulation, structural modifications, flood insurance, relief, and better warning systems.

The construction of engineering works for flood abatement represents the traditional form of river adjustment in the Willamette

Basin. The building of storage dams upstream of the study area has lowered the height of the flood crest but has also given many flood plain dwellers a feeling of false security. Channel improvements and bank revetments are the main form of river adjustment in the study area,and they help to reduce the danger of crop drowning and to control bank erosion.

HIGHLIGHTS IN THE CHANGING RESOURCE PERCEPTION AND LAND USE OF THE WILLAMETTE RIVER FLOOD PLAIN, ALBANY-CORVALLIS AREA

by

ANTHONY JAMES LEWIS

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I. INTRODUCTION

The Study Area and the Study Problem

Man has long occupied and utilized the lowland adjacent to rivers. His assessment of the functional utility of these flood vulnerable lands has been influenced by their generally favorable physical system whose many facets interact to establish a land base from which he has erected diversified economies. The Tigris-Euphrates, the Nile, and the Ganges River flood plains exemplify man's early settlement patterns in conjunction with this type of land area. Early attractions of flood plains were largely a combination of physical conditions that favored agriculture. Naturally productive soils, a comparatively smooth surface, availability of water, and ease of transport focused man's attention on agricultural endeavors. Although agriculture has remained a paramount use, through the years man has increasingly evaluated the flood plain for industrial, residential, and recreational uses.

Since floods are a natural phenomenon, occupying land within the natural boundaries of a river is not without hazard (see Figure 1). A natural tax in the form of flood damage is collected sporadically as

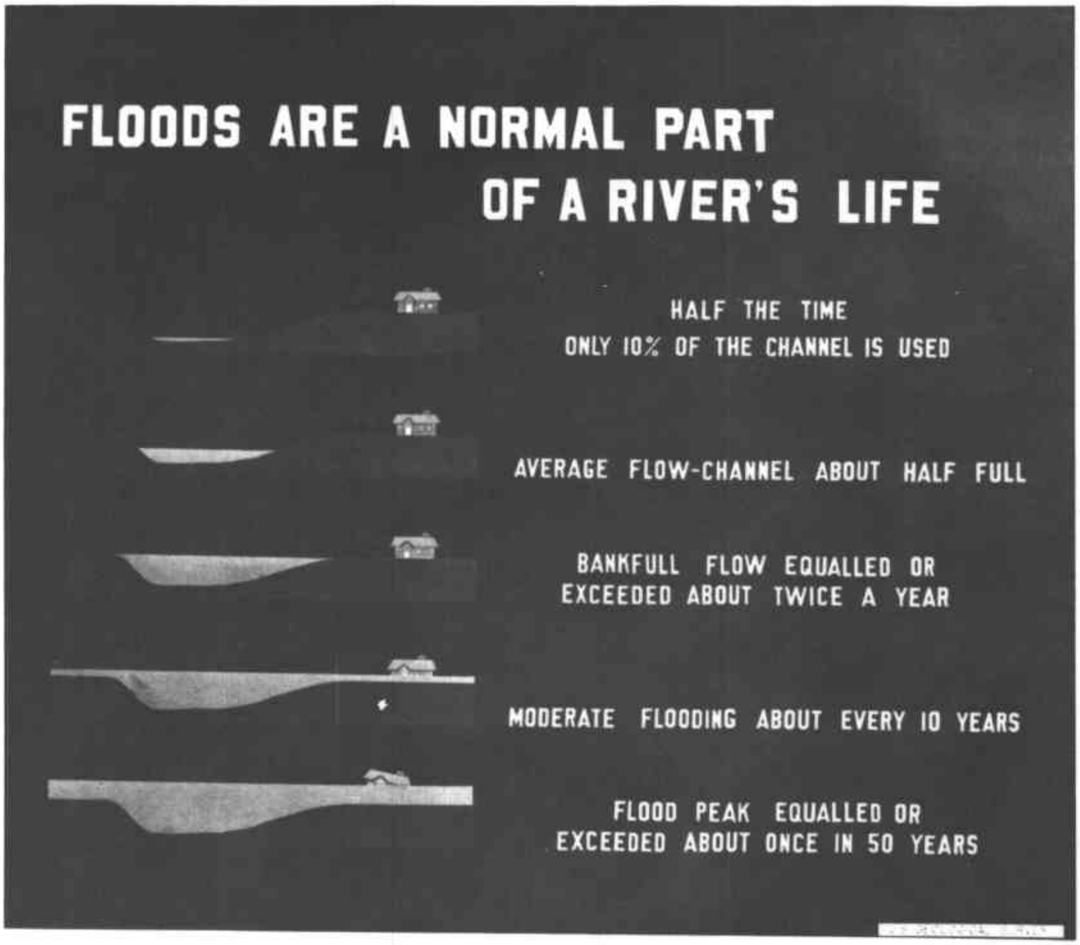


Figure 1. Floods are a normal part of a river's life.

The flood plain is part of a river and is needed periodically to carry some of the flow. A river excavates a channel that can carry within its banks only the peak flows that occur on the average of twice a year. Higher peaks are carried by using the flood plain in addition to the regular channel. The frequency and depth of flow on the flood plain are characteristics that can be determined for a stream (68, p. 54-55).

the river temporarily reclaims lost land. When the natural boundaries of the river have been trespassed, flood damage results. This is a man made problem, the magnitude of which is aligned with the extent of intensification and investment on the flood plain (see Figure 2). As flood plain development has continued, flood control projects have become necessary to protect man against this legitimate marauder. Although complete protection is not feasible, flood control projects have offered a false security and enhanced flood plain investments, and with a larger than design flood, previous losses have been exceeded. Since floods can neither be prevented nor completely controlled, there is a point at which the magnitude of flood damage exceeds economic returns and continued development should theoretically cease.

The flood plain between Albany and Corvallis (see Figure 3) has been selected for study because it is in a relatively youthful stage of economic development and has the physical assets and limitations of most flood plains. The high water line of the 1943 flood, which coincides with natural levees marking the landscape, has been used as the basis for the delineation of the east and west boundaries of the flood plain. The north and south boundaries were arbitrarily set by the use of political and cultural features. The 1965 Albany city limits define the northern boundary, and Oregon Highway #34 as it runs east of the Van Buren Street bridge defines the southern

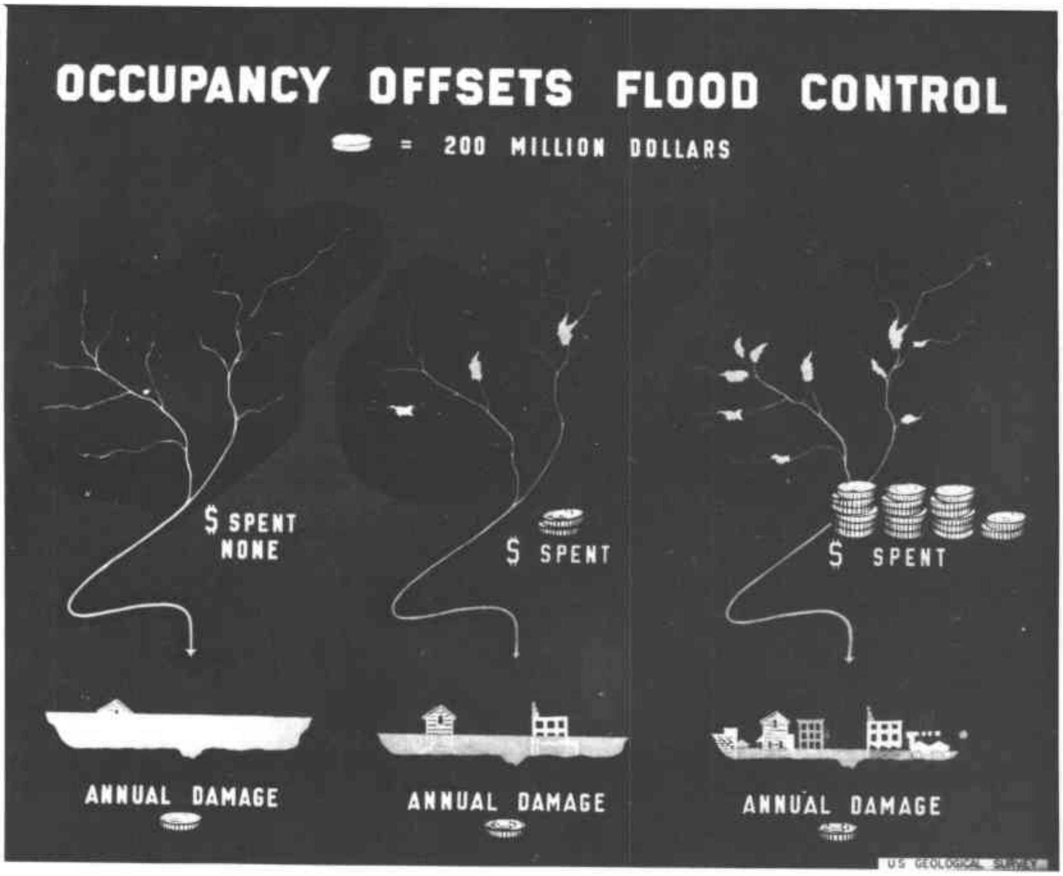
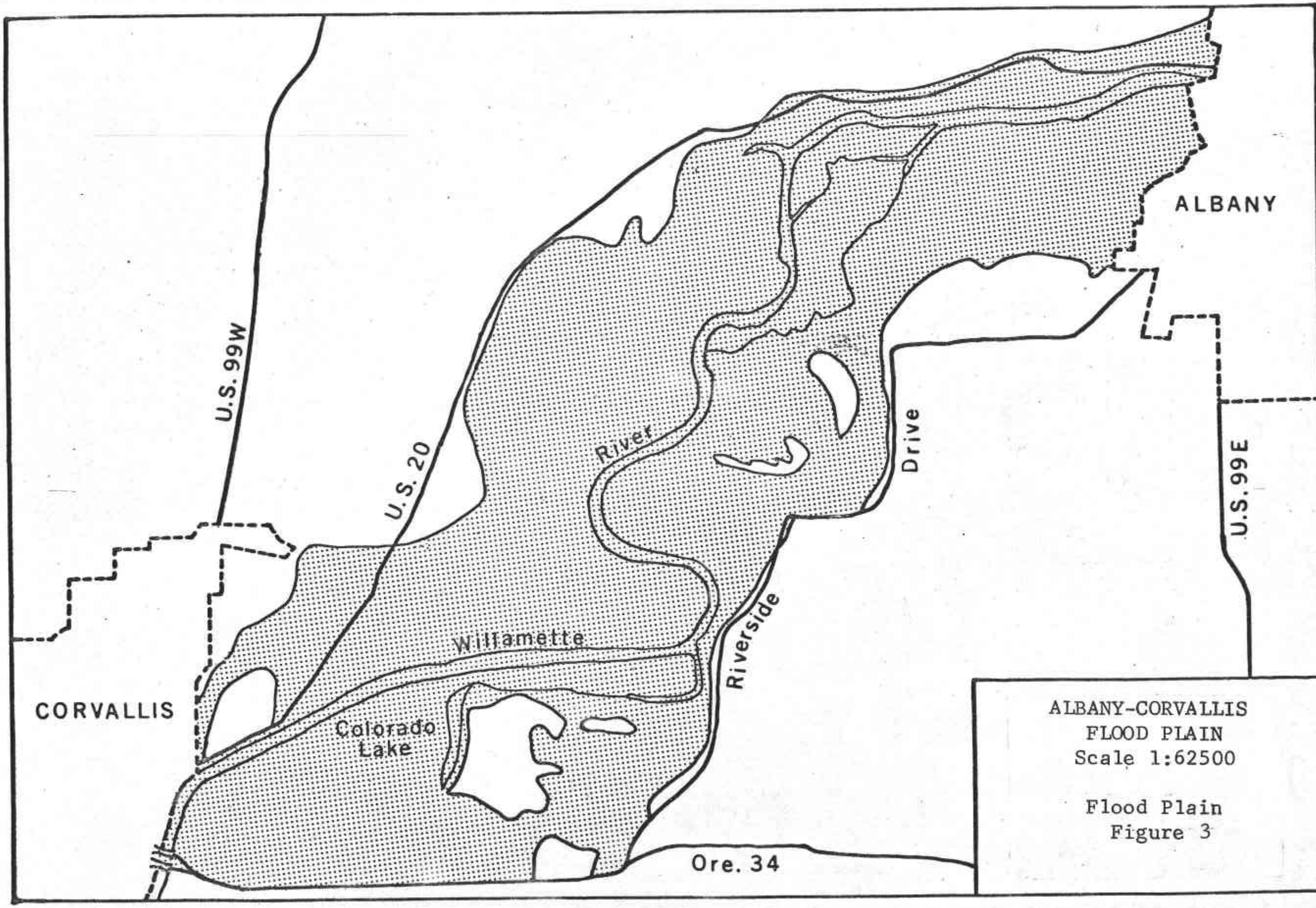


Figure 2. Occupancy offsets flood control.

Complete protection from the catastrophic flood is not economically feasible. Despite the increasing national expenditure for flood protection, the national annual flood damages remain the same because of the increase in occupancy on the partially protected flood plains (68, p. 56-57).



ALBANY-CORVALLIS
FLOOD PLAIN
Scale 1:62500

Flood Plain
Figure 3

boundary. The resulting enclosed rural area has an approximate length of 9.75 miles and an approximate width of 1.7 miles. The total area is 16.15 square miles or 10,316 acres. The area is well suited to agriculture which still prevails as the major economy. This is in contrast to the already heavily developed flood plains in the industrialized part of the United States where major development often has taken place without considering its optimum use as flood plain land. Being located between two evolving urban centers, this rural area will experience the pressures that accompany increasing population and commercial and industrial growth, some of which can already be noticed. For a rational occupance to accompany its impending economic development, order must be introduced to the development plan.

Purpose and Methodology

The purpose of this thesis is to analyze the changing utilization of the Albany-Corvallis flood plain's resources, and will encompass the following:

1. Examining the physical system and flood record as they influence utility;
2. Tracing the changing resource perception as reflected in land use patterns, placing particular stress on the period between 1940 and 1965;

3. Suggesting a rational occupance primarily based upon techniques that have been developed at the University of Chicago by Gilbert White, Robert Kates, Ian Burton, John Shaeffer, and Francis Murphy.

In collecting the information necessary to complete the research involved in this thesis, the author used many of the methods and techniques of a geographer. The primary research procedures were the following:

1. Investigation of flood plain literature, especially the writings of geographers which dealt with flood plain occupance and human adjustment to floods;
2. Perusal of records and literature dealing with the history and settlement of the area;
3. Interviews with the flood plain occupants, the Agricultural Agents of both Benton and Linn Counties, and personnel from numerous state and federal agencies including the Corps of Engineers, the Soil Conservation Service, the Willamette Valley Task Force, the Oregon State Planning Board, and the State Water Resources Board;
4. Preparation of land use maps for 1940 and 1965 based on airphoto interpretation, interviews, and field inspection.

II. THE PHYSICAL SYSTEM

The cultural interpretation of the functional utility of the flood plain's physical system cannot be evaluated accurately without an understanding of its characteristics, including surface features, soils, drainage, climate, and natural vegetation.

Surface, Soils, and Drainage

The Albany-Corvallis flood plain, typical of the Willamette River flood plain as a whole, has a level to gently undulating surface bounded on much of the east and west by natural terraces (see Figures 4 and 5). Local relief is generally under 15 feet with a maximum relief of approximately 77 feet. The slope ranges from zero to seven percent with the greater portion averaging from zero to three percent. Elevation above sea level is from 138 feet to 215 feet. Several islands of higher elevation do rise up to ten feet above the levels of twentieth century floods; however, the entire area was inundated by the 1861 flood. It is at the bases of these higher lands that slopes of three to seven percent are recorded.

The Willamette River and its associated flood plain have the characteristics of the mature stage of river development. These include meanders and meander scars, ox-bow lakes, a braided channel, and a wide flood plain. Other typical features of the landscape are

Figure 4. Flood plain topography.

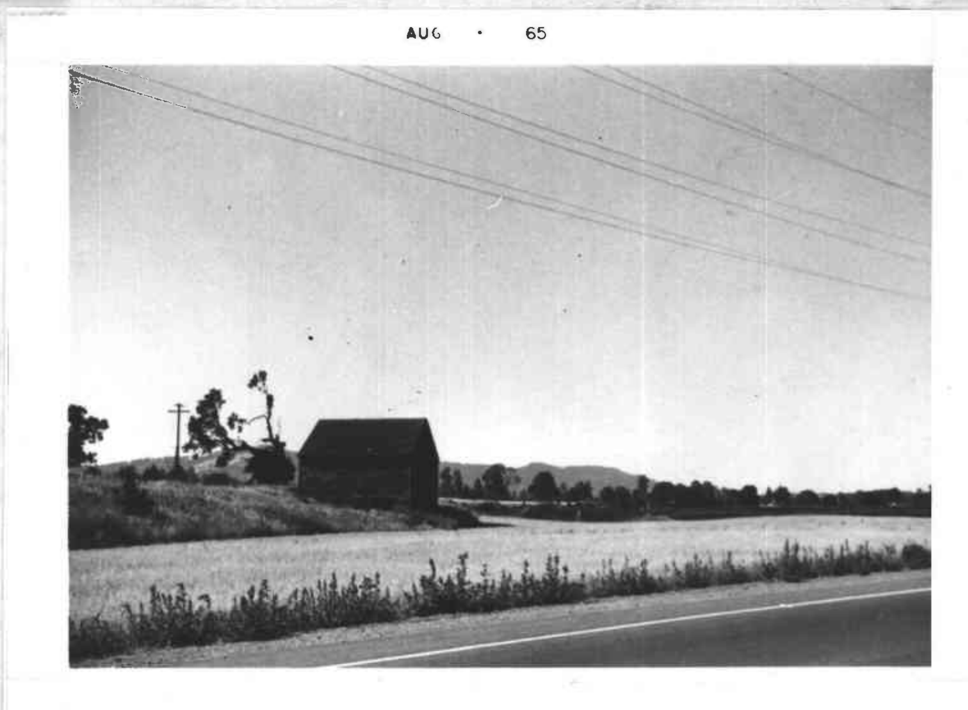


Figure 5. Flood plain terrace.

flood-ways and abandoned channels and bars which are commonly marked by trees and shrubs. The geologic history of the valley, however, is atypical, since the river and adjacent strip of land have not proceeded through all of the stages of river and flood plain development. Rather than resulting from erosion and cutting by a river, the Willamette Valley was formed by folding and warping of the earth's crust. During the Pleistocene period, meltwater from glaciers inundated the valley and lacustrine materials were deposited upon the valley floor forming a smoothly graded surface (50, p. 7). Subsequently, the Willamette River established its course. During lateral movement, lacustrine sediments were removed and alluvium deposited. Today, the alluvial deposits comprise the active flood plain and represent the parent material of the soil.

The soils of the Albany-Corvallis flood plain (see Figure 6) are of recent alluvial origin and are representative of those that occupy the bottom lands of the entire Willamette Valley. The most recent soil survey by the Soil Conservation Service divides these flood plain soils into six series which are grouped into two soil associations. The well-drained soils series, the Chehalis, Cloquato, Newberg, and Camas soils, comprise the Chehalis-Cloquato-Newberg Association; the poorly-drained Wapato and Maytown soils comprise the Wapato-Maytown Association (see Table I for soil characteristics).

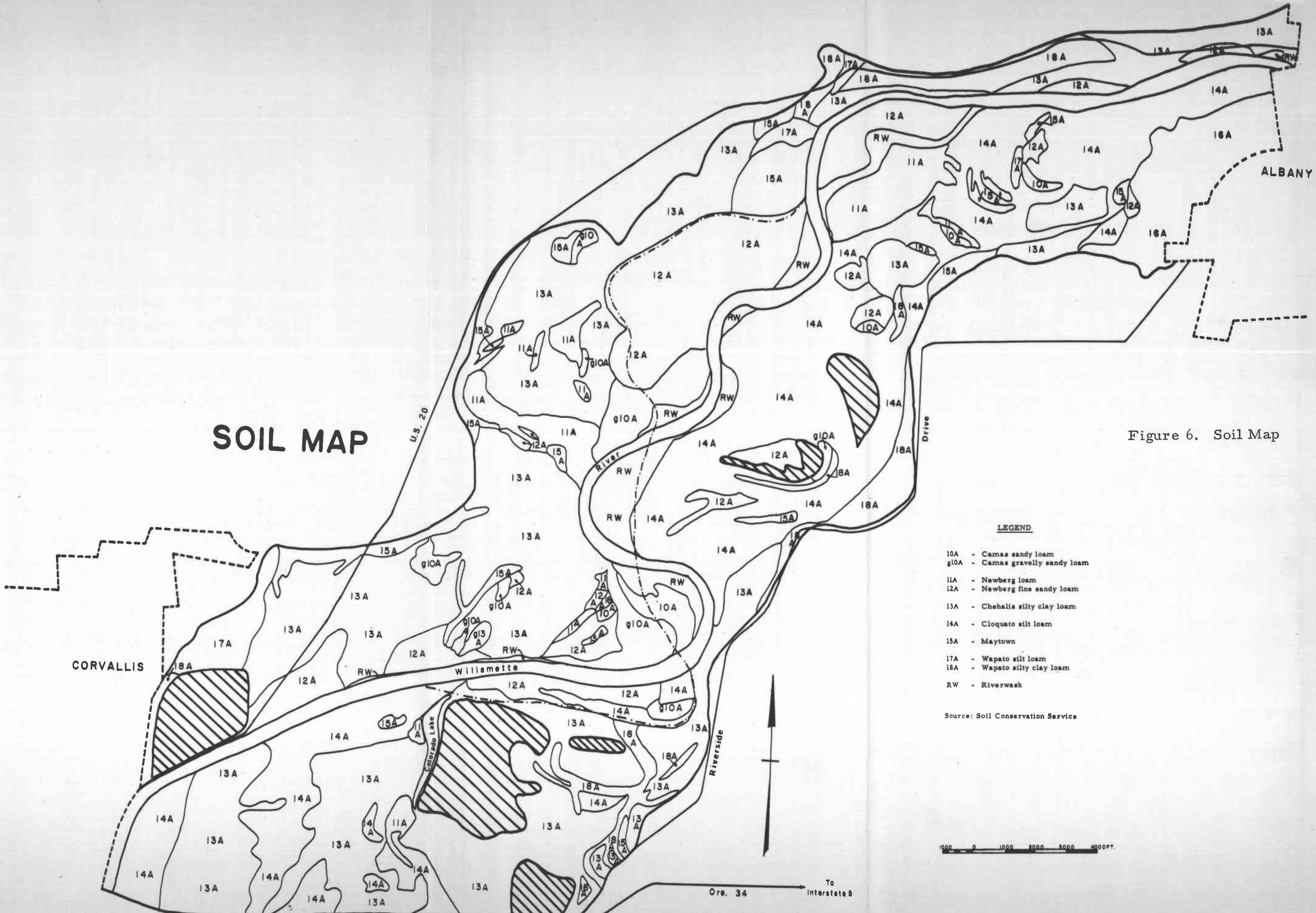


Figure 6. Soil Map

Table I. Soil characteristics.[a]

Soil series	Soil capability	Drainage class	Effective depth (inches)	Subsoil permeability	Topsoil texture	Slope %	Soil color: dry	Soil color: wet	pH	Inherent fertility	Available moisture capacity (inches/5 ft.)	Infiltration rate (inches/hour)	Parent material
Chehalis	II e-1	well drained	>60	moderate	silty clay loam	0-3	grayish brown	dark grayish brown	6.5-7.0	high	10.0	0.5	mixed alluvium
Newberg	II w-1	somewhat excessively drained	>60	rapid	sandy loam	0-3	dark brown	very dark brown	6.0-6.5	med. to high	6.5	0.75	mixed alluvium
Cloquato	II e-1	well drained	>60	moderately rapid	silt loam	0-3	brown	dark brown	6.5	high	10.0	0.5	mixed alluvium
Wapato	II w-1	poorly drained	>60	moderately slow	silty clay loam	0-3	very dark grayish brown	very dark brown	6.0-6.2	med.	10.0	0.5	mixed alluvium
Maytown	II w-2	moderately well drained	>60	moderate	silt loam	0.7	dark brown	very dark brown	6.0	high	10.5	0.5	mixed alluvium
Camas	IV w-2	excessively drained	10-20	rapid	gravelly sandy loam	0-7	brown	dark brown	6.3	low	3.0	0.75	mixed alluvium

[a]Compiled from unpublished SCS data.

Chehalis-Cloquato-Newberg Association

The soils of the Chehalis-Cloquato-Newberg Association are characterized by gently undulating relief and numerous overflow channels cut by flood waters. These soils have developed into moderately coarse to moderately fine textured alluvium with weak to well developed solums. The Chehalis soils are found on the higher elevations that are rarely subject to overflow, whereas the Cloquato, Newberg, and Camas soils occupy the lower positions and are inundated almost annually. The Cloquato soils occur on gently sloping land and meander scars; Newberg soils are found mainly on the natural levees; Camas soils occupy the slightly higher gravelly sections, often being inclusions in the Newberg series. The coarser textured Newberg and Camas soils tend to be more droughty than the Chehalis and Cloquato series and in some cases more difficult to till.

Wapato-Maytown Association

The soils of the Wapato-Maytown Association cover the low backwater areas of the flood plain where the topography is level to gently undulating. The component soils have weak to well developed solums of moderately fine to fine textured alluvium. The Maytown soils occupy the slightly higher elevations of the flood plain and have better drainage than the Wapato soils, which usually are found at the base of the terrace. Along the outer boundary of the active flood plain these low areas are inundated by surface runoff from the adjacent terrace as well as from stream overflow.

Although the soils of both associations rank high in the productivity ratings of the Willamette Valley soils, several limitations may be noted. Both soil associations are plagued with the seasonal extremes of too much or too little water. Overflow during the winter season offers the constant threat of flood damage on all but the Chehalis series. Poor drainage, especially on the Wapato and Maytown soils, prohibits early cultivation unless artificial drainage has been provided. Conversely, droughty conditions during the dry summer months inhibit maximum production of shallow rooted crops on the well drained soils unless supplemental irrigation is provided. Chemical deficiencies of nitrogen, calcium, phosphorous, sulfur, and boron are found in varying degrees on all of the soils. These deficiencies are eliminated by the addition of selective chemicals, to which the soils respond well, rather than by the use of a complete fertilizer.

Climate

The climate of the study area is representative of the Willamette Valley's Dry Summer Marine Climate and is characterized by moderate temperatures, a long growing season, seasonal concentration of precipitation, and comparative freedom from strong winds, hail, and electrical storms. Climate, which is a definite variable from one flood plain to another, is an added positive feature of the Albany-Corvallis flood plain.

The mean annual temperature for Albany is 52.7°F, the mean maximum and mean minimum temperatures being 63.1°F and 41.9°F, respectively (see Figure 7). The mean monthly temperature range is 27.5°F, progressing from 39.3°F in January to 51.6°F in April to 66.8°F in July. Only a slight temperature decrease is experienced from July to August, less than one degree fahrenheit, after which the temperature drops to 53.2°F in October and then to 40.9°F in December. Daily temperatures seldom go above 100°F or below 0°F. Below freezing temperatures rarely last more than three days, and above 90°F temperatures do not frequently remain beyond the afternoon hours. At the freeze threshold temperature of 32°F, the mean number of days between the occurrence of the last spring and first fall freeze is 227 days in Albany and 202 days in Corvallis (see Table II). The period between killing frosts is extended for crops with lower freeze threshold temperatures.

The seasonal distribution of precipitation is unusual in that the maximum precipitation comes during the low sun period. A deficiency of rainfall during the summer months combined with a high evaporation rate produces droughty conditions (see Figure 7 and Table

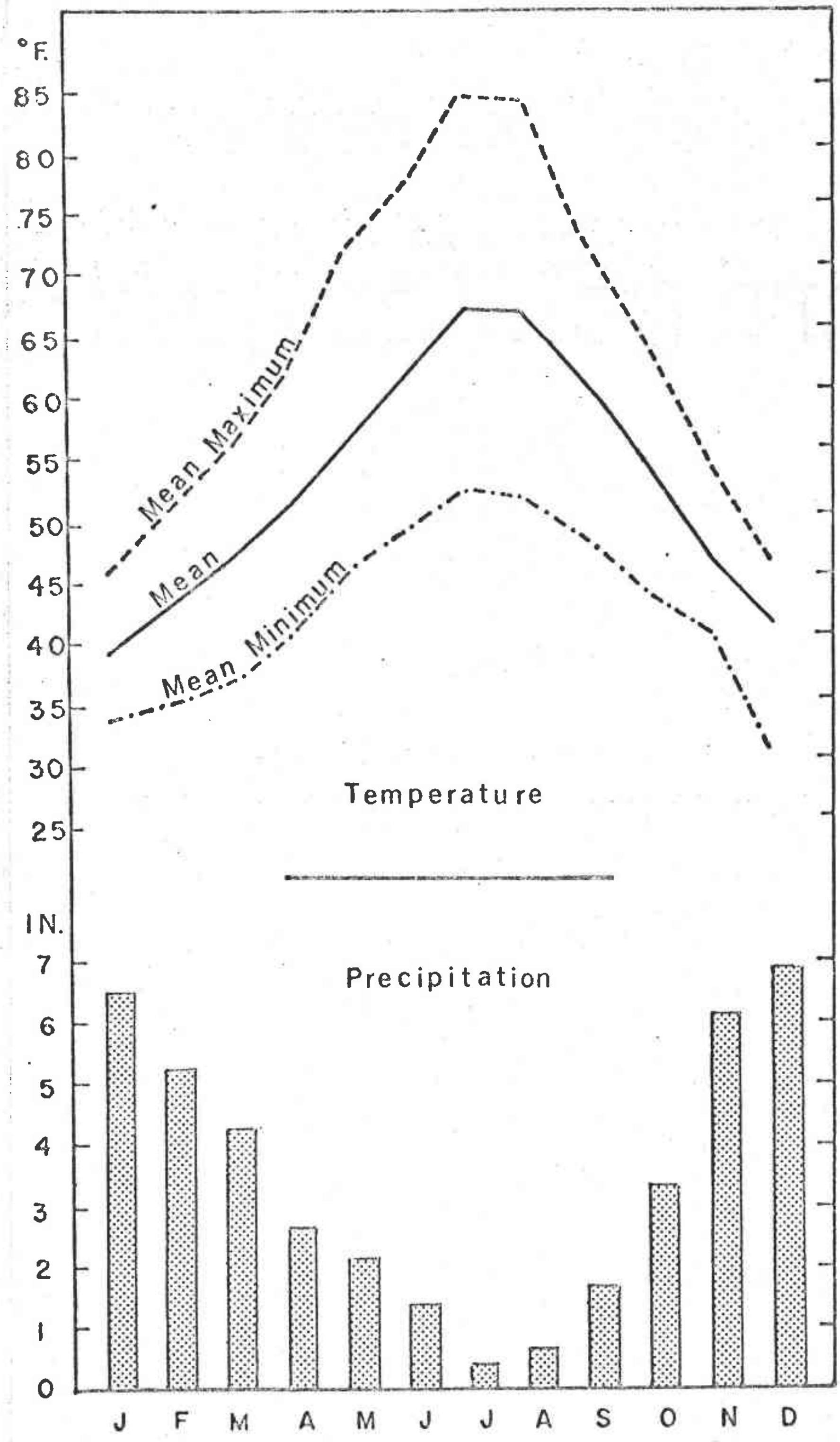


Figure 7. Climatograph of Albany, Oregon

Table II. Mean period between selected freeze threshold temperatures for Albany and Corvallis.[a,b]

Location	Freeze threshold temperature	Mean date of last spring occurrence	Mean date of first fall occurrence	Mean number of days between dates
Albany	32	3/24	11/06	227
	28	2/18	11/24	279
	24	1/23	12/16	327
	20	1/15	12/24	343
	16	1/09	+	+
Corvallis	32	4/12	10/31	202
	28	2/25	11/23	271
	24	1/25	12/15	324
	20	1/17	12/23	340
	16	1/08	+	+

[a]Based on 30 years of record.

[b]Source: (69).

Table III. Mean evaporation for Corvallis in inches.[a,b]

April	May	June	July	August	September	Total
2.88	4.16	5.90	6.44	6.06	3.89	29.33

[a]Based on 40 years of record.

[b]Source: (56, p. 8).

III). Droughts are a usual occurrence during late spring, summer, and early fall, predominating in the months of June, July, and August when the evaporation potential is 18.40 inches and the total precipitation is 2.35 inches. Three drought periods, each of 38 days duration, are recorded in the average year; however, single droughts of 104 days and 111 days have been experienced during exceptionally dry years (5, p. 33). Eighty-five percent of the annual 41 inches of precipitation comes during the flood season from October through April with November through February accounting for 24.70 inches of precipitation. Annual snow fall averages 7.53 inches (equivalent to less than one inch of actual water) and remains as ground cover only a few days (10, p. 3).

Agricultural endeavors long have been favored by the mild, winter-moist climate and long growing season of the area. Although fruit, nut, and grain enterprises benefit from the dry summers which aid maturing, favor harvesting, and restrain disease and insects, the seasonal deficiency of rainfall reduces the effective growing season of shallow rooted crops, such as vegetables and berries having high moisture requirements. With the aid of supplemental irrigation, crop production has been diversified and a stable agricultural economy has developed. Seasonality of overflow, a reflection of winter concentration of precipitation, confines intensive agricultural and commercial use of the flood plain resources to the flood-free season. Flood damage due to erosion or drowning places limitations on fall sown crops, whereas surface flooding inhibits field preparations for spring sown crops. Gravel pit operations also show adjustment to the flood season by increasing their operations in the summer season. Seasonal precipitation is advantageous in that it provides a period during which agricultural and commercial activities can be concentrated without fear of flood damage.

Natural Vegetation

The human history of the area has had marked influence upon the natural vegetation. When the white settlers arrived in the Middle Willamette Valley, the flood plain landscape was covered largely with oak openings, a savanna type vegetation of predominately grass and a few scattered trees, and prairie (19, p. 76; 63, p. 41-42). The establishment of this adventive vegetation was the result of annual field fires set by the Calapooia and Klickitat Indians (31, p. 23). With the elimination of this yearly practice of burning, soft and hardwood trees were able to establish dominancy on uncultivated land. Today, Douglas-fir, alder, cottonwood, oak, and willows are the more prevalent trees and are usually found along the banks of the river and the higher sections of the flood channels and sloughs. Shrubs and grasses predominate in the lower sections of untilled land.

III. FLOOD RECORD

Causes of Floods

Floods in the Middle Willamette Valley result from a combination of meterologic, hydrologic, and topographic conditions which produce runoff of sufficient quantity to exceed the capacity of the channels, causing flood waters to spread over the adjacent lowlands (24, p. 80). The nature of the winter climate is of particular importance. During this period, which corresponds to the flood season of November to April, the study area receives its major portion of precipitation, and soil conditions are conducive to excessive surface runoff. One or two months of above average precipitation followed by three to seven days of high intensity rainfall associated with cyclonic storms traveling north along the major axis of the valley usually heralds the coming of a large flood. Altitudinal lifting of the freezing level adds snow melt to the high water, but is not a major contributor. Differences in stream gradients and characteristics between the Willamette River and its tributaries cause contrasts in water containment capabilities. Large volumes of fast-flowing waters from the Cascade Mountains and Coast Range tributaries cannot be accommodated by the main stream of the river; water backs up and overflow occurs.

Flood History

Essentially every winter the lowlands adjacent to the Willamette River are subject to high water with floods of greater magnitude coming every five to ten years. During the past 71 years, the Willamette River has exceeded flood stage 128 times at Albany, 17 of which were ten feet or more over the bankful stage of 17 feet (24, p. 81). Prior to the twentieth century, major floods in the Willamette Valley were recorded in 1813, 1843, 1861, and 1890 (50, p. 73). The flood of 1861 is the largest on record, having covered 513,000 acres of land, and it is classified as a 100-year flood (see Table IV). The town of Orleans, located on the lower bank of the Willamette River across from Corvallis, was destroyed by the flood of 1861. Today, the only trace of Orleans, which had once rivaled the prosperity of Corvallis, is a collection of old buildings approximately four miles from the original site and off of the active flood plain. Based on the present stage of valley development, a flood of the 1861 magnitude would currently cause 85 million dollars damage. The second largest flood occurred in 1890. This flood inundated 485,000 acres and caused an estimated damage of seven million dollars. A reoccurrence of a flood of the 1890 magnitude would now cause more than 60 million dollars worth of damage (24, p. 82).

Twentieth century floods have been smaller than those of the

Table IV. Selected floods of the Willamette Valley.[a]

Year of flood	Flood frequency Albany, Oregon[b]	Actual acres flooded[c]	Damages in flood plain at time of flood[d]
1861	100-year	513,000	$ 1,000,000[e]
1890	40-year	485,000	7,000,000
1943	17-year	342,300	5,700,000
1945	12-year	368,500	9,900,000
1955	15-year	235,500	8,700,000
1961	15-year	250,000[f]	10,000,000[f]
1964	90-year	380,000[g]	57,500,000[g]

[a]Compiled by the Corps of Engineers, U.S. Army Engineer District, Portland.

[b]This is the long-term recurrence probability of floods based on natural conditions (no regulation) in the valley. A stage comparison cannot be made since the 1861 and 1890 floods were not regulated and the others were subject to different degrees of flood regulation because of continuing reservoir construction in the Willamette River Basin throughout the period from 1943 to 1964. It may be noted that a 100-year flood has a 1-percent chance of occurring in any year and, similarly, a 40-year flood has a 2-1/2-percent chance of occurring in any year.

[c]These figures cannot be correlated with the flood frequencies shown because of the changes in degree of flood regulation and the fact that floods do not always follow the same pattern, so far as intensities in various parts of the basin are concerned.

[d]These figures have not been adjusted to a common price level. They are actual dollar damages at the time of the flood.

[e]From newspaper account - probably conservative.

[f]Complete damage survey not made. Acreage and damages are based on samples and estimates.

[g]Preliminary, as of 12 January 1965, subject to possible modification upon completion of studies now underway.

nineteenth century; nevertheless, flood damages have increased because of greater economic investment and development on the flood plain. Major floods during the first half of the century, in decreasing order of magnitude, were in 1903, 1943, 1901, 1907, 1923, 1945, 1927, and 1916 (50, p. 74). The 1943 flood, used as the basis for the delineation of the study area, was the first major food after flood plain intensification by economic investments took place during the 1930's. Over 340,000 acres in the valley were inundated by this flood, and damages were in excess of five and a half million dollars. The flood of 1945, designated a flash flood because of its narrow crest, covered 368,500 acres and resulted in almost ten million dollars damage. The frequency assigned to this flood is 12-years and to the 1943 flood is 17-years, even though the area inundated in 1945 was larger and damage more extensive (for reasons see Table IV). At the present stage of development, the reoccurrence of a flood of 1943's magnitude would result in damages of 20 million dollars, and a flood of the 1945 magnitude would result in damages on the order of 25 million dollars (24, p. 82-83).

Within the last ten years, three floods are noteworthy: the 1955, 1961, and 1964 floods. Those of 1955 and 1961 have been assigned frequencies of 15-years by the Corps of Engineers. Although each of them inundated less than two-thirds of the land flooded by the 1943 flood, more damage resulted. Damage from the 1955 flood, which covered 235,000 acres, is estimated at 8.7 million dollars. Damages from the 1961 flood, which inundated 250,000 acres, was ten million dollars. The 1964 flood caused approximately 57.5 million dollars in damage on 380,000 acres and much inconvenience and hardship during the Christmas season (see Figures 8, 9, 10, and 11). A 90-year frequency has been designated to this flood.

A percentage breakdown of the total direct damage by any given flood in the Willamette Valley, according to the American Insurance Association, is as follows:

1.	Agriculture	53.3%
2.	Business and residential	23.9%
3.	Highways and roads	12.5%
4.	Municipal and other public works	10.3%
	TOTAL	100.0% (4, p. 72).

Agricultural flood damage in the study area is due primarily to drowning and erosion of crops, removal of fences, deposition of gravel and debris (see Figure 12), and erosion of the solum (see Figures 13, 14, and 15). The spread of disease, parasites, and weeds also contributes to flood damage although the amount is intangible. Flood damage in the study area has been as high as 20 thousand dollars in one year for a single farm (35), but generally it averages less than five hundred dollars per farm per year.

The duration and depth of inundation are critical factors

Figure 8. Road Closed: A familiar sign to flood plain dwellers.

Figure 9. Looking east down Oregon Highway #34 during 1964 flood.

Figure 10. Garden Road a week after crest of 1964 flood.

Figure 11. Garden Road a month after crest of 1964 flood.

Figure 12. Debris deposited during 1964 flood.

Figure 13. Erosion during 1964 flood.

Figure 14. Erosion during 1964 flood.

Figure 15. Erosion during 1964 flood.

governing agricultural flood damage. The nature of the prevailing flood control philosophy, i.e. reduction of the flood crest by construction of large dams, is not aligned with a lowering of agricultural damages. A shallower water level over the land, if anything, increases erosion, and the increased duration of inundation which accompanies flood control by dams is harmful to crops. Alfalfa, pasture, strawberries, and other fall cover crops were drowned during the 1964 flood because the Corps of Engineers were compelled to release water from the upstream storage reservoirs shortly after the downstream crest, thus maintaining a flood level and keeping the lower crop land under water for three to four weeks (7, 21) (see Figure 16).

Figure 16. Drowning of crops three weeks after flood crest.

IV. EVOLUTION OF RESOURCE UTILIZATION

The Period Prior to 1900

Indian and Trapper Stage

Prior to the establishment of the Pacific Fur Company in Astoria in 1812 and the advent of sedentary agriculture as practiced by nineteenth century American settlers, the Middle Willamette Valley was occupied by two semi-nomadic Indian tribes, the Calapooia and the Klickitat, both of which had a population under 1,000 (16, p. 329). The Calapooias, the earlier and more numerous inhabitants, rented certain sections of land to the Klickitats on an annual basis. Their use of flood plain resources was restricted by the low population density as well as by the slight demands and low technological level of the Indian society. Neither tribe made any attempt to cultivate the soil; their use of the land was extensive rather than intensive; they utilized the flora and fauna that required little alteration or processing thereby involving themselves in a hunting, fishing, and gathering type of economy. Wild blackberries, honey, grasshoppers, ants, and wild wheat were gathered, and blue camas bulbs were dug along the banks of the Willamette River. Continuing sustenance was assured by limited needs combined with skillful use of the resources. A primitive but effective form of conservation was their practice of allowing a sufficient number of healthy deer to escape the fire-bounded corrals which they used in hunting. Fires were annually started and maintained to aid in the taking of game by concentrating the animals in an ever-reducing ring of fire. Fires also facilitated the gathering of wild nuts, grains, and insects, and may have been purposefully used to prevent a holocaust and to reduce the natural camouflage utilized by enemies. The annual burning of the vegetation inhibited the development of a climax vegetation by favoring the establishment of grasses instead of trees. This was later to influence land use, especially the forthcoming livestock industry (31, p. 21).

In 1812, Donald McKenzie led the first fur brigade up the Willamette River for the Pacific Fur Company thereby initiating a short period of exploitation of the fur-bearing animals inhabiting the flood plain. By the end of the year, fur brigades were traveling the Willamette River as far south as the present site of Eugene taking deer, elk, and beaver for food and fur. The rudimentary form of conservation as practiced by the Indians, in reality an act of self-preservation, was abandoned by 1813 when Indians began trading with the Northwest Company. Primary fur-bearing animals were rapidly depleted, and by 1846 fur brigades discontinued. By 1850, the Hudson Bay Company, which had made every effort to circumvent any attempt to change the Oregon Country, and particularly the Willamette

Valley, from a fur producing territory to one of agriculture, terminated all operations south of the Columbia River.

Advent of Sedentary Agriculture

By 1885, nearly all of the more desirable land between Albany and Corvallis had been claimed as a result of the influx of settlers during the middle nineteenth century. From the outset of sedentary occupance, agriculture was the dominant economy on the flood plain. Extraction of natural resources in great excess of their replenishment characterized flood plain use from the pioneer years to the early 1900's. Nearly all of the general development of the Valley was at the expense of the resource base. Farming during the middle nineteenth century was extensive. Large acreages of alluvial soil were employed for raising livestock, a major agricultural pursuit motivated by the abundance of grass for grazing. Wheat was the major crop and yielded 15 to 20 bushels per acre. Volunteer seeding was employed for sowing wheat, a chance method by which only the seed that fell to the ground during the harvest was used. Following wheat in acreage were oats and barley. A small amount of acreage was in tree fruits grown for home use (25, 32).

The end of the California gold rush and an increase in agricultural production in southern Oregon resulted in a market decline in and around the study area. Subsequently, the once daily pack trains that left Corvallis destined for the mines in California ceased. This market decline was offset by the completion of the Union Pacific's transcontinental railroad in 1869 which connected Sacramento, California to the East Coast. Overland shipment of goods became even less important with the completion of the East Side Railroad in 1874. This line provided the Middle Willamette Valley with a north-south connection from Portland to Roseburg. In the following ten years, two more railroad lines were built. One provided Corvallis with a transportation connection to San Francisco and the other to Yaquina Bay (31, p. 60). River transportation, steamboats, barges, and scows, of prime importance before the coming of the railroad, afforded the producers and consumers in the Valley a cheap means of shipping bulk goods, but this mode of transportation was curbed during the flood and drought seasons.

As the population increased and transportation facilities improved and farm mechanization became more sophisticated, cattle were moved to the hills, and the growing of cereal and forage crops became increasingly prominent on the fertile flood plain. Wheat was the principal crop. The mines of southern Oregon and California had been the initial market for Willamette Valley wheat, and then, with the appearance of the transcontinental railroad, a new market for Oregon wheat opened in Europe. Both wheat and flour were exported to Europe via California where it often became labeled

California wheat. Constant mono-cropping of wheat combined with the settlers' use of the Indian practice of burning the fields eventually reduced the natural productivity of the soil. Fields were burned primarily to reduce stubble and to control disease.

During the latter part of the nineteenth century (1880-1900) little change in the transportation facilities and market demands occurred. This stability was not maintained in land use. Conversion of vegetable calories to meat calories continued to decrease, and crop acreages changed. Other grains, especially barley, began to replace acreage that was previously in wheat; fruit, berries, and vegetables began to increase in acreage.

An increase in the man-land ratio in the latter years of the nineteenth century necessitated an increase in the number of farms and a decrease in the acreage per farm (31, p. 75). Open ditch drainage was used on a limited basis to open more land for cultivation. Both cash and sharecropping types of farm tenancy commenced with the subsequent one year contracts adding to the already existing problem of soil depletion which had been caused by the constant mono-cropping of wheat and which was being manifested by decreasing yields per acre. At the turn of the century, all of the land suitable for cultivation was farm land. From this time forward, any new farms were formed by subdivisions of existing farms, and any further increase in cultivable land resulted from land reclamation projects.

The Period From 1900 to 1940

Agricultural trends of the later nineteenth century carried over into the early part of the twentieth century. Land use became increasingly intensive. Wheat and barley remained the two most important cash crops on the flood plain in the early 1900's, although wheat acreage continued to decline and was surpassed by barley around 1910. In 1919, the total value of the cereal grains in Benton County was 1.3 million dollars (39, p. 10). To make maximum use of the land, transhumance was introduced locally. Livestock, mainly sheep, returned seasonally to graze in the clover or grain stubble fields of the wintered flood plain. The livestock and dairy industry contributed 0.8 million dollars worth of goods to the economy of Benton County in 1919 (39, p. 10). Acreage in tree fruits and nuts increased after 1920 with prunes, peaches, cherries, and filberts experiencing the largest gains (25, 32).

The initiation of a canning industry had marked effects on the land use of the flood plain. In 1919, the citizens of Benton County donated a site in Corvallis to the Brownsville Canning Company (39, p. 11). This enterprise stimulated diversification of crops and prompted the introduction of new crops more aligned with the canning industry. The new cannery crops, e.g., vegetables, small fruits, tree fruits, and nuts, required more hours of labor per acre but provided greater income per acre and reduced the size of an economical farm unit. Farmers resisted attempts to alter long established farm practices, however, and by 1925 the Brownsville cannery was operating at only 20 percent capacity, and even then, some of the agricultural commodities used for canning were transported in from outside the immediate area. Subsequently, advisers from the cannery were sent into the fields to work with the farmers. Their function was to provide the farmer with information concerning the crops that would benefit both the farmer and the cannery. This proved to be the forerunner of contract farming in the study area and the beginning of the end of the individual farmer's land use decision making.

An initial change from grains to higher valued crops, which was to continue up to the present, became apparent in the early 1920's. As increased growing costs made the production of wheat unprofitable on marginal land, wheat acreage decreased. This trend on the flood plain was exemplified on a county-wide basis as indicated in the Benton and Linn County Agricultural Conference Reports for 1936 which state that by 1936 Benton County was only producing enough wheat for local needs and that wheat acreage in Linn County was reduced more than one-half during the period from 1919 to 1936. An exceptionally dry summer in 1936, which brought heavy loss to wheat farmers, further reduced wheat acreage in the following years.

Accompanying the decline in wheat production on the flood plain was a period of increase in the production of oats and barley. Barley had the advantage of producing more pounds per acre than either oats or wheat. It was used for feed and seed, and a spring variety of barley, Hannchen, developed a market in the 1940's for malting purposes. Special handling and threshing techniques necessary in the production of malt barley made this one of the more intensified grain type enterprises. A large market existed for oats for milling purposes, livestock feed, and seed. Although climate and soils of the flood plain were favorable for the production of field corn, and a market did exist, the initial investment necessary for drying equipment curtailed field corn acreage until after 1940.

The Period From 1940 to 1965

Agricultural Use (see Table V and Figures 17 and 18)

Grain Crops.[1] During the period from 1940 to 1965, grain crop acreage on the flood plain decreased 46.73 percent, a decrease from 2,953 acres to 1,573 acres. Crop diseases such as "take all" and "black root", which were especially destructive to fall sown wheat in the middle and late 1950's, were an added incentive to limit wheat acreage so that wheat, formerly produced in surplus, had to be

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[1] Grain crops grown for seed have been incorporated in the section on grain crops rather than in the section on seed crops because of the inability to always distinguish for which purpose they were grown.

Table V. Land use in acres for the Willamette River flood plain Albany-Corvallis, Oregon.[a]

	1940	1965	Acreage change	Percent change
Agricultural Land	4,746	5,474	728.0	15.33
Grain Crops:	2,953	1,573	-1,380.0	-46.73
Barley	2,158	791	-1,367.0	-63.34
Wheat	724	495	-229.0	-31.62
Oats	71	184	113.0	159.15
Corn	0	103	103.0	N.D.[b]
Forage Crops:	698	1,842	1,144.0	163.90
Hay and Alfalfa	377	1,113	736.0	195.22
Pasture	321	729	408.0	127.10
Seed Crops:	343	328	-15.0	-4.37
Hairy Vetch	169	109	-60.0	-35.50
Austrian Peas	49	9	-40.0	-81.63
Crimson Clover	81	0	-81.0	N.D.
Common and Perennial Ryegrass	0	82	82.0	N.D.
Alta and Chewing Fescue	44	38	-6.0	-13.63
Orchard Grass	0	48	48.0	N.D.
Lotus	0	42	42.0	N.D.
Horticultural Crops:	752	1,731	979.0	130.18
Tree Fruits	236	285	49.0	20.76
Small Fruits	0	43	43.0	N.D.
Vegetables	191	1,026	835.0	437.17
Oil Crops	49	298	249.0	508.16
Hops	256	0	-256.0	N.D.
Special Uses	20	5	-15.0	-75.00
Soil Bank	0	74	74.0	N.D.
Non-Agricultural Land	75	740	665.0	886.66
Commercial	66	155	89.0	134.84
Residential	9	177	168.0	1,866.66
Institutional	0	408	408.0	N.D.

Table V. continued

	1940	1965	Acreage change	Percent change
Uncultivated Land	4,265	2,872	-1,393.0	-32.66
Land not Inundated by 1943 Flood	606	606		
Land Covered by Willamette During Normal Flows	624	624		
Total Study Area	10,316	10,316		

[a]Figures derived from planimeter readings of accompanying land use maps.

[b]N. D. -- Not mathematically definable.

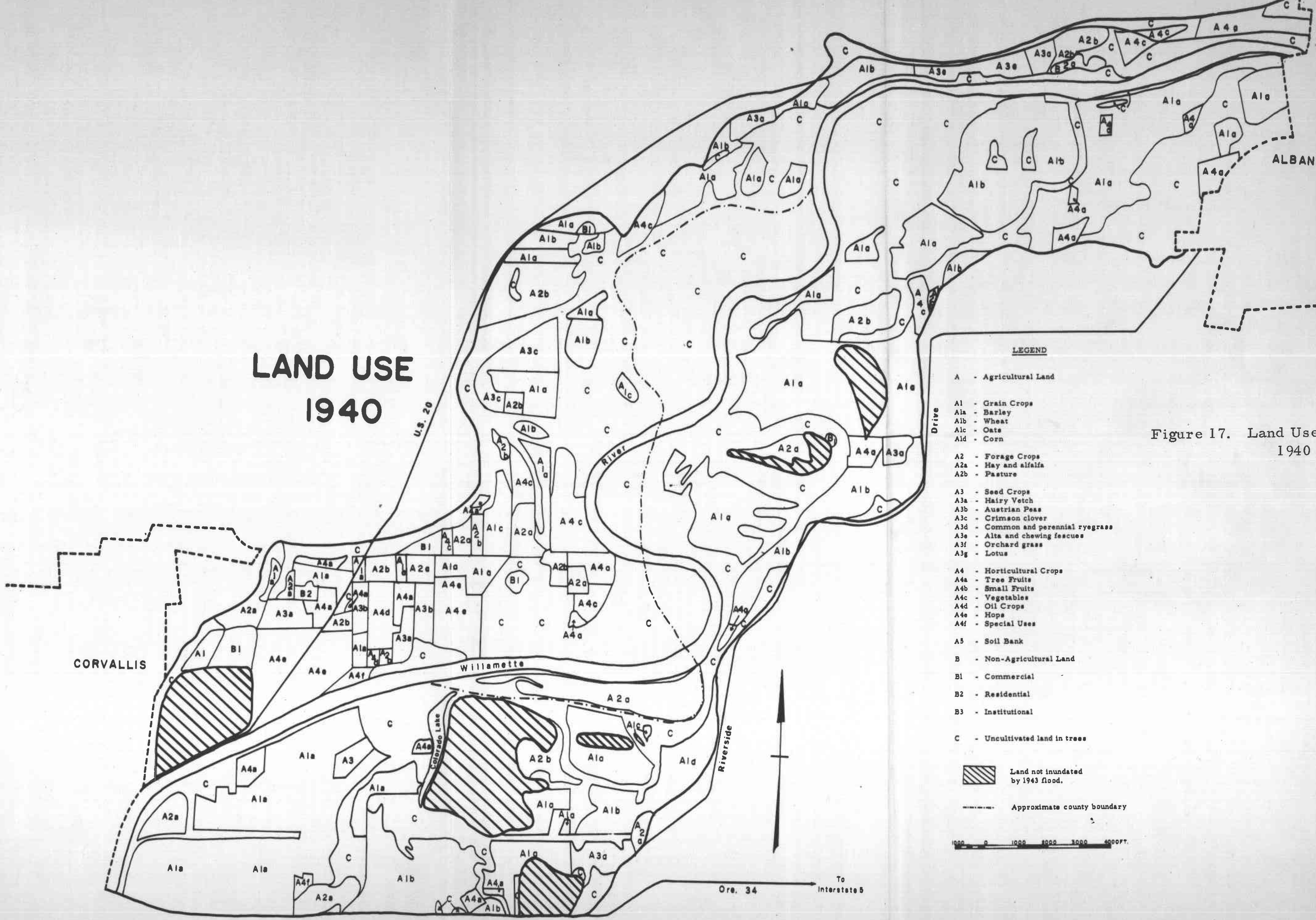

Figure 17. Land Use Map, 1940

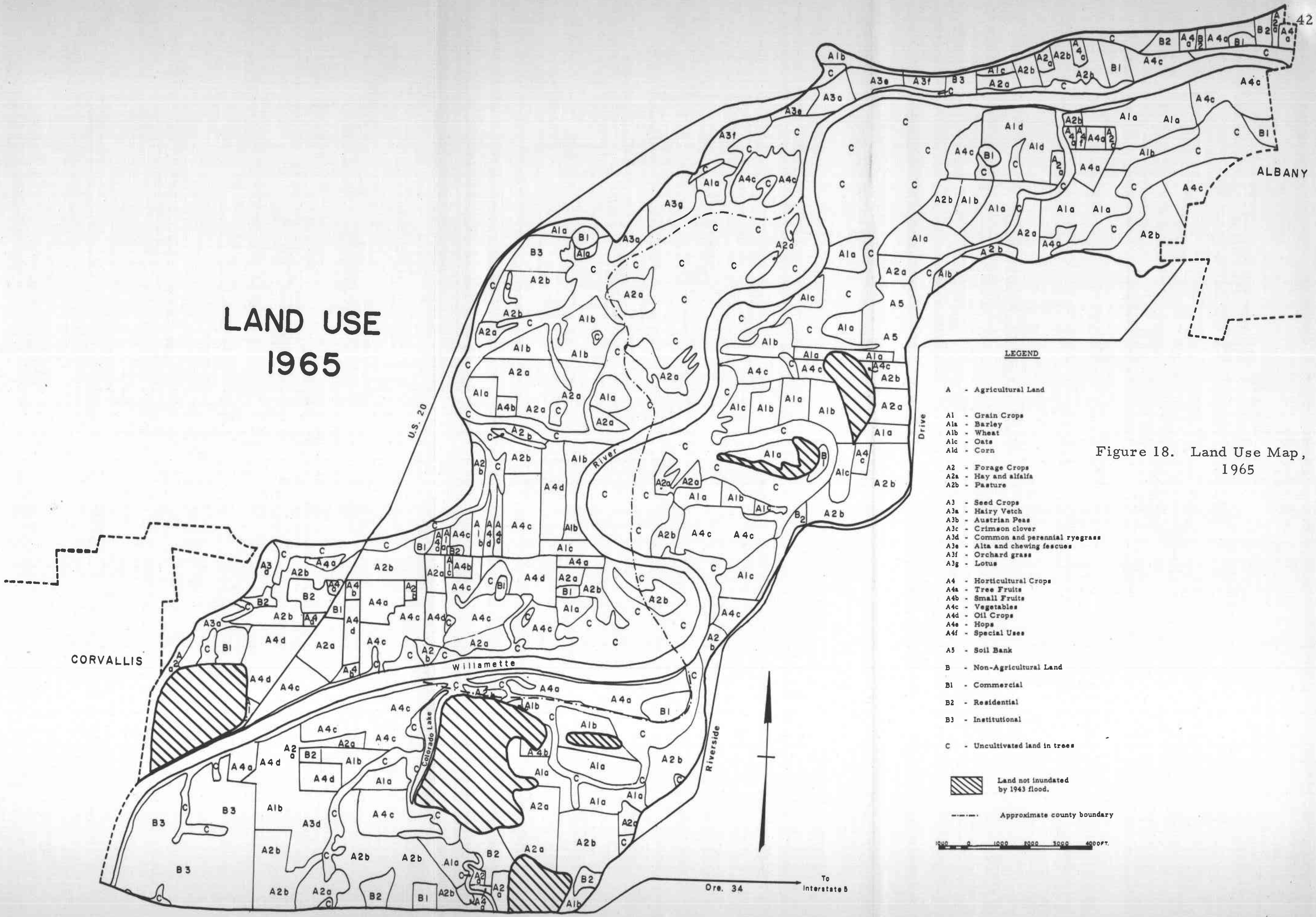

Figure 18. Land Use Map, 1965

imported. Since 1960, an increase in wheat yields has engendered a small increase in wheat acreage. The 1964 Annual Report of the Linn County Extension Service suggests that the defeat of the wheat referendum in addition to high wheat yields in the 1960's accounts for the recent increase in wheat acreage (49). The 1964 Annual Report of the Benton County Extension Service (47, p. 17) attributes the recent high grain yields to the success of the fertilization and weed control program, the development and use of high yielding varieties, and favorable climatic conditions. It states that wheat yields were 55 bushels per acre for fall wheat and 36 bushels per acre for spring wheat. This recent rise in acreage has not offset the overall decreasing trend in wheat acreage on the flood plain which has dropped 31.62 percent, or 229 acres, since 1940. The combination of increased acreage and yields per acre has, however, eliminated the need to import wheat. The local market provides a good outlet for flood plain wheat which eliminates any present need to use the federal grain price support program.

Barley had the largest crop acreage change during the 25 years following 1940; it decreased 63.34 percent, which is a relinquishment of 1,367 acres. Some of the land formerly in barley was put under irrigation and is presently supporting forage and horticultural crops. The same reasons that account for the wheat decline; the growing pressure to intensify land use, several exceptionally dry summers, and problems with disease; are applicable to barley. As in the case of wheat, barley in recent years has had higher than average yields, producing 1.25 tons per acre (47, p. 17).

Oats and field corn have undergone acreage increases of similar magnitude since 1940, each increasing about 100 acres. Oats have been produced in surplus the majority of years encompassing 1940-1965; based on an average per acre yield of 1.25 tons for Benton County in 1964 (47, p. 17), approximately 230 tons of oats were harvested from flood plain farmland between Albany and Corvallis in 1965. Field corn acreages increased after several privately owned and operated dryers were constructed in the early 1940's following a preliminary report by the Benton County agricultural agent in 1936 that artificial drying of corn would increase profits. Today, most of the 103 acres of field corn grown find a market as seed rather than feed, a change representing further agricultural intensification of flood plain land.

Forage Crops. Forage crops increased from 698 acres in 1940 to 1,842 acres in 1965, a 163.9 percent increase. Hay and alfalfa increased 736 acres, or 195.22 percent, over this 25 year period, and pasture acreage rose 408 acres, or 127.0 percent. Forage crop increases paralleled livestock and dairy production which increased sharply during the middle 1940's (41, p. 26) and leveled off during the 1950's and 1960's. The general location of forage crops, especially pasture, on the more frequently flooded land suggests a successful and rational land use practice since forage crops provide ground cover during the flood season thus helping to reduce soil erosion and flood damage. Irrigation of alfalfa (see Figure 19) and pasture has intensified land use and increased yields per acre.

Seed Crops. Although Benton and Linn counties have been notable seed producers since the 1940's, their major portion of production has taken place off of the active flood plain. At the present time, there seems to be no indication of a change in trend, seed crop acreage on the flood plain having changed very little during the past 25 years. The need for large acreages to produce an economical seed producing unit is perhaps the most important factor keeping seed production off of the flood plain. It is interesting to note that although Linn County was one of the nations leading producers of common ryegrass seed in the late 1940's, little or none was grown in the study area during the same time.

Horticultural Crops. Representative of the move toward greater agricultural land use intensification is the major horticultural development which took place during the 1940's and 1950's. Although horticultural crops experienced neither the greatest absolute nor percent acreage increase, their increase of 979 acres or 130.18 percent represents the largest valued agricultural land use increase of any

Figure 19. **Supplemental irrigation of alfalfa by sprinkler systems.**

Figure 20. Sweet corn grown under contract.

previous 25 year period. Based on farmer interviews, it was determined that the most important horticultural crops in the study area are sweet corn, peppermint, strawberries, snap beans, dill, and filberts.

Vegetable and small fruit horticultural endeavors have been strongly influenced by labor supply, availability of contract, and disease. Contracts given by the canning and freezing plants have controlled the amount of land put in horticultural crops (see Figure 20). Contracts became essential in assuring an outlet for the perishable crops which otherwise were apt to be dumped on the market regardless of price during the relatively short period of harvest (see Figure 21). A labor shortage and limited market during World War II stifled the production of small fruits and berries in the early 1940's. During the late 1940's and 1950's the frozen food industry developed and a larger labor supply and market were available for small fruits and vegetables. The quality of the fruit and vegetables was good enough to compete with other areas on distant markets. Other factors contributing to the increase, as reported in the Atlas of Oregon Agriculture, have been irrigation development, fertilization, improved strains, new techniques and equipment, and growth of farmer interest (22, p. 31-34). Markets, which control the availability of contracts, have been the limiting factor of fruit and vegetable acreage, rather than the physical system. Diseases, such as

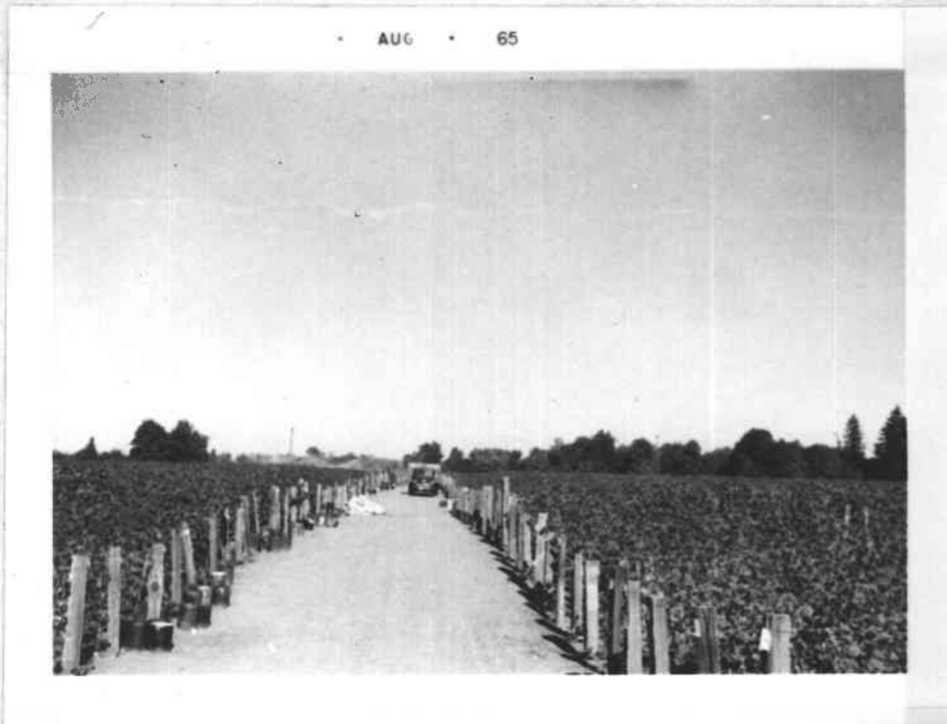

Figure 21. Snap bean field during harvest.

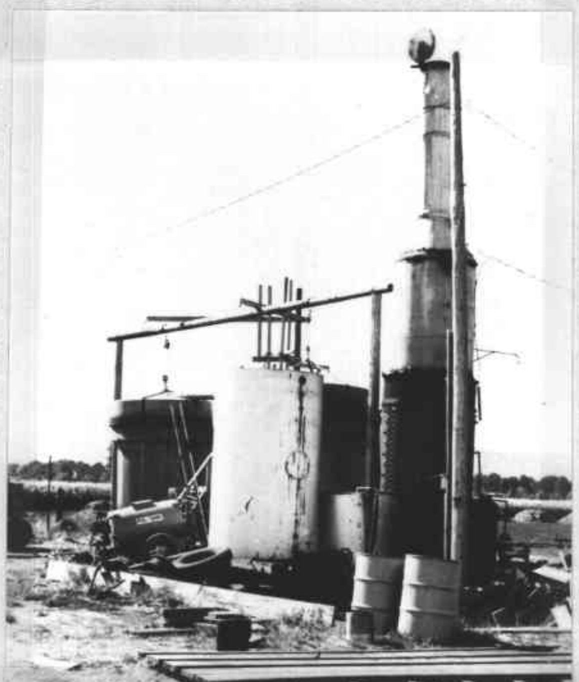

Figure 22. Peppermint distillery.

rust and white mold, and insects, such as symphyleds and nematodes, have been a problem to small fruit and vegetable producers since the 1940's. Strawberries, snap beans, carrots, and beets have been especially affected. Insecticides, herbicides, etc. have helped control these diseases and pests but have not been able to eliminate them. Flood waters annually carry disease and insects over previously clean land adding to the problem of control.

The oil crops, peppermint and dill, have steadily expanded from 49 acres in 1940 to 298 acres in 1965, a growth of 249 acres or a 508.16 percent increase. Contracts are desirable for both peppermint and dill although peppermint is often grown without contract. A scarcity of dill contracts in recent years was accompanied by reduction of dill acreage (2). Peppermint has been an important horticultural crop on the flood plain since the middle 1950's. Several mint distilleries are locally owned and operated in the study area to cut down on transportation costs of a high-bulk product (see Figure 22). The distilled product, a mint extract, is then marketed for food and gum flavoring. Mint farmers often graze sheep and geese in the mint fields to help control weeds during the growing season (see Figure 23). Verticillium wilt has been a problem to mint growers and occasionally causes a switch in land use to a vegetable crop such as sweet corn or snap beans. This rotation scheme coincides with disease control practices advocated by the agricultural agents of

Figure 23. Geese grazing in mint field to keep down weeds.

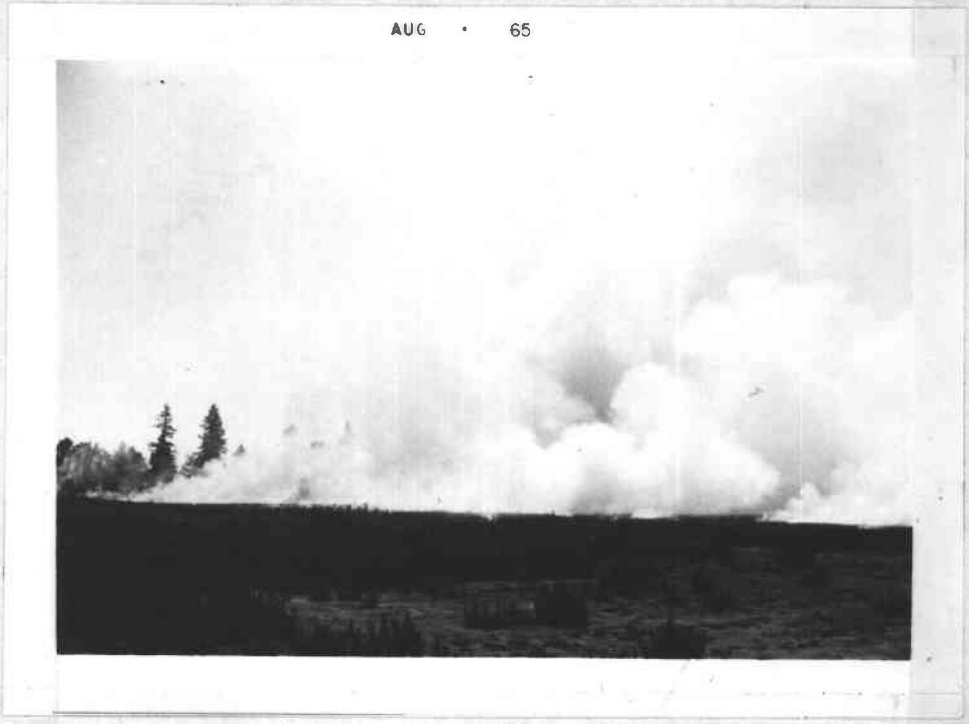

Figure 24. Burning off of grain stubble to help control pests and disease.

both counties, namely rotation of crops and use of clean stock. Berries are not substituted since they are also susceptible to verticillium wilt.

Not all of the horticultural crops underwent large acreage or percent increases after 1940. Tree fruits and nuts had been well established prior to 1940 (52, p. 19). Walnuts and filberts are the two tree nuts produced in the study area. Peaches, prunes, apples, and cherries are the main tree fruits. Production of filberts at present is on a slight increase in the Garden Road area. Production of peaches and cherries has declined and that of prunes and apples has remained static (25). Lower grade tree fruits from out of state have provided strong competition on the local market. High winds of the Columbus Day Storm on October 12, 1962 inflicted heavy damage on orchards causing lower than average yields from the tree fruits in 1963 (48). If any expansion of tree fruit acreage takes place in the study area, it will most likely be with filberts, cherries, and prunes (25).

Hop acreage in the study area began to decrease after reaching a probable maximum in 1945 (53, p. 19). The decrease was rapid, and before 1955 the only hop field in the study area was on Oregon State Experimental Station land. The reasons for decline in production according to Elbert Miller and Richard M. Highsmith, Jr. were as follows:

1. Yields per acre were lower than in the hop producing regions of Washington and California;
2. Climatic conditions, cool temperature and humid conditions, fostered the spread of downy mildew;
3. Sprinkler irrigation fostered the spread of downy mildew, and flood irrigation was too expensive to install;
4. Unlike in interior areas, three years were required before a good crop could be harvested, and farmers hesitated to invest in a crop when no immediate profit could be realized;
5. Poor quality brought a low price per pound (33, p. 77).

The production of poppy seed had its beginning and end between the years of 1940 and 1965 and is therefore not listed on the map. Nevertheless, as many as 25 acres were planted in poppies during a single year. The product, poppy seed, was sold to local bakeries where it brought a good price. Operations were terminated by the Federal Bureau of Narcotics as a preventative measure against the production of opium (21). In 1945 an attempt was made to raise daffodils and lilies for cut flowers. The lack of ground cover made this enterprise highly susceptible to erosion during the winter flood season. That year, flood waters covered and eroded the ten acres in flowers and carried away many of the bulbs. The damage inflicted was approximately 20,000 dollars and caused the termination of this endeavor (35). Other special uses, such as holly farms and

Christmas tree farms, are the only other horticultural endeavors that have declined since 1940. The five acres presently in special use are in Christmas trees.

Livestock and Poultry. An indication of the importance of the livestock industry is reflected in the amount of acreage in pasture on the 1940 and 1965 Land Use Maps. Livestock production expanded rapidly during World War II, but afterwards suffered a slight setback as prices for meat and dairy products decreased and production costs increased (44, p. 26-28). Dairymen were especially caught in this squeeze and were forced to either sell out or enlarge. Those remaining have had to employ scientific methods of breeding, feeding, and milking to insure a high volume of milk per cow which in turn demands a further increase in dairy cows to pay for higher overhead. A recent state law setting milk production quotas for individual farmers based on their previous production tends to favor the established dairymen though it can stifle his growth as well as that of the unestablished dairyman. To meet butterfat and bulk production demands, mixed herds of Jersey and Holstein cows are raised. Since the 1950's there has been an increase in the number of beef cattle on the flood plain as a result of increased pasture irrigation and more efficient land utilization. Feeder stock are also brought to the flood plain during the winter to fatten up in the grass seed fields. The number of sheep on the flood plain has been minimized by the greater prevalence of stomach worms with sheep grazed on irrigated pasture (44, p. 36).

In 1940, there was one commercial egg operation in the study area; however, the increased cost of feed and decrease in marketable value of eggs made this enterprise of four to five hundred chickens uneconomical. Production ceased before 1950 (35).

Agricultural Management and Practices

Not until the establishment of the Agricultural Conservation Program in 1936 did the farmers of the Albany-Corvallis flood plain become interested and involved in conservation practices. The strong attraction of this program was the provision of payments to the farmer for carrying out certain prescribed land use practices. Exploitation of the soil and other natural resources of the valley had continued until the early 1930's and paralleled a continuous decrease in crop yields per acre.

The diversification and intensification of agriculture since 1940 has been accompanied by and favored by the expansion of supplemental irrigation. Growth prior to 1940 was suppressed by the individual farmer's lack of knowledge concerning the benefits of supplemental irrigation commensurate with his cultural ties to grain farming. High profits from grain crops and the lower population density of farmers in the study area also contributed to the lack of enthusiasm for its introduction. Factors that stimulated the growth of supplemental irrigation after 1940, as outlined by R. M. Highsmith, Jr., (23, p. 102) were as follows:

1. Introduction of lightweight aluminum pipe;
2. Accessibility of surface and subsurface water;
3. Availability of electricity at reasonable rates to run electric motor pumps;
4. Trend towards smaller farms;
5. Possibility of increasing the intensity of land use and farm output;
6. Education of farmers as to potentials of irrigation;
7. Growth of market outlets consequent on the establishment of new processing plants;
8. Favorable returns from irrigated crops.

Irrigation in the study area is carried out exclusively by sprinkler systems operating from permanent or portable main lines. Several of the advantages of sprinkler irrigation are that it:

1. Saves leveling, labor, and water costs;
2. Saves soil fertility by avoiding heavy grading;
3. Permits light, frequent irrigation of the A-horizon of the soil profile;
4. Permits successful use of small irrigation heads (57, p. 410).

Exact figures are not available for the number of acres irrigated; however, using farmer interviews as the basis, the 1940 acreage irrigated should correspond closely with acres in horticultural crops and partially with acres in pasture, and the 1965 acreage irrigated should correspond to the acreage of horticultural crops and all forage crops. Employing this rationale, the present amount of land irrigated is approximately 3,573 acres, or better than three-fifths of the total cultivated land. The acreage increase from 1940 is in excess of 2,000 acres.

The overall impact of irrigation has been the introduction of new crops--the growth of horticultural crops would not have been possible without irrigation--and the intensification of land use attendant with superior yields, double cropping, as with alfalfa, and increased initial investment. Increases in production value on irrigated land average 33 dollars per acre per year (53, p. 15). Pasture irrigation has helped to increase the number of dairy cows and beef cattle on the flood plain. The future of further expansion of irrigation depends on the development of storage reservoirs on the major streams, although to date only a few wells suffer from insufficient flow during the summer,[2] and the expansion of market demands.

The use of fertilizer expanded rapidly throughout the study area

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[2]Only two of the 11 farmers interviewed indicated any need to curtail irrigation due to an insufficient water supply.

during the war years concomitant with the large agricultural markets available then (42, p. 16). Potash and lime were the major flood plain soil deficiencies. They were remedied easily, but at an additional cost, by the use of commercial fertilizer. Good prices and increased yields more than paid for the additional expense. Nitrogen, phosphorous, potassium, boron, gypsum, and lime were the primary chemical deficiencies supplied by commercial fertilizer in Benton County in 1956 at an average of 140 pounds per acre of farmland (40, p. 18). At this time approximately five percent of Benton County's gross agricultural income was spent on commercial fertilizer, and by 1964 the amount was seven percent (47, p. 118). These figures, although county based, give an indication of the relative importance of fertilizer on the flood plain as well as of the trend towards the use of more fertilizer and a more intensive use of the land.

A three year crop rotation scheme was being practiced by 1940. The land was planted in wheat the first year, clover the second year, and oats the third year. Since the crop that followed clover would benefit by the added nutrients, this rotation scheme may be viewed as indicating the decreasing importance of wheat as a cash crop. Presently, the rotation of horticultural crops is employed to combat the spread of disease, especially verticillium wilt and white mold, and to enrich depleted soils. Burning off of stubble from grain fields is also practiced to reduce disease and pests (see Figure 24).

The implementation of tile and open ditch drainage techniques has opened more land for agriculture. Only the soils of the Wapato-Maytown Association are considered to suffer from insufficient drainage. It has been on this soil association that drainage techniques induced marked improvement since the soils could be worked sooner in the spring and fall planted crops were less likely to drown.

Erosion control has taken two main forms between the years 1940 and 1965: winter cover crops and bank revetments. Winter cover crops, such as grass, act as a mat over which the annual flood waters will pass without eroding into the top soil. Bank revetments, which have been constructed by the Corps of Engineers, serve to curb erosion and undermining of the river banks; however, to date soil erosion along the banks remains a problem because winter flooding continually damages the revetments, reducing their effectiveness.

Contract farming provides the farmer with the assurance of a market, which is a necessity for such high value, perishable crops as strawberries, sweet corn, snap beans, and other horticultural crops, once he acquires the contract. Investments for snap beans are as high as 1,000 dollars per acre or more, labor being the highest expenditure at about 700 dollars per acre, and such intensive use requires that there be a "home" for the crop (35). A loss of independence accompanies the stability of contract farming since the contractor controls the crop from planting to processing. The contractor sets the acreage and planting date, the selling price, and the grade to be met before the crop is sown. The seed is either furnished by or bought from the contractor to assure a level of quality. The farmer's problem is obtaining the type and size of contract he wants. This is especially true for the newer, less established farmer. Often the only way he can obtain a contract for a particular crop is to take a bundle contract which will include a contract for a less desirable crop. By offering bundle contracts, the contractors have forced the farmer to diversify land use.

Hand picked horticultural crops, such as strawberries, black and red raspberries, and snap beans, during the harvest season require a large labor force which is usually supplied by local children. There are several problems connected with this type of cheap, unskilled labor force. The pickers are apt to be slow so that an exceptionally large number of pickers per acre is required. The pickers are prone not to pick the rows clean, and as a result there is a loss of product. In some cases, as much as fifty percent of the strawberries are left in the field to spoil (28). This inefficiency has influenced one farmer to move his strawberry patch to Stayton, Oregon, where, according to him, the children are harder workers (18). Snap bean farmers encounter an additional problem of insufficient help as the harvest season overlaps with the beginning of the school year. Twenty-five to 50 tons of beans are lost annually on one farm because of the lack of and type of pickers (35).

Despite the increase in man-land ratios, between 1920 and 1940 a decrease in the family size farm was evident on the flood plain and the higher lands of Benton and Linn Counties, as indicated by a 70 percent increase in farms over 1,000 acres from 1920 to 1945 (43, p. 4). Farms under 50 acres increased 69 percent from 1920 to 1945. Part-time farming increased as the small farmer's need for a supplemental income developed. These jobs were usually connected with the lumber industry or gravel operations. By 1952, 120 to 150 acres of rich alluvial soil of the Chehalis and Newberg series were required for the minimum economic farm unit (44, p. 7). Greater or lesser acreages were required depending on the type of farm operation. Diversified farm units, or grain, hay, and field seed farm units, had minimum requirements of 200 to 300 acres of productive soil. More intensified units such as those engaged in the production of tree fruits or cannery crops needed a minimum of 50 acres of suitable soil. The decreasing margin between cost of production and value of product marketed, as reflected in price indexes for Oregon, forced the farmer to adjust towards maximum efficient production units by expansion, intensification, or part-time farming. In 1957, the Benton County Farm and Home Development Conference reported that 50 percent of Benton County's farmers were using outside employment for additional income (44, p. 7).

Non-agricultural Use

Non-agricultural use of the flood plain increased from 75 to 740 acres during the period 1940 to 1965, a growth of 665 acres. The greatest acreage increase was in institutional land, 408 acres, and the greater part of this increase was for crop experimental use by Oregon State University. A small piece of land was purchased by the United States Government to establish a recreational area to be used by Air Force personnel from Camp Adair. Commercial land use has expanded from 66 acres in 1940 to 155 acres in 1965. For the most part, this increase has been the result of the expansion of gravel operations, the location and limits of enlargement being defined by the presence of Camas gravelly sandy loam (see Figure 25). Other commercial enterprises include a gas station, a miniature golf course and driving range (see Figure 26), and a privately operated recreational area at Colorado Lake for swimming, fishing, and picnicking.

The acreage increase in residential land use from 1940 to 1965 was 168 acres or from 9 to 177 acres. This acreage change of 168 acres represents a substantial increase in per acre value. Residential growth on the flood plain (see Figure 27) has taken place primarily within a mile from the Corvallis and Albany city limits in Benton County and from the southern tip of Colorado Lake in Linn

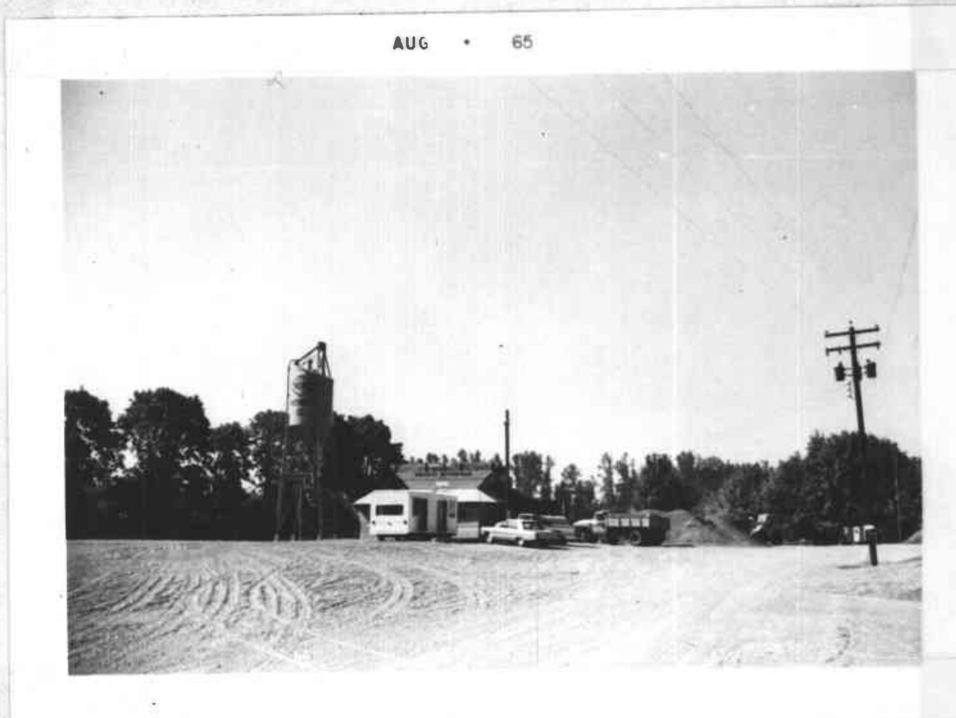

Figure 25. Recently expanded gravel operation.

Figure 26. Driving range on the flood plain.

Figure 27. New residential development one-half mile northeast of Corvallis on Seavy Road.

County. Other residential development has taken place along Riverside Drive. Agriculture use as of yet has not suffered a loss of acreage to residential growth because of reclamation of land; nevertheless, as Albany and Corvallis continue to grow, agriculturally oriented flood plain land will be under great pressure for residential development.

V. RATIONAL OCCUPANCE: SUMMARY AND PROJECTIONS

The major and least desirable land use change in the immediate future on the Albany-Corvallis flood plain will involve continued residential expansion onto flood prone land. Residential expansion has thus far taken place within the rural-urban fringe of Albany and Corvallis along the two main north-south roads in the study area that mainly traverse the higher bench lands off of the flood plain. Encroachment onto the flood plain has therefore been kept to a minimum but, even so, has taken place at an alarming rate (see Table V). As the bench lands near Albany and Corvallis are developed, the pressure for residential expansion onto the flood plain will increase. By 1985, assuming continuation of present trends, 174,000 people are expected to reside on the flood plain of the Middle Willamette Basin, with Corvallis and Albany as major centers (14, p. 5-6). The study area during this period will probably exhibit a marked expansion of residential development and subdivision growth, a situation incongruent with optimum use.

Commercial growth is a more remote flood plain problem but could be a major consideration 20 years hence. Commercial non-agricultural uses presently found on the flood plain are represented by two recreational enterprises, a gas station, and several sand and gravel operations. This limited commercial development does not represent a great misuse of flood frequented land. Justification of sand and gravel operations on flood prone land arises from the location of land suitable to this activity on present and past stream beds. Washing and separating equipment associated with gravel operations are economically justified if the cost of transporting the raw material off of the flood plain is greater than the annual flood damages accrued. Further processing of the sand and gravel should be done off of the flood plain. The driving range and miniature golf course, located on the east side of Oregon Highway #20, suggest reasonable commercial use of flood plain land. Pasture-like conditions of the driving range protect the land from flood erosion; the miniature golf course is less desirable since deposition of sand, gravel, and other debris can cause damage to its operation.

Evolving with economical, technological, and social changes, agriculture has remained the predominate land use form. Rational agricultural land use practices are evident throughout the study area. Farmers have wherever possible built their farmsteads on the higher bench lands and have regulated agricultural use by such procedures as placing the land inundated annually in pasture and hay crops thereby keeping the land covered and protected during the flood season. Fall-sown crops subject to extensive flood damage have not been planted. Livestock enterprises are able to benefit from sufficient flood warning which allows livestock to be removed to higher ground, and as long as the immobile farm equipment is located off of the flood plain, flood losses are kept at a minimum. The relatively small distance between the terrace or bench land and the river makes it possible in many areas to have river frontage and flood free land on the same farm.

Most of the land placed in the institutional category is under cultivation by the Oregon State Agricultural Experiment Station. The very nature of the land use may at times increase the flood damage potential beyond immediate economic justification; however, long range benefits of such experimentation far outweigh the increased flood loss. The remaining portion of institutional land is owned by the Federal Government and functions as a recreation area for U.S. Air Force personnel from Camp Adair. The facilities provided are such that flood damage is minimal.

It is evident that a relatively satisfactory arrangement of land use presently exists on the Albany-Corvallis flood plain; however, present land use practices in the study area reflect a rational use of flood subjected land primarily because the pressures of industrial and commercial development have not as yet been heavily felt. The most immediate problems relating to flood plain use between Albany and Corvallis are the preservation of present rational uses, containment of irrational trends, and protection of already ill-used land where change is not feasible. The first two problems implicate human adjustment of man's activities whereas the latter primarily involves the adjustment of the river to man's needs by physical means.

Human Adjustment

The course of human adjustment to floods was first concretely established by Gilbert White in 1945 in his research study Human Adjustment to Floods: A Geographical Approach to the Flood Problem in the United States in which he recognized that flood plain occupance cannot be considered realistically as a matter solely of man against the marauder but must be considered as a matter of adjusting human occupance to the flood plain environment so as to utilize most effectively the natural resources of the flood plain and, at the same time, to apply feasible and practicable measures for minimizing the detrimental impacts of floods (72, p. 2). Many of the human adjustments suggested by White, and later elaborated on by his colleagues at the University of Chicago, are applicable to a future course of orderly occupancy in the Albany-Corvallis study area. The most drastic form of human adjustment, abandonment or evacuation of the flood plain, is impractical and unnecessary in this particular case study area. One of the more applicable local forms of adjustment is the directing of flood plain use, which involves land elevation, land use regulation, structural modifications, flood insurance, relief, and better warning systems (72, p. 47).

Land elevation techniques, although an expensive means of escaping flood waters, are presently being practiced in the study area as exemplified in the construction and improvement of highways and railroads. The recent elevating of Oregon Highway #34 east of Corvallis will circumvent the need to close this road during the annual floods. Economic justification may also warrant the elevation of Oregon Highway #20 in the vicinity of Garden Road. The Oregon Electric Railroad has employed elevating techniques successfully immediately outside of Albany. Justification beyond transportation arteries is difficult, and they are highly unlikely to be used in rural or residential development in the study area.[3]

As Albany and Corvallis expand, land use regulations become increasingly necessary as a means of protecting the agricultural community, guiding urban expansion, and preventing further increase in flood damage potential. The requirements and provisions for zoning ordinances, building codes, and subdivision regulations must be determined in light of economic justification as well as political and social implications.[4]

One of the more plausible legal means of asserting the needed

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[3]See pages 131 and 132 in: Gilbert White, Human Adjustment to Floods, (Chicago University, 1945).

[4]For more information see Appendix A in: Gilbert White, Choice of Adjustment to Floods, (Chicago University, 1964).

regulatory measures is by enacting zoning ordinances that are determined by the degree of hazard involved by both floods and urban sprawl.[5] In Oregon, the authority to enact flood plain zoning, when it is for the public interest, health, comfort, and convenience, is provided for indirectly in two statutes, ORS 227.200 and ORS 215.110. The power to enforce such regulations lies with the cities and counties, although the local governments in the Willamette Basin have been hesitant in enacting flood plain regulations for fear of placing themselves at a disadvantage in the city and county competition for increased residential, commercial, and industrial land.

The enactment of zoning ordinances is useful only when proper engineering, planning, and legal attention is given to their preparation. Before zoning ordinances are put into effect, it is necessary to study the nature of the flood plain. This initial step toward guided development of a flood plain by zoning ordinances should include a competent study of the hydraulic and hydrologic aspects of the flood problem that would include maps of the flood record, profiles of the river, cross-sections of the channel and flood plain, a flood frequency curve, hydrographs of past major floods, and data on

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[5] Francis Murphy deals in depth with the legal aspects of zoning as well as with the current practices in regulating flood plain development in his research paper, Regulating Flood Plain Development, (Chicago University, 1958).

monetary extent and type of flood damage previously experienced (36, p. 149-151). The scope of such a study requires federal funds which are made available to the local governments through the Corps of Engineers. The Central Lane Planning Council was the first in the Willamette Basin to take advantage of available funds oriented for this purpose, and a two year comprehensive study of the flood plain in the Eugene-Springfield area was initiated in 1962. The findings may lead the way for an up-to-date classification of zones on a flood plain that is subject to major floods and large accompanying damages (65, 66). The next study which is to be undertaken by the Corps of Engineers is of Salem, Oregon, as requested by the Mid-Willamette Planning Council. A similar study should be initiated in the Albany-Corvallis area so that all agencies engaged in flood plain management may have a solid foundation on which to construct sound policies.

Theoretical zones proposed by Robert Kates and Gilbert White provide a logical basis on which to establish flood plain zones in the study area. Based on flood frequency, three general zones, which could be overlaid on the Corps of Engineers' maps that would be an outcome of the above proposed study, were established and are illustrated in Figure 28. In order to understand how these zones were derived, it is first necessary to define the lines used. Lines "A" and "Z" delimit the area in need of some type of flood plain regulation. "A" is part of the main river channel and is underwater

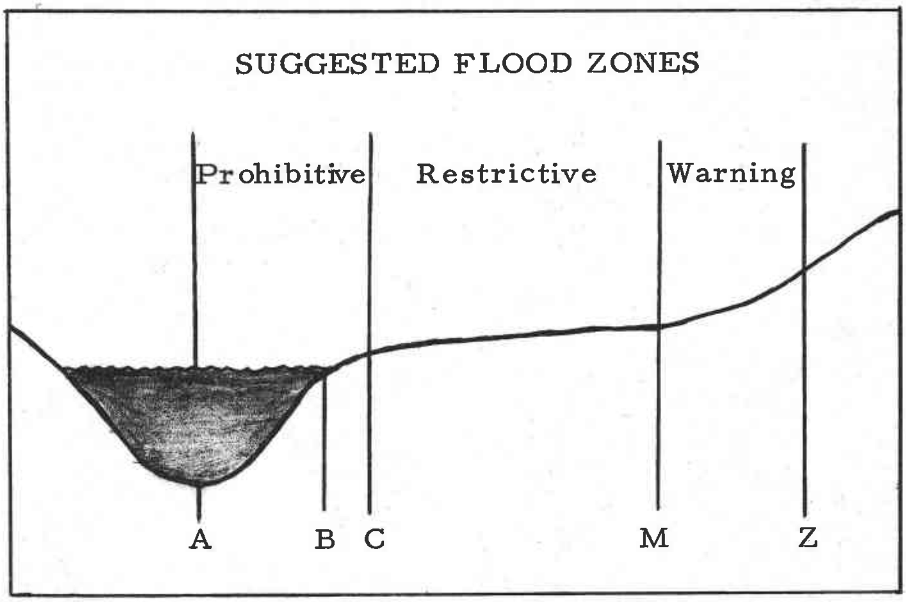

Figure 28

even during low flow; whereas, "B" marks the average level of stream flow. "Z" indicates the maximum extent of flood damage. The use of line "C" is to distinguish between "floodway" and "pondage". Line "C" applies only to a flood of a given magnitude. "M" is a culturally defined line dividing areas of major flood damages from those having minor or infrequent damages. This line is subject to change. Using these lines as a framework, Kates divided the flood plain into three zones as follows:

1. Prohibitive--A-C--That zone where any encroachment would, without clear justification to the contrary, be presumed to be against the public interest;

2. Restrictive--C-M--That zone where it would advance the general land use aims of the community to restrict uses in relation to flood hazard;

3. Warning--M-Z--That zone where it would be in the interest of property managers to receive warning of the risks involved but in which restriction is not desirable.

The number of zones and the flood frequencies used for the zonal boundaries depends on the objectives and needs of the community using flood plain zoning. An example of the possible flood frequencies used for delimiting zonal boundaries might be as follows:

1. Prohibitive Zone: less than 10 years
2. Restrictive Zone: from 10 to 75 years
3. Warning Zone: greater than 75 years to maximum probable flood (73, p. 141-142).

Subdivision regulations and building codes are alternate routes available for flood plain regulation. The prerequisite for adequate enforcement of both is the same as of that for zoning, a detailed study of the hydraulic and hydrologic aspects of the flood plain. By the use of subdivision regulations, platting land that is subject to severe flooding for residential or other unsuitable occupance could be prohibited unless provisions such as land elevation or construction of levees or drainage channels were made by the subdivider for protection against floods. The maximum limits of flooding could also be required on all final plats (36, p. 87-97). Building codes, although they establish only minimum requirements for the safety of a structure by regulating its design, construction, occupancy, and location, are a useful tool for reducing flood damage. The actions to be taken are very closely aligned with the practice of floodproofing as described by John Sheaffer, and they include such methods as anchoring wood-frame structures to their foundations, prohibiting basements or providing temporary sealing of basement floor drains, requiring shut-off valves in sewer lines, treating foundations with waterproofing compounds, utilizing grease or plastic covering for machinery and other equipment, and using emergency water-tight bulkheads, sump pumps, and similar devices (62, p. 3).

The nature of floods prevents the establishment of flood insurance on a local level. Private companies would have to be prepared to suffer great losses at almost any time. Government subsidy was once thought to be the answer to this dilemma, and in 1955 the United States Congress enacted legislation by which the Federal Treasury would share the cost of flood insurance. Then Congress, apparently reflecting dissatisfaction with the resultant insurance policies proposed, refused to appropriate the necessary funds (67, p. 7). As a result, only specific items, such as automobiles covered by comprehensive insurance policies, crop damage to wheat, and unemployment, are fully covered by insurance available at low premiums to the flood plain inhabitants. National flood insurance as it stands now "is an inert symbol of intention to deal with floods in a new fashion, but its effect upon the bill for flood losses will depend upon the way it is carried out if and when the funds are appropriated" (74, p. 31). Representative flood insurance premiums based on the flood damage potential of the property and the flood frequency have been proposed by White for representative establishments (71, p. 79), but there is no empirical basis for deciding if those residing in or expecting to reside in the study area would pay these premiums providing the insurance was available.

Flood insurance, used in conjunction with other flood control and regulatory measures, may not decrease flood damage in the near future but could encourage a more rational occupance. Gilbert White suggests that flood insurance would force a direct decision on flood adjustment because financial officers would inquire about its use each time the property was transferred (71, p. 80).

Most of the annual flood damages are presently borne by the private and public property owners and wage earners of the study area. Public relief is experienced only following a highly infrequent and catastrophic flood when aid is then received for cleanup and partial rehabilitation. Loans available from federal agencies, such as the Farmers' Home Administration, the Federal Housing Administration, and the Small Business Administration, provide financial aid at low interest rates for repairs, rebuilding, or other rehabilitation expenses. The Bureau of Public Roads provides direct assistance for reconstructing or repairing flood damaged highways. Other agencies called upon are the American National Red Cross, the National Guard, the Office of Civil Defense, and the Oregon State Health Agency. The national trend has been, and continues towards, increased public assistance for flood plain dwellers whether they be those who needlessly occupy the flood plain or those who are located there because of advantageous factors in earning a livelihood (72, p. 199). Although the short-range benefits of public relief are above reproach, the long-range benefits are questionable. Gilbert White stated in 1945 that, "On the whole, public relief policy helps to freeze present occupance, to encourage further encroachment, and to obscure the differences in factors of advantage and disadvantage between the flood plain and nearby areas" (72, p. 199).

The strong seasonality of floods in the Willamette Basin, as well as the meteorological and hydrological conditions necessary prior to a major flood, eliminates the danger of a truly flash flood. Flood forecasting plays an effective role in reducing flood damage. The study area benefits from its mid-valley location and receives sufficient flood warning to prevent loss of life, both to humans and livestock, to reschedule operations, and to enact necessary emergency floodproofing techniques. With the utilization of radar for detecting high intensity rainfall over large areas and of computers for analyzing precipitation and hydrologic data, the time and error of flood forecasting will continue to be reduced.

River Adjustment

The construction of engineering works for flood abatement represents the traditional form of river adjustment practiced in the Willamette Basin and throughout the United States. Of the five major types of engineering works in use for flood protection, levees, channel diversions, reservoirs, channel improvements, and bank revetments, only the latter two have been practiced within the boundaries of the study area, although the construction of storage reservoirs on the headwater tributaries and on the principle tributaries of the western slopes of the Cascade Range have had noticeable effects in reducing flood crests in this area (see Table VI). Channel improvements have been undertaken by both governmental agencies and private concerns for the purpose of lowering the flow line by maintaining an enlarged channel capacity and increasing the velocity of the flow. Because this adjustment helps to speed up the release of storage water, reducing the period of land inundation, it is of special importance to the farmers of the Willamette River flood plain who farm the lower reaches of the flood plain. Several farmers in the study area indicated this as the most important technique in

Table VI. Flood stage reductions-major floods, Albany-Corvallis sites.[a,b]

Item	Willamette River Corvallis	Willamette River Albany
	Feet	
Bankful stage	16.0	16.5
Major flood	26.0	27.0
1861 FLOOD		
Natural stage	32.2	36.0
Regulated stage	25.9	27.6
Stage reduction	6.3	8.4
1890 FLOOD		
Natural stage	30.7	33.9
Regulated stage	24.6	26.0
Stage reduction	6.1	7.9
1943 FLOOD		
Natural stage	28.5	31.0
Regulated stage	22.6	23.4
Stage reduction	5.9	7.6
1945 FLOOD		
Natural stage	28.1	30.4
Regulated stage	22.4	23.2
Stage reduction	5.7	7.2
1955 FLOOD		
Natural stage	28.7	31.2
Regulated stage	23.2	24.2
Stage reduction	5.5	7.0
1961 FLOOD		
Natural stage	28.4	30.9
Regulated stage	23.7	24.9
Stage reduction	4.7	6.0

[a]Note: Based on present river conditions with 14 reservoirs in operation.

[b]Source: (24, p. 87)

reducing flood damage on their agricultural land.

The Corps of Engineers has constructed bank revetments in the form of stone walls lining the streambanks for protection against erosion. Existing authorization will permit additional construction in the future.

The greatest expenditure for flood protection in the Willamette River basin has been, and will continue to be, for the construction of storage reservoirs of which there will be a total of 14. Seven of the reservoirs are presently in operation, four are under construction, and the remaining three are authorized, but funds have not yet been appropriated. Seven of the nine existing reservoirs are located upstream of the Albany-Corvallis area and provide stream flow regulation for this area during both the flood and drought seasons. With the provision of funds by Congress, a reservoir will be constructed on the Calapooia River, which enters the Willamette River at Albany, that will reduce the flood crest for those occupants immediately upstream of Albany by partially eliminating the back up of flood waters at the confluence of the Calapooia and the Willamette Rivers. Upon the completion of all of the proposed reservoirs, approximately 940,000 acre-feet of storage, or 42 percent of the total storage space of the entire Willamette River Basin, will be available to contain potential flood waters (50, p. 75). Most of the dams are multi-purpose, serving for irrigation, navigation, power generation, water quality control, and recreational purposes as well as for flood control. All of these purposes are evaluated for economic justification along with other more subtle gains and losses by the Corps of Engineers before construction is approved.[6]

Although land use on the Albany-Corvallis flood plain is for the most part rational, there are indications that this may not be the case in the future. As economic development continues in the Willamette Valley the demands of industrial and commercial needs will be felt and pressure from residential growth increased. Whether or not rational occupance will prevail depends largely on the foresight of the flood plain occupants and the local governments in recognizing the need for a comprehensive planning scheme, involving both river and human adjustment, based on land and water oriented studies. One such study is underway in the Willamette Valley and several reconnaissance studies (50, 51) and reports (1, 14, 15, 17) have already been completed. Of course, acceptance of the findings of the studies and implementation of their suggestions is prerequisite to rational occupance.

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[6] The benefit-cost ratio is discussed more thoroughly in: Gilbert White, Human Adjustment to Floods, (Chicago University, 1945), p. 151-165; W.R.D. Sewell, "Benefit-Cost Analysis and the Evaluation of Alternative Adjustments to Floods", In: Spatial Organization of Land Uses: the Willamette Valley, ed. by J.G. Jensen, (Oregon State University, 1964), p. 113-123; and Gilbert White, ed., Papers on Flood Problems, (Chicago University, 1961), p. 21-45.

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