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Irrigated Agriculture in Texas

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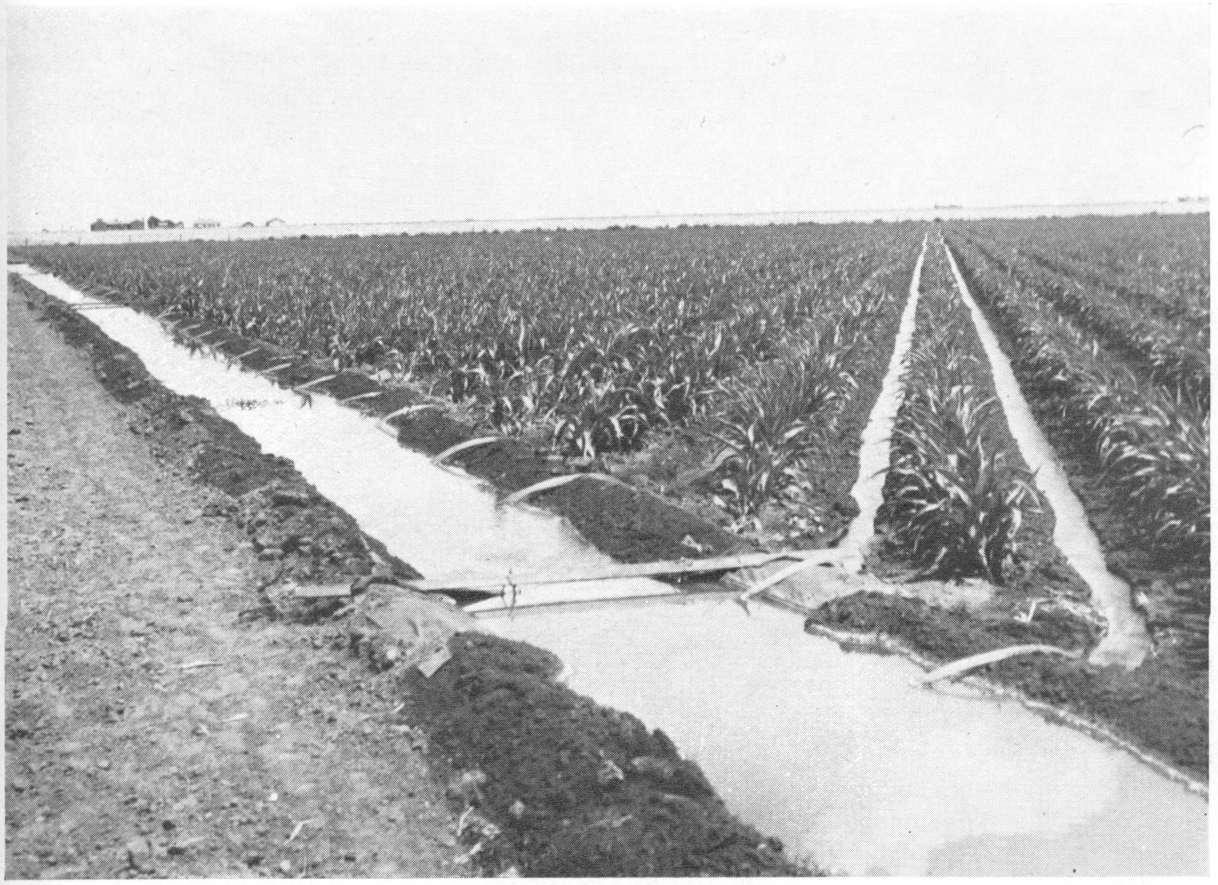

THE TEXAS AGRICULTURAL AND MECHANICAL COLLEGE SYSTEM
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Digest

The expansion of irrigation during the war and postwar years advanced irrigation farming to a significant place in Texas agriculture. During the 9-year period, 1940-48, the area under irrigation expanded from 1,045,000 to 2,885,000 acres. In the latter year, nearly 30,000 Texas farms were partly or wholly dependent for their production upon water supplies obtained either from surface or underground sources.

Approximately 10 percent of the State's total acreage of principal crops harvested in 1948 was from irrigated land. What is more significant, crops from irrigated land accounted for nearly 30 percent of the total farm value of all principal crops grown in Texas.

Most of the expansion in irrigated land resulted from individual developments of ground-water resources. These developments account for 1,369,000 acres, almost three-fourths of the 9-year increase, as compared with an increase of 463,000 acres in developments utilizing surface-water supplies.

Except for the decennial Censuses of Irrigation, no comprehensive survey of irrigation has been conducted since 1914. This publication, which presents a compilation of statewide data, is intended to serve as a source of basic information on this increasingly important subject.

Presented herein is a review of the existing situation and its contributing factors. The several possibilities for additional development and the possible consequences arising from the present extent of development are not treated.

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The Front-cover Picture

Irrigating grain sorghum near Lockney on the High Plains.
(SCS photo.)

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Irrigated Agriculture in Texas

WILLIAM F. HUGHES and JOE R. MOTHERAL*

IRRIGATION IS A practice of long standing in Texas. It has been carried on near El Paso, San Antonio and along the San Saba River for centuries and in other parts of the State for more than 50 years. It is only within recent years, however, that irrigation has figured significantly in Texas agriculture.

According to the 1940 Census, less than 5 percent of the farms and a little more than 3 percent of the harvested crop acres were irrigated. Substantial increases in irrigated cropland have occurred since the 1940 Census, particularly during 1946, 1947 and 1948. As a result, the acreage of irrigated cropland harvested in 1948 was 3 times as great as that in 1939, and accounted for about 10 percent of the State's total harvested crop acres and 30 percent of the value of crops produced.

Development of irrigation since 1939 expanded the agricultural output of Texas in two ways: first, by increasing the volume of production in established farming areas and, second, by adding new farms and production from areas not previously in cultivation. It also made other contributions to the general economy. Increased volumes of production and the specialized requirements of irrigation farmers have stimulated employment and business activities in many parts of the State. With approximately 10 percent of the cultivated lands and 30,000 farms now irrigated, current data regarding the extent, location and use of these newly developed irrigated lands are needed in formulating governmental crop programs, in appraising present and potential production situations in specific areas and in meeting the various needs of interested agencies, institutions and individuals.

Several state and federal agencies prepare and issue reports on the status of irrigation development, particularly for those areas in which they are currently interested. Some of these are annual progress reports, whereas others originate after completed specific areal investigations. Collectively, these reports cover a large part of the irrigation practiced in the State, but as many of them result from field investigations in different years, their usefulness, although indicative, is limited in any statewide appraisal of the extent of irrigation in a particular year.

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The study upon which this report is based was designed primarily to compile current information regarding the extent and location of irrigation farming in Texas. Results of studies of a similar nature, although not so comprehensive in some respects, were published in 1898,[1] 1902,[2] 1910[3] and 1914.[4]

Secondary objectives of the study were to determine the trends in irrigation development; the acres irrigated by different types of water; the acreage, yield and farm value of various irrigated crops; and the acres and number of farms served by the different types of organizations that provide water.

Data for this study were obtained largely from secondary sources, supplemented by field investigation from March to October 1949. The data presented relate to the 1948 crop season, a season of deficient moisture supplies in some areas in which both irrigation and dry farming are practiced. As a result, the benefits from irrigation are of greater magnitude than would reasonably be expected in a year of more favorable moisture supplies.

Each individual irrigation development (project or area) is characterized by a specific combination of physical conditions differing in some respects from others. Certain points of similarity, however, permit the grouping of individual developments into areas of broad significance.

For convenience in presenting the material, the State was divided into 7 areas. In 6 of these areas, delineations were based on the combination of irrigated crops, practices or source of water supply peculiar to the area. The seventh area is one of miscellaneous conditions. For purposes of orientation, 6 of the 7 areas are named for the predominant geographic area of the State included in the delineation. Except for those areas in which subsequent development necessitates a different grouping, the irrigated areas presented here are in general agreement with those defined by earlier investigators.

[1]Hutson, William F., "Irrigation Systems in Texas," U. S. Geo. Sur., Water Supply and Irrigation Paper No. 13, Washington, D. C., 1898.

[2]Taylor, Thomas U., "Irrigation Systems of Texas," U. S. Geo. Sur., Water Supply and Irrigation Paper No. 71, Washington, D. C., 1902.

[3]Nagle, J. C., "Irrigation in Texas," USDA Office of Experiment Stations Bulletin 222, Washington, D. C., 1910.

[4]Rockwell, W. L., "The Water Resources of Texas and Their Utilization," Texas Department of Agriculture Bulletin No. 43, May-June, 1914.

Table 1. Total irrigated acres, number of farms and type of water used, by areas, Texas, 1948[1]

Area[2]	Acres irrigated	Number of farms	Type of water used		
			Surface	Ground	Combination
			Acres	*Acres*	*Acres*
Panhandle—High Plains	1,384,600	7,500	.....	1,384,600	.....
Pecos Valley—Trans-Pecos	193,300	2,284	119,720	49,180	24,400
West-Central	19,200	438	15,550	3,050	.....
Rio Grande Plain	150,300	2,027	84,520	65,520	260
Lower Rio Grande Valley	592,100	14,864	587,100	5,000	.....
Coast Prairie	525,420	1,942	393,248	131,372	800
Other	19,780	724	19,570	210	.....
Total	2,884,700	29,779	1,219,708	1,639,532	25,460

[1]See Acknowledgments, p. 35, for sources of data used in this and most of the tables that follow.
[2]For area delineations see centerpiece, Figure 5.

To meet the needs of various technicians, the data are presented in tabular form by type-of-farming areas and by drainage basins in Appendix Tables 1 and 2.

This report is presented in 3 parts. The first part consists of a statewide summary regarding the extent of irrigation, type of water used, irrigated crops, production and farm value, and organization for irrigation purposes. The second treats of the history and trends in irrigation development, changes in type of irrigation farming and factors affecting irrigation-enterprise organization. The more salient conditions that exist in different parts of the State are discussed in the third part, which treats the 7 irrigated areas individually.

PRESENT EXTENT OF IRRIGATION DEVELOPMENT

Exclusive of the area in home gardens, 2,884,700 acres were irrigated on 29,779 Texas farms in 1948 (Table 1).[5] Generally the type, need and practice of irrigation increase with decreases in precipitation across the State from east to west (Figure 5). Exceptions to this are in the production of rice in humid areas and the usually small

[5]Except when the need for precision requires otherwise, text references to acreage and numbers of farms are rounded to the nearest 1,000 throughout the remainder of this report. The various tables carry the detailed data. The census definition of "farm" applies throughout the report.

Table 2. Acres of various crops irrigated, by areas, Texas, 1948[1]

Crop	Acres	Area						
		Panhandle High Plains	Pecos Valley-Trans-Pecos	West-central	Rio Grande Plain	Lower Rio Grande Valley	Coast Prairie	Other
		Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Cotton	939,500	482,700	135,800	1,880	16,330	295,740	.....	7,050
Grain sorghum	566,600	518,600	1,478	3,200	22,500	18,000	.....	2,822
Rice	525,300	.....	.....	.....	.....	.....	525,300	.....
Wheat	268,600	266,900	.....	.....	.....	.....	.....	1,700
Commercial truck crops	245,200	8,870	[2]	.....	73,800	162,530	.....	[2]
Citrus (all)	122,500[3]	.....	.....	.....	1,400	121,100	.....	.....
Alfalfa	90,705[4]	55,900	25,578	2,970	250	4,000	.....	2,077
Forage sorghum	63,330	23,700	7,000	6,100	14,760	11,000	.....	770[5]
Miscellaneous	37,945	11,530	8,049	4,190	6,345	5,000	20	2,811
Total harvested	2,859,680	1,368,200	177,905	18,340	135,385	617,370	525,320	17,160
Pasture	86,128	22,300	460	848	39,835	20,000	100	2,585
Crop failure	17,752	1,965	15,787	[6]	[6]	[6]	[6]	[6]
No harvest[7]	18,547	[6]	[6]	12	[6]	18,500	[6]	35
Total	2,982,107	1,392,465	194,152	19,200	175,220	655,870	525,420	19,780
Less double cropping	97,407	7,865	852	[6]	24,920	63,770	[6]	[6]
Net irrigated	2,884,700	1,384,600	193,300	19,200	150,300	592,100	525,420	19,780

[1]See Acknowledgments for sources of data.
[2]Acreage of commercial truck crops small, included in miscellaneous crops.
[3]Net citrus acreage 168,700; only 122,500 acres with trees of bearing age.
[4]Net alfalfa acreage 83,205; 7,500 acres harvested for seed.
[5]Includes 502 acres of clover.
[6]None reported.
[7]New plantings not yet in production.

experimental irrigation ventures that take place from time to time in other parts of the State.

The practice of irrigation, except for that used in the culture of rice, is followed mostly in the portions of the State where the annual rainfall is less than 25 inches. West of the line indicating the boundary between the semi-arid and humid regions of the State, crop production without irrigation is seldom attempted (Figure 5).

A supplemental type of irrigation is practiced east of this dividing line. In most years some crop production is possible without irrigation. Moisture is frequently insufficient for a satisfactory level of production, however, and water is applied where possible to supplement deficiencies in precipitation. Under these conditions, the acreage irrigated in a particular year does not necessarily reflect the acreage equipped for irrigation. In a year of low rainfall, the acreage irrigated may be low simply because the available water supplies will not serve as large an acreage as in years of more favorable rainfall. On the other hand, in a year of high precipitation the actual number of acres irrigated may be low because there is less need for irrigation.

Generally, where supplemental irrigation is practiced, irrigated cropland constitutes only a part of the total cropland per farm. The chief exceptions are the wholly irrigated citrus and vegetable farms of the Winter Garden and the Lower Rio Grande Valley.

Type of Water Used

Wide differences are found in the problems of development, cost of operation and outlook for future water supplies between areas using water from underground sources and those obtaining water from surface sources. These differences are of such significance both for the present and for the future that it appears advisable to tabulate acreage utilizing water from the 2 sources separately.

Water was obtained exclusively from wells in almost 57 percent of the area irrigated in Texas during 1948 (Table 1). Expansion in ground-water irrigation has been substantial in recent years, increasing from 267,000 acres in 1939 to 1,640,000 acres in 1948.[6]

Although ground-water resources in several of the areas are under artesian pressure, only a small part of the water supply is obtained from flowing wells. A number of flowing wells are used but the yield is usually so small that pumping is necessary; consequently, almost all ground water used in the State is obtained by pumping.

Water from surface sources was used on 1,220,000 acres, or 42.2 percent of the irrigated acres. Most surface-water supplies were pump-diverted. Only 174,000 acres, or 14.2 percent of the lands irrigated by surface water alone, obtained water by gravity diversion.[7]

[6]All water obtained from flowing or pumped wells is classed here as ground water.

[7]Water from streams, lakes, springs, tanks and sewage is classed here as surface water.

Table 3. Yield per acre, production and value of various crops, total and irrigated, Texas, 1948

Crop	Unit	State total				Irrigated crops			
		Acres[1]	Average yield per acre[1]	Production[1]	Farm value[2]	Acres	Average yield per acre	Production[3]	Farm value[4]
				Thousands	*Thousands*			*Thousands*	*Thousands*
Cotton—lint	bale	8,610,000	0.37	3,153	$466,939	939,500	0.79	745	$110,334
Cotton—seed	ton	.....	.....	1,306	94,163	.....	.....	317	22,856
Grain sorghum	bushel	4,635,000	16.50	76,434	94,014	566,600	41.80	23,724	29,181
Rice[5]	bushel	525,300	46.50	24,459	59,191	525,300	46.50	24,459	59,191
Wheat	bushel	5,629,000	10.50	59,104	118,799	268,600	17.50	4,706	9,459
Commercial truck	.....	384,800	.....	.....	59,475	245,200	.....	.....	42,625
Citrus (all)[6]	.....	168,700	.....	.....	22,385	168,700[7]	.....	.....	22,385[8]
Alfalfa—hay	ton	130,000	2.70	351	8,775[9]	83,240	3.40	283	7,078[9]
Alfalfa—seed	bushel	10,000	3.50	35	668	7,500	4.00	30	573
Forage sorghum	ton	2,248,000	1.22	2,750	60,500	63,300	2.20	138	3,036
Corn	bushel	2,709,000	16.50	44,698	69,282	13,700	49.60	680	1,054
Oats	bushel	863,000	16.50	14,240	13,813	9,730	43.00	418	405

[1]"Summary of Crop Statistics," Bureau of Agricultural Economics, Austin, Texas, Dec. 27, 1949, mimeographed.

[2]"Production, Prices and Values of 1948 and 1949 Crops—Texas," Bureau of Agricultural Economics, Austin, Texas, Dec. 29, 1949.

[3]Compiled from reports listed in 1 and 2 above, crop census of individual projects by the Bureau of Reclamation, Production, and Marketing Administration, gin records and individual reports.

[4]State average prices times total irrigated production.

[5]Acreage from this inventory, Bureau of Agricultural Economics published estimate 526,000 acres.

[6]1947-1948 crop.

[7]Total acreage in citrus; acreage in bearing orchards was 122,500: "Citrus Fruits," Bureau of Agricultural Economics, Washington, D. C., Oct., 1949.

[8]As sold by all methods of sale.

[9]Estimated value at $25 per ton.

A combination of both types of water, ground and surface, was used on 25,000 acres, or less than 1 percent of the total acres irrigated. Most of the combination use is along the Pecos River where ground-water supplies have been developed to augment scant surface-water supplies.

Irrigated Land Use

The 2,885,000 acres irrigated represents the net land area to which water was applied. Because of various land uses and double-cropping practices, the gross acreage utilized by irrigated crops harvested, irrigated crop failure, irrigated "no harvest" and irrigated pasture exceeds the net acres irrigated by almost 100,000 acres (Table 2). The 2,860,000 acres of harvested crops constitute a little more than 10 percent of the State's total harvested acres of principal crops as reported by the USDA Bureau of Agricultural Economics.[8]

Except for rice, citrus and alfalfa, the principal irrigated crops grown in the State are also the principal cash crops. Acreages of individual irrigated crops for the State and for the 7 areas are given in Table 2, and the proportion of the particular crop irrigated is shown in Figure 1.

According to the Bureau of Agricultural Economics, the farm value of Texas crops in 1948 amounted to $1,148,845,000. The proportion of

[8]"Summary of Crop Statistics," USDA Bureau of Agricultural Economics, Austin, Texas, Dec. 1949. This release carries an estimate of 27,840,000 acres for principal crops harvested. It does not include citrus, 122,500 acres in bearing trees. Acres of principal crops harvested on which the above comparison is made are composed of the original estimate plus citrus acreage minus 700 acres for difference in rice acreage estimates (See footnote 5, Table 3) totaling 27,961,800 acres.

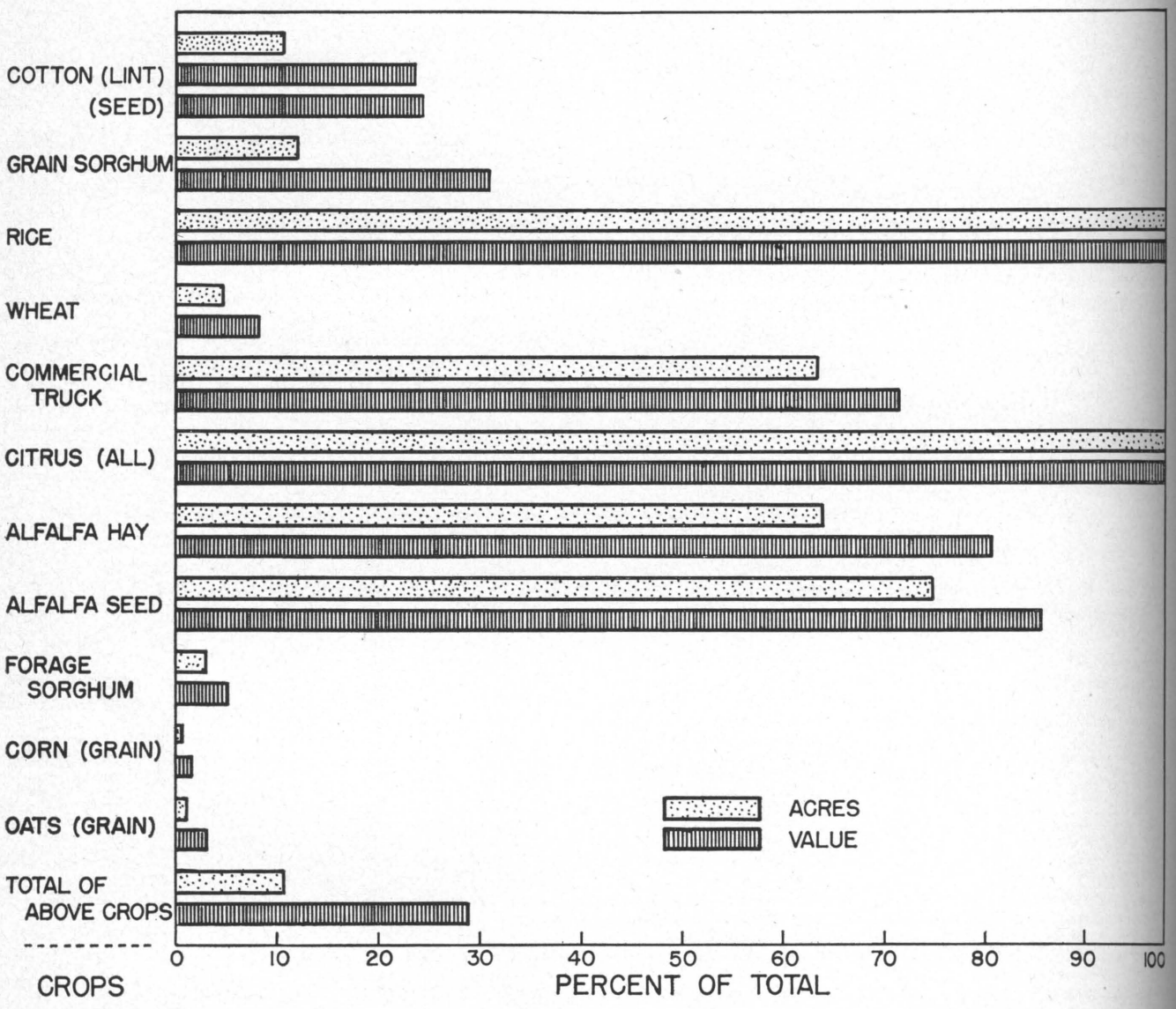

Figure 1. Percentage of acreage of each crop that was irrigated and percentage of the value of each crop that was from irrigated acreage, specified crops, Texas 1948.

total farm value contributed by irrigated crops is approximated for the 10 principal crops listed in Table 3. These 10 crops account for 93 percent of the State's total crop acres harvested and 99.8 percent of the irrigated crop acres harvested in 1948. The list does not include all irrigated crops as there is no readily available method of determining the farm value of production from nurseries and from seed and other miscellaneous irrigated crops of small acreage.

The farm value of the 10 principal crops amounted to $1,062,986,000, or 92.5 percent of the State total. Farm value of irrigated crops amounted to $308,177,000, or 28.9 percent of the value contributed by the 10 principal crops. The proportion of individual crop acres irrigated and the farm value of production are given in Figure 1. Inasmuch as farm value of irrigated crops was computed by multiplying total production of individual irrigated crops by average prices for the State, and does not take into account seasonability or quality of production, the estimate of the proportion of total farm value contributed by irrigated crops is conservative.

Organization for Irrigation Purposes

Water supplies for a little more than 63 percent of the irrigated land and 40 percent of the farms were obtained from individual or partnership-owned wells or diversion structures. These are *independent enterprises.*[9] Expansion in ground-water irrigation, a type of development that does not require an organized approach, brought a sharp increase in the proportion of irrigated acreage served by independent enterprises. According to the 16th Census, only 33.4 percent of the irrigated land in the State was served by this type of enterprise in 1939, as compared with 63 percent in 1948. On practically all acreage irrigated by ground water, the water is obtained from individual or partnership-owned wells, the main exception being the combination uses near Barstow where the irrigation district owns and uses a number of wells.

A little more than 10 percent—181,000 acres—of the acreage irrigated by surface water was supplied by independent enterprises. With a few exceptions, lands irrigated by surface water and served by this type of enterprise are in small, isolated tracts. Most such tracts larger than 200 or 300 acres are included in some form of group enterprise for providing water.

There are a number of formally organized enterprises for water control and development purposes which are referred to here as *organized enterprises.*[10] Only 75 of these, however, include

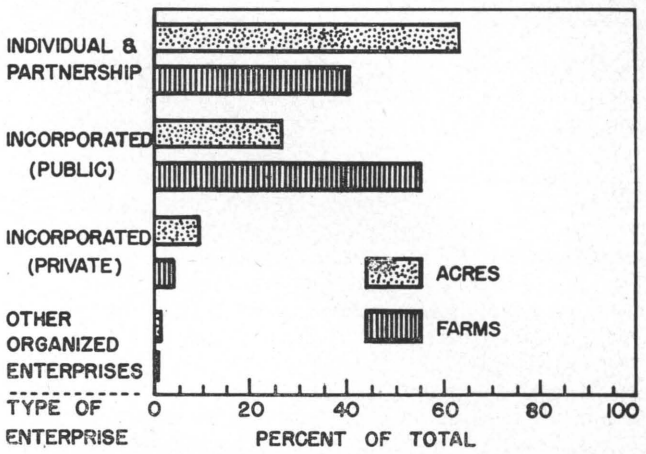

Figure 2. Percentage of acreage and farms irrigated, by type of irrigation enterprise, Texas, 1948.

the provision of irrigation water among their functions. The others, although similarly organized and operated, deal with other phases of water control and development.

About 37 percent of the irrigated acres and 60 percent of the irrigated farms obtained water through organized enterprises in 1948 (Figure 2). With new organizations being formed and older organizations being expanded, the acreage served by this type of enterprise has increased since 1939. The proportion of total acreage served, however, declined from 66 percent in 1939 to 37 percent in 1948.

Organized enterprises are subdivided into public corporations, private corporations or other, depending on the ownership of the facilities involved. The relative importance of the various types of organization is shown in Figure 2.

Public corporations are organized enterprises owned by the landowners concerned. Included as public corporations are 30 water improvement districts, 15 water control and improvement districts, 2 mutual organizations, 2 navigation districts, an irrigation district and a valley authority, all of which were engaged in some form of irrigation activity during 1948. These enterprises served 26 percent of the irrigated acres and 55 percent of the irrigated farms.

Private corporations, as the name implies, are privately owned enterprises operated for profit. They function mostly as public utilities, subject to the rules and regulations of appropriate State agencies. Twenty-one private corporations provided water for 9 percent of the irrigated acres and 4 percent of the irrigated farms in 1948.

Other organized enterprises are those whose ownership differs somewhat from that of public or private corporations. They were relatively unimportant in 1948, serving less than 1 percent of the irrigated acres and less than one-half of 1 percent of the farms.

[9]For purposes of this discussion, independent enterprises are defined as those enterprises belonging to individual or neighboring farmers who control and operate them without formal organization.

[10]Organized enterprises are group undertakings owned and operated by the farmers or private companies. They are corporate bodies, both public and private, organized according to one or more of the permissive statutes.

HISTORY AND TRENDS IN IRRIGATION DEVELOPMENT

Development of irrigation in Texas has been affected by a wide range of events and conditions, some of which have tended to restrict development while others have advanced it rapidly. The influence exerted by a particular event rarely can be precisely determined. Expansions in irrigated lands followed the Canal Act of 1876, railroad construction in the latter part of the 19th Century, widespread promotional activities of private land and water companies, introduction of specialized crops, technological improvements in pumping equipment and power units, and the stimulus of prosperous conditions in the general economy. Such influences may overlap or be neutralized by offsetting factors, and in all cases the causal relationships are hard to measure. The response sometimes has been immediate; at other times, a period of years elapsed before any effect became apparent.

Early Development

The first record of irrigation farming in Texas is found in old Spanish reports. According to Coronado, an early Spanish explorer, Indians were irrigating crops in the vicinity of the present city of El Paso when his expedition reached there in 1541.[11] This, however, was not the first irrigation practiced in the State. Remnants of prehistoric irrigation structures near the perennial springs of the Trans-Pecos area are reported by Hutson, who states:

> Several of the valleys of the Trans-Pecos country show signs of having once supported a teeming population. The lines of their irrigation canals can yet be traced for miles, while arrowheads, stone implements for grinding corn, and other relics can be found in considerable quantities. . . .[12]

For almost 200 years following the time of Coronado's expedition, the history of irrigation farming is unknown. The old mission canals at San Antonio were constructed by Franciscan fathers between 1716 and 1744.[13] Franciscan fathers established the San Saba Mission and built canals at the presidio on the San Saba River in 1756.[14]

Development Following 1853

One of the first irrigation developments by Anglo-Americans occurred in 1853 near the present town of Balmorhea in the Trans-Pecos.[15] Other scattered developments in the same general area and along the Rio Grande came shortly after.

From these early beginnings, irrigation farming expanded both in acreage and areas wherever it was practiced in the State. The trend in acres irrigated, although always upward from one census enumeration to the next, has not been one of steady progress. Characteristically, increases in irrigation farming have been marked by periods of relatively rapid expansion followed by periods of consolidation in which the number of irrigated farms increase at a disproportionate rate compared with the increase in area irrigated (Figure 3). The acreage irrigated has fluctuated widely within most individual areas. Declines in one area, however, have been more than offset by increases in others.

Decennial census reports for 1939 and earlier are the only source of data relating to the total acreage irrigated in the State. The published materials of Hutson, Thomas, Nagle and Rockwell indicate the extent within certain areas but not the total acreage under irrigation at the time their work was issued.

The 11th Census, which covered the crop year 1889, reported a total of 18,000 acres irrigated on slightly more than 623 farms (Figure 3). By 1899, the acreage and the number of farms irrigated had increased to 50,000 and 1,325, respectively. The period 1900-09 was one of comparatively rapid settlement.

Developments following 1910 were on a somewhat reduced scale compared with the rate of increase between 1900 and 1910. By 1920, the area irrigated was up to almost 600,000 acres, an increase of about 135,000 acres over the acreage of 1910. The number of irrigated farms did not increase in proportion to the area irrigated (Figure 3).

From 1920 to 1930 the acreage irrigated increased about one-third while the number of irrigated farms almost doubled. The decade of 1920-29 marked the rise of the citrus industry in Texas. Real estate promotions and expansion in citrus plantings were responsible for most of the increase in irrigated acres and farms in this 10-year period.

Irrigation increased by almost a quarter of a million acres during the 1930-39 period, a slightly larger increase than that recorded for the previous decade—246,000 acres compared with 213,000 acres. The number of irrigated farms almost doubled, an increase proportionally comparable with that reported for the 1920-29 period. Many new factors arose to influence development. The 1930-39 period was one of widespread drouth and economic depression. Drouth conditions stimulated interest in irrigation farming, but economic conditions were not favorable to its development, particularly for large-scale enterprises. This is reflected in the type of irrigation developments: 204,000 acres out of the 246,000 acres developed during this time were irrigated by ground water.

Although the acreage irrigated by ground water did not become especially significant until 1940, wells had been used on a moderate scale

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[11] Hutson, William F., *op. cit.*, p. 18.

[12] *Ibid.*, p. 17.

[13] *ibid.*, p. 43.

[14] Texas Almanac, 1949-1950, p. 566.

[15] Report on the participating agencies, *Pecos River Joint Investigations*, National Resources Planning Board, Washington, D. C., June, 1942, p. 141.

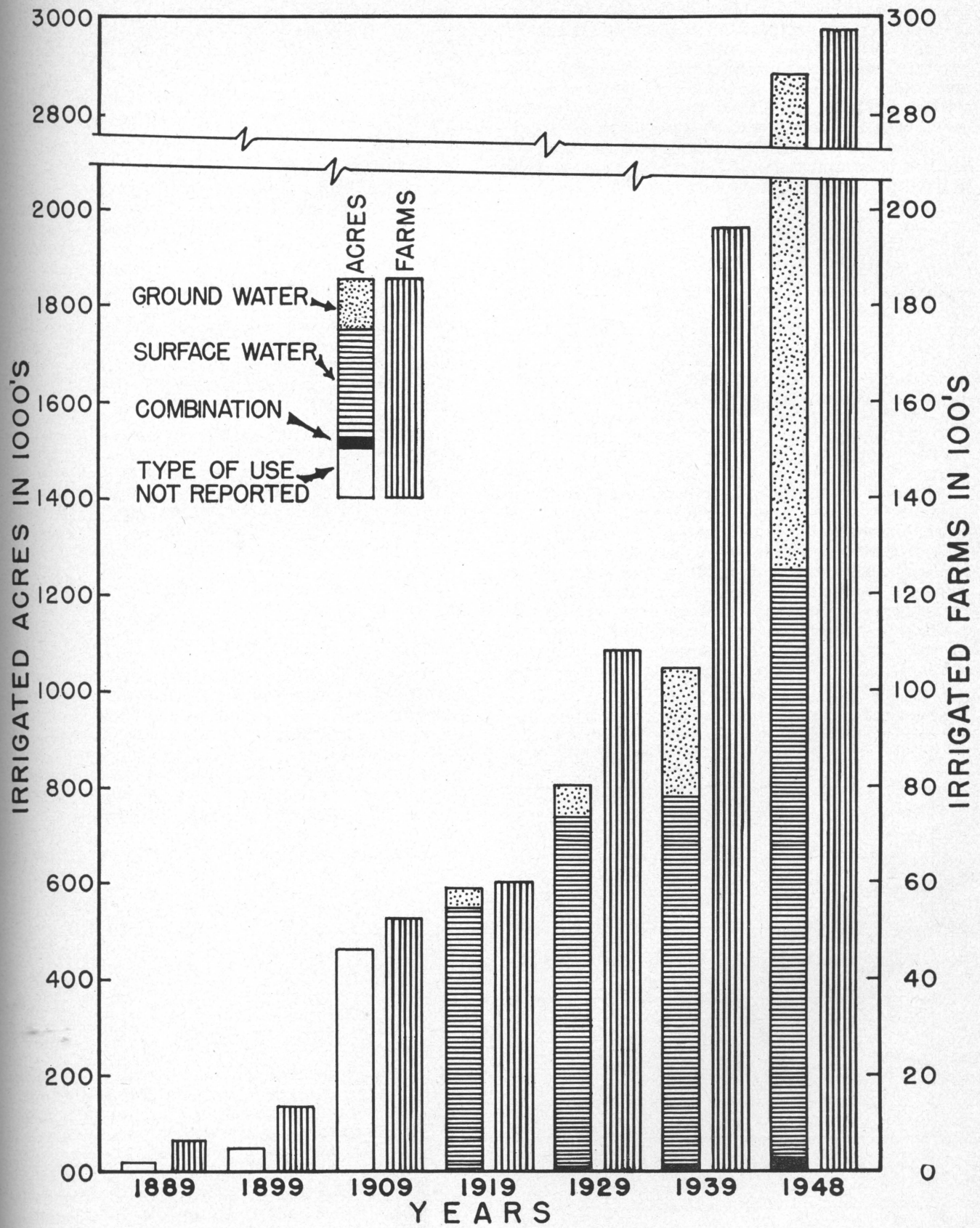


Figure 3. Acres irrigated and number of farms, by source of water, Texas, 1889-1948. Source of data—1889-1939 U. S. Census of Agriculture; 1948 this inventory.

for many years. The 11th Census reported flowing and pumped wells as sources of water supply in 1889. Ground-water use in the Galveston-Houston area, near San Antonio, in the Winter Garden area, near Pecos and in the High Plains was reported by Hutson in 1898.[16] Despite the foregoing references to ground water as a source of supply and those carried in later census reports, the first statewide enumeration of acreage irrigated by ground water was reported in the 1920 Census.

According to the 14th Census, ground water was used in 1919 as the sole source of supply on 44,000 acres and in combination with water from other sources on 499 acres, a little less than 8 percent of the total acres irrigated. By 1930, the use of ground water had expanded to 63,000 acres, an increase proportional with that of surface-water use during the same period.

Technological improvements in pumping equipment and improved economic conditions contributed to the increase in the use of ground water. Early irrigators using ground water depended on flowing wells, low capacity plunger-type pumps or centrifugal pumps with relatively low lifting capacity. The centrifugal pump is suitable for pumping from open water such as streams and lakes where the pump can be placed near the surface of the water. It is not so suitable for pumping from wells, particularly deep wells or wells in which the water level draws down materially once pumping is under way. The development of the turbine-type pump, a highly efficient pump designed for deep well operations, removed some but not all of the limitations to ground-water development.

The next technological improvement, following the introduction of the turbine pump and its subsequent improvements, came when the light automotive-type engine and direct drive replaced the heavy, slow, oil-burning engine as a source of pump power. This latter improvement, which came into general use about 1934, brought a sharp reduction in the costs of construction.

With construction costs reduced and interest sharpened by a number of drouth years, the stage was set for an acceleration of ground-water use. Expansion followed, although perhaps not as fast as the interest warranted. Depressed economic conditions tended to retard its development. Despite the general scarcity of capital during the depression years, once the improved mechanical means were available, the interest was such that the use of ground water advanced rapidly. Most of the 204,000-acre increase in land irrigated by ground water recorded during the 1930-39 period, came after 1936.

Increases in the acreage irrigated by surface water were rather small during the depression years. The 16th Census reported a total of 757,000 acres irrigated from surface sources in 1940, as compared with 732,000 acres from the same sources in 1930, a gain of only 25,000 acres. Interest in the development of the surface-water supply was perhaps as high as that in ground water, but a number of factors combined to restrict expansion. For one, most of the surface-water supplies that could be utilized without substantial construction had already been put to use.

Some of the increase in irrigated lands during the 1930-39 period can be attributed to expansion within established surface-water areas, but most of it stems from ground-water developments. The substantial increase in irrigated farms during this period reflects the "back-to-the-farm" movement of the mid-thirties, plus ground-water developments on farms not previously irrigated.

[16]Hutson, William F., *op. cit.*, pp. 26, 46, 60 and 64.

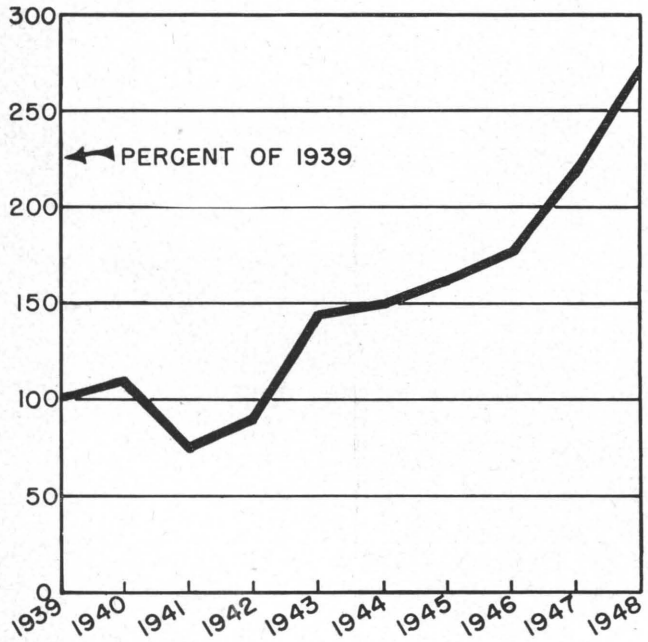


Figure 4. Trend in acreage irrigated, Texas, 1939-48.

Development Since 1939

Data are not available for a complete tabulation of the acreage irrigated by years since 1939. Enough are available from published and unpublished sources, though, to indicate the approximate extent of development in particular years (Figure 4).[17] Areas covered by these reports contained about 92 percent of the irrigated acres reported by the Census for 1939 and slightly more than 94 percent of the irrigated acres in 1948.

Trends in development, particularly for ground water, were extended through 1940. After 1940, however, a different set of circumstances prevailed. Moisture supplies were ample during 1941

[17]Data for Figure 4 were compiled from water bulletins of the International Boundary and Water Commission, annual operating reports of Pecos County Water Improvement District No. 1, U. S. Geological Survey and State Board of Water Engineers reports on ground-water utilization in the High Plains, and rice acreage reports by the Bureau of Agricultural Economics.

and 1942; consequently, there was little inducement for irrigation. This is reflected in Figure 4 where the acreage irrigated in those years fell below that reported in 1939.

Beginning in 1942 and carrying through 1945, the "all-out" war effort influenced irrigation development in two ways. High farm commodity prices encouraged development, but scarcities of equipment and materials restricted it. Investment capital, which had been a limiting factor in the years immediately preceding the war, became readily available from both public and private sources.

Government lending policies, prior to 1942, were such that irrigation development loans could not be obtained in most of the established ground-water areas. The immediate need for increased food and fiber output forced a change in lending policies, which brought some increase in irrigated areas, but did not overcome the scarcity of pumping equipment.

Interest in irrigation increased during the war, the acreage irrigated increasing by about 100,000 acres annually during the 1942-45 crop years (Figure 4). Postwar agricultural prices bolstered by price supports, with no limitations on production, stimulated this interest still more. After the end of the war in 1945, the tight equipment situation eased somewhat, but not enough to meet the demand. Nearly 1,000,000 acres of new irrigation were developed between 1946 and 1948, almost as many acres as had been developed in the State during the 400 years of irrigation history before 1939. Approximately three-fourths of this came through ground-water developments in the High Plains. By the end of the 1948 crop year, irrigated acreage in Texas had expanded to 2,885,000 acres, an increase of 1,839,000 acres since 1939. Ground-water developments during the 9-year period accounted for 1,369,000 acres, compared with an increase of 463,000 acres in surface-water use. Increases in both types of water use were unprecedented for any equivalent period in Texas history.

Trends in Type of Irrigation Farming

The type of farming practiced under irrigation has varied with the eras of Texas agricultural history: early subsistence, transition and commercial or cash-crop farming. In one respect, these eras in irrigation farming do not parallel equivalent periods of Texas history. The early subsistence era of irrigated farming, represented by the Indian irrigators of the Trans-Pecos region and the Franciscan fathers at San Antonio who were primarily interested in producing food crops for their own consumption, was on the decline at the turn of the 19th Century. There is no clear line of demarcation between the ending of one era and the beginning of the next. They merge into each other, reflecting the impact of increasing settlement, technological improvements and changed economic conditions.

Emphasis on the production of food crops for home use declined through the years following the establishment of the Spanish missions at San Antonio. Production for home use was replaced by increasing emphasis on feed crops for livestock consumption. The era of feed crop production probably reached its peak in the latter part of the 1880's. It declined thereafter as the era of cash crop farming got under way, a trend that is still continuing. The cash crop nature of irrigated farming, which predominates today, had its beginnings in the promotional efforts of private land and water companies.

The passing of the Canal Act of 1876 reflected a growing interest on the part of the State in encouraging the development of its natural resources. Under this act, the State encouraged this development by grants of land for the construction of canals. Stimulus was provided for private development; but in the absence of transportation to outside markets, few canal developments were started. With the increase in railroad building in the latter part of the 1880's this impediment was removed, and private development followed rapidly railroad construction into various parts of the State.

In the 30 or 40 years of irrigation farming preceding the commercial development period, major emphasis was placed on such crops as corn, oats, alfalfa and forage crops. This situation also prevailed for some time afterward, but increasing settlement shifted the emphasis to cash crops.

The trend toward the production of cash crops and the impetus given this trend by the favorable agricultural price situation during the 1940's is shown in Table 4. Acreages in the 4 cash crops have increased with the years, particularly in the 1939-48 period. The acreage planted to the cash crops—cotton, grain sorghum, rice and wheat—amounted to 47 per cent of the total irrigated acreage in 1929, declined to 44 percent in 1939, but increased to 80 percent in 1948. The increase in acreage for cotton and rice is substantial, but it leaves these crops in about the same position relative to total irrigated acres that they occupied in 1929. This does not apply for grain sor-

Table 4. Acreage in specified irrigated crops, Texas, 1929, 1939 and 1948

Crop	Irrigated crops[1]		
	1929	1939	1948
	Acres	*Acres*	*Acres*
Cotton	264,317	178,106	939,500
Grain sorghum	5,205	28,204	566,600
Rice	103,973	186,230	525,300
Wheat	3,065	66,846	268,600
Alfalfa (hay)	25,079	51,730	84,800
Forage sorghum	17,980	64,677	63,300
Corn (for grain)	31,112	45,573	13,700
Oats (for grain)	4,591	8,997	9,730

[1]The 1929 and 1939 acreages from census reports, 1948 acreage from this inventory.

ghum and wheat, which occupied about 20 and 10 percent, respectively, of the irrigated land in 1948, as compared with less than 1 percent each in 1929. The striking rise in irrigated grain sorghum and wheat is attributable to the expansion of irrigation in the High Plains where these 2 crops are commonly grown.

Trend in Irrigation Enterprise Organizations

Most surface-water developments, especially the more substantial ones, are essentially community enterprises. Lack of suitable diversion points, and the fact that a number of tracts using water from a common source could be supplied more economically through single constructions, forced a cooperative approach at an early date. This approach required organization to assure equitable distribution of water, to arbitrate disputes, to maintain structures and to further the operation generally. In carrying out these functions, which have grown in complexity and magnitude through the years, a number of different forms of group enterprise organization have evolved. These range from formal or informal partnership enterprises to highly organized enterprises possessing taxing and regulatory powers subject only to legislative and constitutional limitations.

Early cooperative efforts. The first evidence of cooperation in providing a common water supply is afforded by the mission activities at San Antonio early in the 18th Century. Cooperative enterprises established by the missions functioned for more than a century. Other unincorporated cooperatives were the *acequias* of the Mexicans in the area below El Paso, but the founding dates of these community organizations are obscure. They probably antedate Anglo-American developments by a number of years, however, as they were reported to have been "old ditches" in 1897.[18]

Early Anglo-American developments following 1853 were individual undertakings which utilized the flow from springs and streams. As development continued and larger and more expensive works were constructed, other forms of organization developed.

Rise of private corporations. The next form of organization to emerge was the commercial irrigation company, the first incorporated organization for providing water. The year 1875, or thereabouts, marked the beginning of a period of commercial irrigation development in Texas. The Canal Act of 1876 and the adoption of the prior appropriation statute in 1889 aided the rise of commercial efforts. The Canal Act encouraged development by providing free land for canal construction, whereas the appropriation statute provided a legal means of protecting a water supply from subsequent encroachments.

The private organization, represented by the irrigation companies, was the only class of group enterprise capable of raising funds for developmental purposes. The constitutional amendment of 1904 made it legally possible for public organizations for water control and development purposes to issue bonds secured by real assets.[19]

Private land and water companies became active in different parts of the State after railroads were constructed and as special crops were introduced. Although a few land and water companies became active in the Pecos River Valley as early as 1875, the main period of commercial development came after railroad construction in the 1880's. Commercial developments in the Coast Prairie came after rice was introduced in 1895, whereas those in the Lower Rio Grande Valley came after the railroad was completed in 1904.

With the possible exception of companies located in the Coast Prairie, the history of commercial development is marked by widespread failure. Rates of settlement were slower and construction costs a great deal higher than had been anticipated in the original construction plans. Then, too, some of these efforts were promoted without adequate consideration of possible deficiencies in land and water resources. As a result, many, if not all, soon experienced financial difficulties.

By 1900, investors were becoming wary of further investments in water development schemes and promoters began searching for other means of financing. This led to attempts to amend the State Constitution. A joint resolution by the Twenty-fifth Legislature providing for the formation of irrigation districts, as bodies corporate having all the rights and liabilities of ordinary irrigation corporations and the right to issue bonds for irrigation construction subject to the same restrictions as county and city bonds, was submitted to the people at a special election August 3, 1897. This amendment, which stemmed largely from the efforts of promoters in the Wichita River Valley, was rejected by a large majority. Another attempt by the same interests met a similar fate in 1899.

A number of commercial developments came after 1900, particularly in the Lower Rio Grande Valley and in the rice-growing area of the Coast Prairie. Some of these later commercial efforts were organized differently from the pioneer ventures. Early commercial enterprises were designed primarily to function as public utilities, deriving their revenues from the sale of water once the lands were sold. Some of the later enterprises were organized as stock companies in which control passed to the water users as the lands were sold.

Water users, acting under the provisions of the Irrigation District Act of 1913, organized irrigation districts and took over the works and functions previously exercised by private companies.

[18] Hutson, William F., *op. cit.*, p. 65.

[19] Article III, Section 52 a and b: adopted Nov. 8, 1904; proclaimed Dec. 29, 1904.

Operating through a board of directors and a manager, the irrigation district maintained about the same corporate structure as the private corporation. The main result was a new group of owners—the water users themselves—and a writing-off of a large part of the construction costs.

Rise of public corporations. The era of stock company operations was short-lived. The stock company type of enterprise was well adapted for placing control in the hands of water users once a project was constructed. It was not so well adapted for project constructions.

For construction purposes, an enterprise must be in a position to advance large sums of construction capital and to be able to maintain itself during the period of development with little or no return on its investment. This latter requirement was one of the primary causes of failure in early commercial development efforts. The stock-company approach proved satisfactory where projects were already constructed. It did not, for the aforementioned reasons, meet the needs of people interested in new construction.

The State Constitution was amended in 1917 when the "Conservation Statute" was adopted. Section 59, Article 16 of the Constitution, adopted at a special election August 21, 1917, provided for the formation of conservation and reclamation districts. In the language of Section 59 (b) of the Statute:

> . . . districts shall be governmental agencies and bodies politic and corporate with powers of government and with authority to exercise such rights, privileges and functions concerning the subject matter of this amendment as may be conferred by law.

Methods of financing irrigation were also provided in the amendment. Section 59 (c) provided that all improvement and maintenance could be financed through the sale of district bonds. It also authorized districts to levy and collect within their boundaries all such taxes as were necessary to retire the bonds. All indebtedness of a district, evidenced by bonds, constituted a lien upon all property assessed for the payment thereof. This amendment cleared the way for the organization of public corporations and closed the period of commercial development efforts in all but the Coast Prairie.

The irrigation district form of enterprise was largely replaced by the conservation and reclamation district following the constitutional amendment of 1917. Only one irrigation district was functioning in 1948. Reorganizations following the acts of 1919 and 1925 removed the conservation and reclamation district from the ranks of irrigation enterprises. They still function in different parts of the State, but not in connection with irrigation.

Except for the Coast Prairie, where commercial irrigation companies predominate, only two commercial irrigation companies were in operation during 1948. One of these was organized in the 1870's, the other in the early 1900's. Another small area still bears the name of the company that developed it, but it has long since been taken over by the water users. Water improvement districts (Act of 1919) and water control and improvement districts (Act of 1925) were the predominant forms of group enterprises in 1948.

Slightly more than 66 percent of the irrigated land developed before 1939 was included in group enterprises. In contrast, less than 20 percent of that developed since 1939 has been included in group enterprises. Most of the increase in irrigated land since 1939 resulted from individual developments, that is, irrigation wells or independent stream flow diversions.

IRRIGATED AREAS

AREA I: PANHANDLE-HIGH PLAINS

This area includes the irrigated lands of the Panhandle-High Plains where ground waters are used exclusively. The High Plains comprise a broad, smooth plain, rising from about 2,500 feet above sea level in the southeast to slightly less than 5,000 feet in the extreme northwest.[20] Aside from the vast expanse of plains, the most outstanding topographic features are the strongly eroded areas bordering the Canadian River and the bold escarpment marking the eastern edge of the High Plains.

The climate is sub-humid, with average annual precipitation ranging from less than 15 inches in the west to about 22 inches in the east. Annual precipitation has varied from about 6 inches to more than 40 inches at a number of recording stations. More than three-fourths of the annual precipitation normally occurs during the growing season. The amount of precipitation received borders on the lower limits for successful crop production, and comparatively small departures from the amount normally received, or maldistribution, can affect crop production materially.

The length of the frost-free growing season increases from north to south, averaging about 180 days in the north to a little more than 210 days in the south. Other climatic characteristics common to the area are: low relative humidity, high percentage of possible sunshine and strong wind movement. Winters are open with comparatively little snowfall.

This was one of the last farming areas of Texas to be developed. Crop production began about 1890, but was not important before 1910. From about 1910 to 1920 farming increased rapidly in the southern part, whereas in the northern part the expansion came mostly during the 1920-29 period.

Although this is one of the most recently developed irrigated areas in the State, the presence

[20]The boundaries on the map, Figure 5, follow the county lines that come nearest including the "caprock," or eastern boundary of the High Plains.

and approximate extent of ground-water resources have been known for a number of years. Water resources were investigated by Johnson in the late 1890's,[21] by Gould in 1904-05,[22, 23] Mienzer in 1909[24] and by Baker in 1914.[25] A number of investigations have been conducted, particularly since development of these resources got under way. A systematic program of well inventory and water level measurements is now conducted cooperatively by the State Board of Water Engineers and the U. S. Geological Survey.

The source of water in the High Plains has been a subject of considerable speculation among people of the area. Hydrologists, who have investigated and reported on the subject, however, are in agreement. According to White, *et al.*, the source is as follows:

> . . . Inasmuch as the water bearing beds are cut off in all directions from outside sources of water except through underlying rocks containing poor water, it follows that the source of fresh water must be entirely within the High Plains area and must be the rain and snow that fall on its surface. . . .[26]

Barnes, *et al.*, made a more recent study and reached similar conclusions.[27]

Trend in Irrigation Development

According to Hutson, windmills were used to irrigate small garden and feed crop tracts near Midland and Plainview in 1897.[28] The beginning of well irrigation, however, is generally credited to a development near Plainview in 1911. Progress in the 20 years or so following 1911 is described by Broadhurst:

> . . . By 1914 about 140 irrigation wells had been completed in three districts—Plainview, Hereford and Muleshoe. The development as a whole was only moderately successful, and during the next 20 years, from 1914 to 1934, only about 160 additional pumping plants were installed, many of the older ones being unused during that period. A part of the lack of success was due to the high cost and relatively low efficiency of the low-speed pumps and oil-burning power units then in use. Following the advent of the moderately-priced high-speed turbine pumps, powered by a small automobile engine with direct drive, the efficiency of the pumping plants rose sharply.[29]

Table 5. Acreage irrigated, Southern High Plains of Texas, 1936-48[1]

Year	Acres irrigated	Year	Acres irrigated
1936	80,000	1943	400,000
1937	160,000	1944	450,000
1938	200,000	1945	550,000
1939	230,000	1946	650,000
1940	250,000	1947	900,000
1941	[2]	1948	1,250,000[3]
1942	[2]		

[1]Adapted from Table 8A, "Geology and Ground Water in the Irrigated Region of the Southern High Plains in Texas," Progress Report No. 7, Texas State Board of Water Engineers in cooperation with the U. S. Department of Interior, Geological Survey, March, 1949.

[2]Acreage irrigated was small because of exceptionally high precipitation.

[3]This acreage differs from that reported for the area in this report. Figures above relate to the main body of pump irrigation lying south of Canadian River and do not include as large an area as is included in this report.

The rate of development accelerated after 1934. The area irrigated had increased to 80,000 acres by 1936. Most of the development in the years following 1936 is given in Table 5.

Developments since 1936 have been affected by several factors. Scarcity of capital during the depression years is reflected in the rate of increase from 1936 to 1940. Precipitation was ample in 1941-42 and there was little need for irrigation, but the construction of wells continued through these years (Table 5). As a result of the war, pumping equipment and well casing became exceedingly scarce early in 1942 and continued in short supply until after the war. Meanwhile, the value of irrigation having already been demonstrated, interest was further stimulated by favorable agricultural prices.

Increasing quantities of equipment became available late in 1945 and early in 1946, and increased still more through 1947 and 1948. Demand, which was further stimulated by high postwar agricultural prices, was so great, however, that it was not until mid-1948 that supplies of pumping equipment and well casing ceased to be a limiting factor to development.

Present Development

Development has expanded from the early centers near Plainview, Hereford and Muleshoe into almost every county of the area (Figure 1). During 1948, there were 1,385,000 acres irrigated, comprising 48 percent of the irrigated land in the State (Table 1).

[21]Johnson, W. D., "The High Plains and Their Utilization," U. S. Geol. Survey, 21st Annual Report, part 4, Hydrography, pp. 609-741, 1901; 22nd Annual Report, part 4, Hydrography, pp. 637-669, 1902.

[22]Gould, C. N., "The Geological and Water Resources of the Eastern Portion of the Panhandle of Texas," U. S. Geol. Survey Water-Supply Paper 154, 1906.

[23]Gould, C. N., "The Geological and Water Resources of the Western Portion of the Panhandle of Texas," U. S. Geol. Survey Water-Supply Paper 191, 1907.

[24]Mienzer, O. E., "Ground-Water Resources of Portales Valley, New Mexico," (manuscript report in files of U. S. Geol. Survey, Washington, D. C.).

[25]Baker, C. L., "Geology and Underground Waters of the Northern Llano Estacado," University of Texas Bulletin 57, 1915.

[26]White, W. N., Broadhurst, W. L., and Lang, J. W., "Ground Water in the High Plains of Texas," U. S. Geol. Survey Water-Supply Paper 889-F, 1946, p. 386.

[27]Barnes, J. R., Ellis, W. C., Leggat, E. R., Scalapino, R. A., and George, W. O., "Geology and Ground-Water in the Irrigated Region of the Southern High Plains in Texas," Progress Report No. 7, Texas Board of Water Engineers, U. S. Geol. Survey, 1949.

[28]Hutson, William F., *op. cit.*

[29]Broadhurst, W. L., "Ground-Water in the High Plains in Texas," Progress Report No. 6, Texas Board of Water Engineers and U. S. Geol. Survey, Jan., 1947.

Number of Wells

There were between 11,000 and 12,000 irrigation wells by the end of the 1948 calendar year. Slightly less than 10,100 of these were used in 1948. The other wells were completed too late to be of service during that irrigating season.

Well Characteristics

Irrigation wells range in depth from about 150 to more than 600 feet in different parts of the area and are usually cased to the bottom. Most of the wells that exceed 350 feet in depth are on the uplands north of the Canadian River. The situation regarding well performance in the area south of the Canadian River is described by Barnes, *et al.*:

> The average depth to the static water level is about 75 feet, and the average pumping lift is about 110 feet. On the edges of the irrigated region the pumping lift in a few wells exceeds 250 feet. Pumps are of the multistage deep-well turbine type and are powered in some districts by electric motors, but the most common power units are the industrial engines or the ordinary automobile engine fueled with butane or gasoline. Yields of wells range from about 300 to 2,000 gallons per minute and average about 750 gallons per minute. The specific capacity (gallons per minute per foot of drawdown) varies considerably over the South Plains because of differences in the permeability and thickness of the water-bearing sands and because of differences in the construction of wells. . . .[30]

A similar situation prevails in part of the area north of the Canadian River. Wells in northwest Dallam County are equipped much the same as those south of the Canadian River, but their yield is usually higher, averaging about 800 gallons per minute.[31] Except for wells in Dallam County, most wells north of the Canadian River have high pumping lifts, and some of them are reported to be lifting water 400 feet or more.[32]

Number and Size of Irrigated Farms

The 1,385,000 acres irrigated in 1948 were included in 7,500 farms. Farms on which irrigation is practiced range in size from small 10 or 20-acre suburban tracts near Lubbock, Plainview and Amarillo to large wheat farms of 2,000 acres or more. For the area as a whole, the average irrigated acreage per farm is about 184 acres. In the southern part, where sandy loams predominate, the average irrigated acreage per farm is about 160 acres. Where the soils are clay loams, the farms are larger and the average irrigated acreage per farm rises to a little more than 250 acres.

One well per farm was typical in the early stages of development. The acreage that can be irrigated from an individual well depends on the capacity of the well, the kind of soil irrigated and the particular irrigating season. The acreage served per well in 1948 averaged about 90 acres where the soils were loose and open, 120 acres where soils were sandy loams and a little more than 160 acres where clay-loam soils predominate.

Most farms contain more cropland than can be irrigated from a single well; consequently, part of the cropland is dry-farmed. The trend toward wholly irrigated farms, which has been on the rise for some time, progressed rapidly under the impact of short moisture supplies in 1948. The area as a whole had an average of 1.3 wells per irrigated farm in 1948. Farms with 5 or more wells are not uncommon in the older developed areas.

Type of Farming

With some exceptions, this area was fully developed before irrigation became extensive. Crops, crop dependence and farm practices were rather generally established in the 20 years or more of farming operations preceding the expansion of irrigation. Essentially, irrigation was imposed as another farm practice supplementing those already being applied. With minor exceptions, the major crop dependence is the same on irrigated and dryland farms.

The extensive irrigation farming of this area results from a combination of conditions rather than from any single condition. Lack of suitable market outlets for crops that lend themselves to intensive operations has tended to perpetuate the type of farming or crop dependence that prevailed before irrigation expanded. Mechanization of row crop farming, the rise and acceptance of which preceded the expansion of irrigation by a few years, enabled farmers to handle large units despite the additional labor and costs involved in irrigation farming.

With farms larger than their water supplies, farmers seldom strive for maximum per-acre yields. They choose instead to spread water over the greatest possible acreage with the accent on increased total production rather than on the highest per-acre yields.

Irrigated farming in the Panhandle-High Plains area is largely an extensive cash crop operation centering on the production of cotton, cotton and grain sorghum, grain sorghum and wheat, or wheat alone depending on the particular location in the area. Generally, livestock enterprises are not important on irrigated farms.

Irrigated Crops

Grain sorghum, cotton and wheat were the main irrigated crops in 1948, occupying 92 percent of the irrigated land in the area (Table 2). Alfalfa ranked fourth with almost 56,000 acres, but occupied only 4 percent of the irrigated land in 1948.

Grain sorghum is grown throughout the High Plains, both with and without irrigation. Although it is the most extensively irrigated crop,

[30]Barnes, *et al.*, *op. cit.*, p. 29.

[31]Martin, Stephan D., Assistant Engineer-Appraiser, Farm Credit Administration.

[32]Reported by county agricultural agents.

it is seldom the only one irrigated. From about Plainview north, grain sorghum is grown in combination with wheat, while to the south of Plainview it appears in similar combination with cotton. Thirty-eight percent of the irrigated lands of the Panhandle-High Plains was in grain sorghum during 1948. Where cotton predominates, grain sorghum occupied about 25 percent of the irrigated acreage, whereas in the wheat-growing areas it occupied upward of 60 percent.

Cotton ranked second to grain sorghum in acreage irrigated in 1948. At one time or another, the production of cotton has been attempted throughout the area, but it has long been centered in the sandy lands south and west of Plainview. In 1948, 483,000 acres of cotton were irrigated in this area, amounting to 51 percent of the total irrigated acreage of cotton in Texas. Cotton occupied 35 percent of the irrigated land of the Panhandle-High Plains area, but in counties where production centered, it occupied 70 percent of the irrigated land. Farms with 100 percent of the acreage in cotton were not unusual. Distribution of irrigated crops on the average farm in the sandy cotton-growing area was about 70 percent cotton, 25 percent grain sorghum and 5 percent other crops. It should be noted that this was the crop distribution for 1948; it is by no means fixed. The proportion of the farm devoted either to cotton or grain sorghum in a particular year (disregarding governmental allotment programs) is materially influenced by moisture conditions early in the season and by the comparative price or labor outlook for the two crops.

Slightly more than 19 percent of the irrigated acreage in the Panhandle-High Plains was in wheat in 1948. The 267,000 acres of wheat irrigated, most of which was grown on the heavy lands north of Plainview, comprised almost 100 percent of the irrigated wheat in Texas.

Alfalfa ranked fourth in acreage with 56,000 acres in 1948 (Table 2). For the area as a whole, alfalfa is relatively an unimportant crop, but it is locally important, particularly where soils are heavy.

Forage sorghum and corn are other minor crops, both irrigated and dryland. Most irrigated forage sorghum is grown in connection with livestock enterprises, particularly in the southern half of the area where soils are sandy. Commercial irrigated production of corn centers in Deaf Smith and Dallam Counties, although most irrigated farms have a few rows of corn for roasting ears.

Some interest has been displayed within recent years in developing irrigated pastures. There were a little more than 22,000 acres of irrigated land in pasture in 1948. Most irrigated pasture land was in sweet Sudan, alfalfa, grass mixtures or native grass. Irrigated pasture tracts are usually small, seldom exceeding 5 or 10 acres.

The development of irrigation opened the way for alternative crop enterprises and stimulated the introduction of several crops, particularly in those areas in which cotton is not adapted. Irish potatoes and sugar beets were introduced in the Hereford area about the same time that irrigation was developed. Production of commercial onions started in 1938, and other crops such as carrots, peas, lettuce, tomatoes and cantaloupes have been grown.

Although Irish potatoes came into the area about 1911, the potato industry had its major growth after 1936. According to the Production and Marketing Administration, 7,067 acres of Irish potatoes were grown in 1948. The rise of sugar beet production occurred mainly after 1940. Slightly more than 5,200 acres of sugar beets were grown in the area between Hereford and Plainview in 1948. Acreage in other crops such as blackeye peas, carrots, lettuce, tomatoes, cantaloupes and popcorn approached 5,000 acres during 1948. Production was scattered throughout the Panhandle-High Plains irrigated area.

Irrigated Crop Yields

Under supplemental irrigation as practiced here, land and water are to a certain degree interchangeable. Farmers have the option of producing an equivalent amount of crop on a relatively large acreage without irrigation, on a smaller acreage with light water application or on a still smaller acreage by heavier applications of water. As already stated, most irrigation farmers in the area with large, highly mechanized farms strive for maximum total production rather than for high per-acre yields. With this objective, relatively small amounts of water—3 to 6 acre-inches per application—are applied as conditions warrant. Inasmuch as irrigation is used to supplement precipitation, no definite schedule can be followed. The irrigation program, like the proportion of the farm planted to an individual crop, depends on conditions prevailing in a particular year.

Climatic conditions that prevail in a particular year inhibit or enhance the response from water applied at strategic times. In general, the higher irrigated yields are obtained when climatic conditions are also favorable for dryland farming. This is reflected in the 1948 irrigated crop yields. Moisture supplies were rather ample from the vicinity of Plainview north, whereas with local exceptions, they were deficient south of Plainview. Yields of both irrigated and dryland crops were lower in the moisture-deficient part of the area than in the part where moisture supplies were more adequate.

Because of the unfavorable moisture situation in the southern part of the area, where the acreages of cotton and grain sorghum are concentrated, the difference between irrigated and dryland yields was much greater than usual.

According to the Bureau of Agricultural Economics, there were 2,182,730 acres of cotton in the Panhandle-High Plains area in 1948, with a total production of 678,020 bales.[33] The 482,600 acres and 373,960 bales of irrigated cotton are included in these figures. Irrigated cotton occupied only 22 percent of the Panhandle-High Plains cotton acreage, but produced 58 percent of the total cotton. Production per irrigated acre was equivalent to a little more than 4 acres of dryland cotton. The usual production ratio is about 2 to 1 in favor of irrigated cotton.

For the area as a whole, irrigated grain sorghum averaged slightly more than 42 bushels per acre in 1948. Variation in yields from farm to farm, like those for cotton, reflects both variations in the amount of water used and the precipitation received. Reported yields ranged from 100 bushels per acre to as low as 25. County average yields were higher by 7 to 10 bushels in the area above Plainview where moisture supplies were more plentiful than in the area south of Plainview where natural moisture was short.

Because of natural moisture deficiencies, yields of non-irrigated grain sorghum ranged from about 15 bushels per acre in the south to about 25 bushels per acre in the north. The over-all average yield for the Panhandle-High Plains approximated 18 bushels per acre in 1948. Production per irrigated acre was equivalent to almost 2.5 non-irrigated acres, about twice the usual irrigated-non-irrigated ratio.

Irrigated wheat averaged 17.5 bushels per acre in 1948. There was a wider variation from the average in reported yields of irrigated wheat than in any other irrigated crop. Reported yields ranged from almost 60 bushels to slightly more than 5 bushels per acre. Wheat yields averaged a little higher in Randall and Deaf Smith Counties, where growers have had more irrigation experience with this crop than in areas where the irrigation of wheat is a more recent practice. Wide differences in yields were not confined to the areas where irrigation of wheat is of more recent origin; they were reported in the older areas as well. For the area as a whole, irrigated wheat yields averaged about twice those of non-irrigated wheat in 1948. In contrast, there was no difference in irrigated and dryland wheat yields in 1947, which was a good dryland wheat year.

Alfalfa yields ranged from a little less than 2 to as much as 5 tons per acre in 1948. The more commonly reported yield was 3 to 4 tons per acre.

Sugar beet yields ranged from a high of 27 tons per acre to outright failure. The more commonly reported yields ranged from 9 to 12 tons per acre. This compares favorably with yields obtained in northern sugar beet producing areas. Prior to 1948, the sugar content of High Plains beets was comparable with that of beets grown in Colorado, Kansas and Nebraska. The 1948 sugar content, however, was somewhat lower than that of previous years.

[33]Compiled from Bureau of Agricultural Economics county listing sheets, unpublished.

Cost of Development

The main cost of irrigation development in the Panhandle-High Plains lies in the construction of wells.[34] Throughout most of the area where irrigation has been developed, the topography is so smooth that only a small amount of preparation is necessary before the land is ready to receive water. Costs per acre of land leveling and ditching preparatory to water application are probably the lowest of any area of the State. Although some farmers, especially those who have recently installed bench terraces, report expenditures of upward of $40 per acre in land preparation, the average cost of land preparation for the area as a whole probably will not exceed $5 per acre.[35]

The 10,100 irrigation plants used during the 1948 irrigation season represent an estimated capital investment of a little more than $41,000,000. The total investment in all plants through 1948, those used and those constructed too late for 1948 use, approximates $49,400,000. With costs of construction increasing sharply, investments have increased at a faster rate than irrigated acreage. During the irrigating seasons of 1946-48, irrigated acreage increased 150 percent, whereas the investment in wells increased 229 percent.

The systematic program of water level measurements, conducted by the State Board of Water Engineers and the U. S. Geological Survey since irrigation became extensive, reveals that water levels have declined in the irrigated sections south of the Canadian River. The decline in water levels from 1938 through 1948 ranged from something less than 5 feet to more than 45 feet, depending in part on the concentration of wells.[36] The drop in water levels exceeds 10 feet throughout most of the sections of heaviest pumping.

Declines in water levels have not been continuous. The levels have fluctuated in response to rainfall. In 1941 and 1942, when precipitation was high, water levels rose throughout the area, reaching a higher level in some wells than when the measurement program was started. The effect was only temporary, however, and within 3 years most of the rise had been dissipated, with water levels declining to 1940 levels. With the exception of a slight rise in the areas where sandy soil predominates following heavy precipitation in the spring of 1947, the downward trend in water levels continued through 1948.

[34]The term as used refers to the complete irrigation plant.

[35]Estimates of development costs are based on field interviews with a sample of more than 500 farmers in the area.

[36]Barnes, *et al., op. cit.*, Figures 22A and B and map showing distribution of irrigation wells.

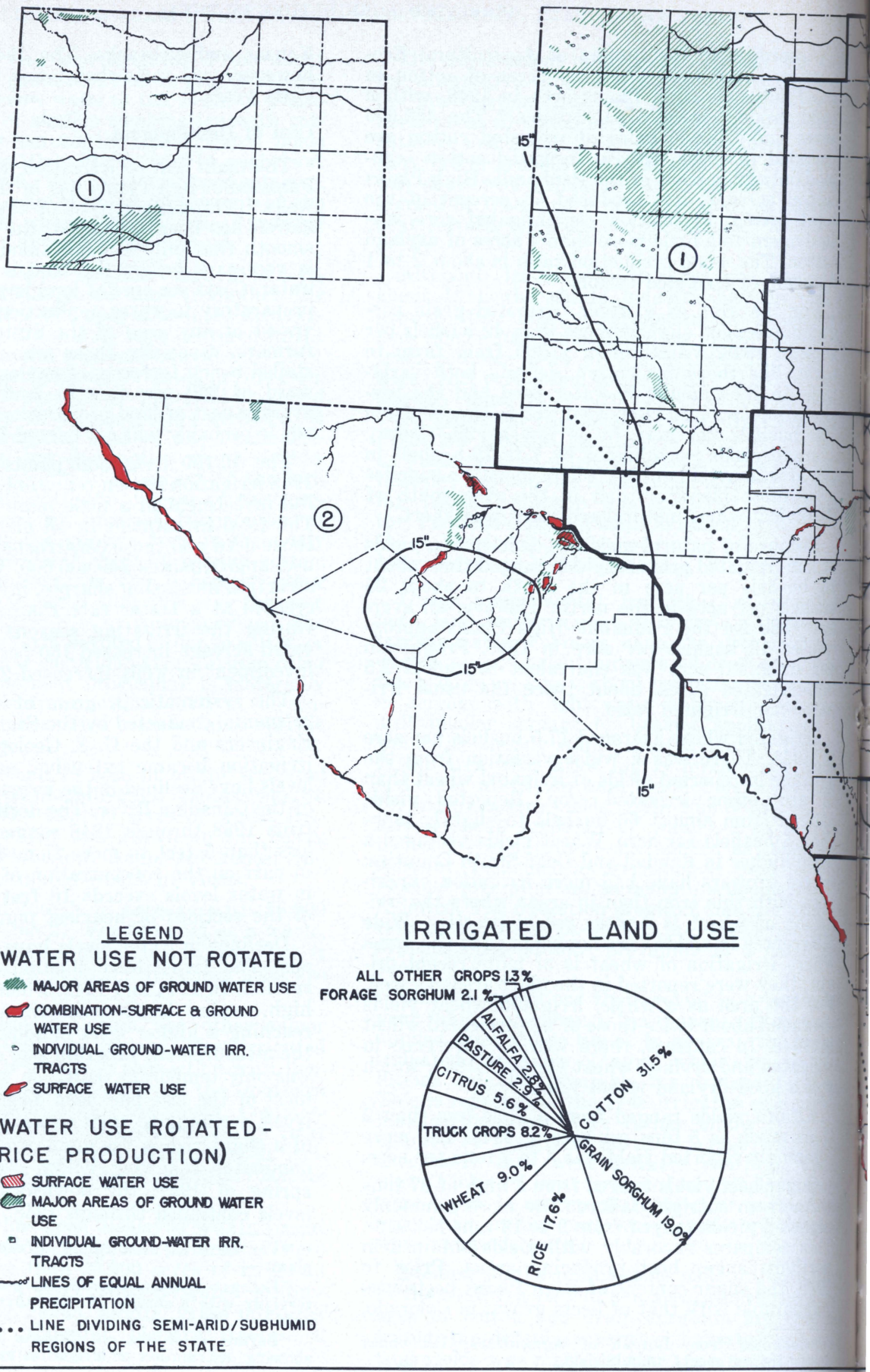
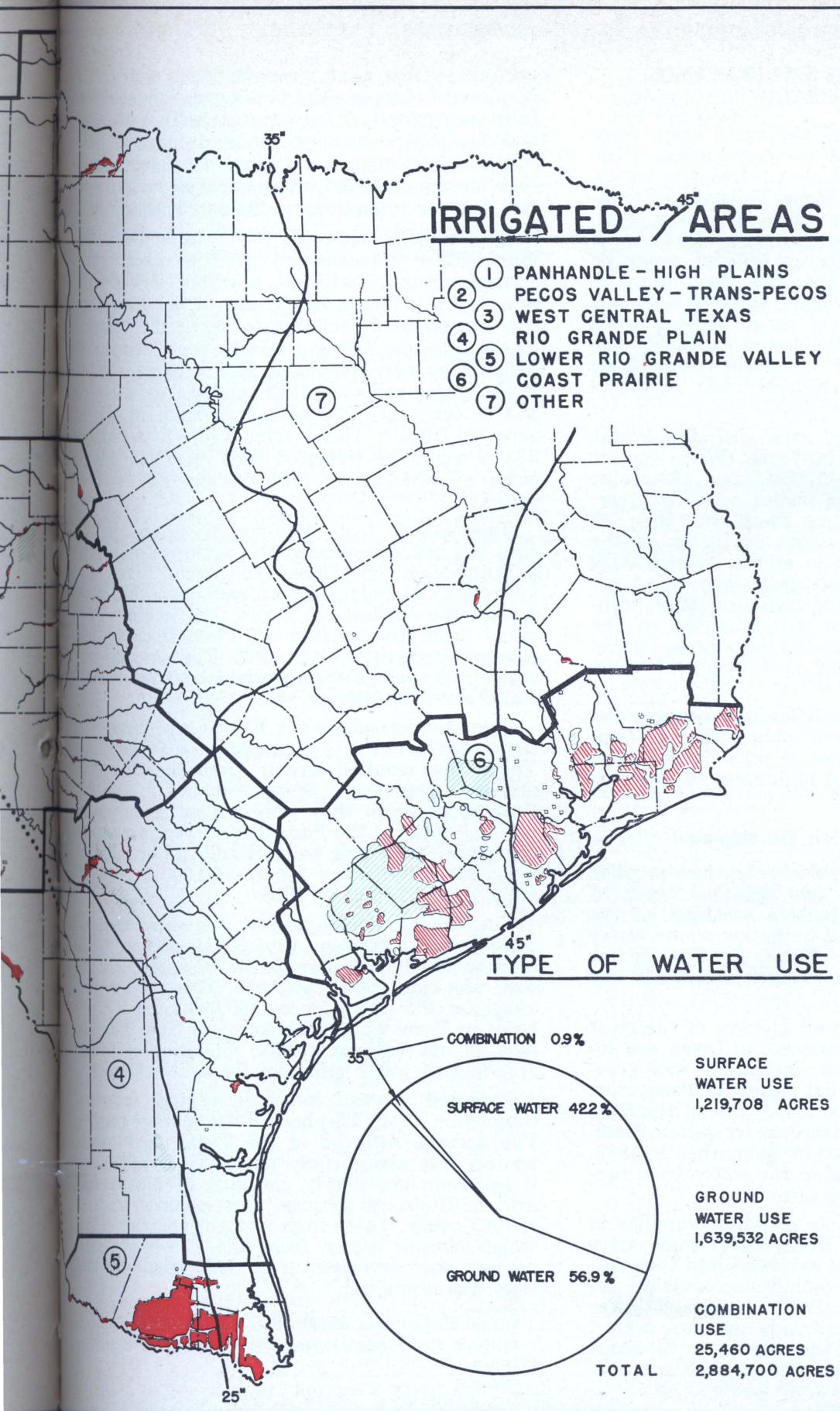


Figure 5. Location, land use and wat



d water irrigated areas of Texas.

AREA II: PECOS VALLEY AND TRANS-PECOS

The western portion of the State drained by the Rio Grande and Pecos Rivers above their confluence and associated closed drainage basins is designated here as the Pecos Valley and Trans-Pecos irrigated area (Figure 5). This is a semi-desert open plains country in the north with mountains rising abruptly as isolated peaks or ranges; to the south, in the "Big Bend" area, is found some of the most rugged country in Texas. Elevations above sea level range from a little less than 1,500 feet in the lower valleys of the Pecos and Rio Grande to mountain peaks above 8,000 feet. Most of the irrigated lands lie at elevations between 2,500 and 3,600 feet.

It is a sparsely settled area with the lowest average annual rainfall in Texas. With the exception of a small area in the Davis Mountains where rainfall exceeds 15 inches annually, average annual rainfall ranges from less than 10 inches near El Paso to about 14 inches in the Pecos Valley. Variations in annual precipitation are wide, yet the greatest amounts received are seldom if ever sufficient for crop production without irrigation. More than three-fourths of the rainfall occurs during the growing season, largely in the form of torrential downpours of short duration.

Other climatic characteristics are: a long growing season (over 210 days), high summer temperatures, high percentage of possible sunshine, low relative humidity and high rates of evaporation.

Agricultural and Irrigation Development

The combination of physical conditions peculiar to this area has led to two principal types of agricultural activity: extensive ranching on the plains and mountains, and irrigation where water supplies can be obtained (Figure 5). With a few exceptions, the two types of agricultural activity are not combined.

Some of the oldest as well as some of the most recent irrigation developments in Texas are located in the Trans-Pecos. Irrigation was practiced in the vicinity of what is now El Paso when Coronado reached there in 1541.[37] One of the first, if not the first, Anglo-American irrigation developments in Texas occurred at Balmorhea in 1853. Other developments utilizing the water from perennial springs came soon afterward.

Large-scale developments of water supplies in the Rio Grande and the Pecos River came after 1880 when railroads were extended into the area. Development progressed rapidly once outside rail communications were available. Land and water companies followed the railroads and were active, particularly along the Pecos River, until about 1914. Development along the Pecos River progressed so fast that water supplies were overdeveloped before several of the projects could be fully constructed. A few projects were abandoned and the others soon encountered financial difficulties. Subsequent upstream developments in New Mexico curtailed water supplies, resulting in still further reductions in irrigated acreage.[38]

As originally planned, 10 projects along the Pecos River encompassed 173,000 acres.[39] The acreage actually irrigated, however, has not approached this figure. Few if any of the developers ever constructed facilities to serve the contemplated acreage. Other projects were abandoned before they were completed. The acreage irrigated in these projects since 1914 ranged from a low of 15,000 acres in 1934 to a maximum of 37,000 acres in 1924.[40] These same projects contained 30,000 acres of irrigated land in 1948, 16,000 acres of which used both ground and surface water.

Development from the major springs in the area has not experienced the same water supply difficulties as those along the Pecos River. Developments at Fort Stockton and Balmorhea were among the earliest in Texas. The acreage irrigated from the springs at Fort Stockton has changed very little since 1926. The acreage irrigated from springs at Balmorhea, however, has declined about 30 percent since 1926.

Developments along the Rio Grande came at a somewhat slower rate than along the Pecos River. These, too, resulted largely from the efforts of private corporations. Water supplies in the Rio Grande, although they were not as heavily salt-laden as those of the Pecos River, were even more uncertain. According to Rockwell, water supplies were not satisfactory for the 20,000 acres irrigated near El Paso in 1913.[41]

The Elephant Butte project, the only federally-constructed irrigation project supplying Texas land, is on the Rio Grande in New Mexico. The dam was constructed by 1916. This project provided for the irrigation of 160,000 acres (70,000 acres in Texas and 90,000 acres in New Mexico), plus an international treaty obligation of 60,000 acre-feet of water annually for use in Mexico.

Irrigated acreage increased rapidly following completion of the Elephant Butte storage project. The acreage included in the Texas part of the project was almost fully developed by 1925 and it has remained nearly constant (Table 6). The area in Hudspeth County, now included in Hudspeth County Water Improvement District No. 1, which obtains water from the Elephant Butte project, was developed after 1923 when the district was organized.

[37] Hutson, William F., *op. cit.*

[38] Unpublished data compiled by the late V. L. Sullivan.

[39] "Pecos River Joint Investigation," National Resources Planning Board, 1942.

[40] *Ibid.*

[41] Rockwell, W. L., *op. cit.*, p. 43.

Surface water supplies of the Rio Grande have been fully utilized for some time. Some new developments have occurred since 1939, but these appear to have been achieved at the expense of others. This is indicated in water bulletins published by the International Boundary and Water Commission. According to these bulletins, irrigated acreage along the Rio Grande in Presidio County has declined while that in Hudspeth County has increased.[42]

Development Since 1939

Irrigated acreage in the Pecos Valley-Trans-Pecos area has increased by nearly 50,000 acres since 1939. Almost all of the increase came through development of ground water.

Ground-water supplies near the city of Pecos have been utilized for about 50 years. Hutson reported in 1897 that water from flowing wells was used to irrigate gardens in the vicinity of Pecos.[43] According to Rockwell, a number of wells were being pumped near Pecos in 1913.[44] Despite these instances of early use, it was not until late 1946 and early 1947 that ground-water development gained momentum.

Favorable postwar cotton prices attracted investment capital and by 1948, ground-water supplies had been put to use in 5 parts of the area: Salt Flats, near the Texas-New Mexico boundary in Hudspeth County; Hermosa Flats, just west of Pecos in Reeves County; and near Fort Stockton, Bakersfield and Imperial in Pecos County (Figure 5). New development was in process in Lobo Flats which lies south of Van Horn in Culberson and Jeff Davis Counties, near Girvin in Pecos County and along Coyanosa Draw northwest of Fort Stockton.

Ground-water developments here are relatively expensive because of the high costs of clearing and well construction. Where ground-water developments are possible, the land is rather smooth and once the heavy cover of mesquite and other low-growing brush is cleared, it requires a minimum of leveling. In early developments, the brush was removed by hand, a slow and laborious process. In recent developments, it has been cleared by heavy machinery in much less time and at about the same dollar cost despite the rise in the general price level. Costs of construction for a well capable of serving 140 acres, the average acreage served per well, range from about $7,000 to around $12,000. The average cost per well for the area as a whole is $9,000.[45]

Raw, brush-covered land could be bought as

[42]"Flow of the Rio Grande and Tributary Contributions," U. S. Department of State International Boundary and Water Commission—United States and Mexico, Water Bulletins 9-17 inclusive.

[43]Hutson, William F., *op. cit.*, p. 62.

[44]Rockwell, W. L., *op. cit.*, p. 41.

[45]Based in part on information provided by Troy Patrick, manager of crop finance, Western Cottonoil Co., Pecos, Texas.

Table 6. Acres irrigated, by crops, Rio Grande project, Texas part, 1922-48[1]

Year	Acres in specified uses					
	Cotton	Alfalfa	Miscellaneous crops	Not cropped	Net irrigated	Total
1922	7,276	14,766	11,119	2,063	33,161	35,224
1923	17,115	12,932	8,546	1,363	38,593	39,956
1924	32,122	10,900	6,000	7,486	49,112	56,598
1925	42,413	10,018	5,201	5,821	57,632	63,453
1926	41,473	11,181	5,735	6,670	58,389	65,059
1927	38,686	13,550	9,592	1,683	61,828	63,511
1928	49,121	9,622	4,544	2,375	63,287	65,662
1929	48,483	9,109	4,250	3,580	61,842	65,422
1930	44,255	11,904	5,941	4,058	62,100	66,156
1931	39,416	12,753	7,573	5,333	59,742	65,075
1932	30,946	14,792	11,175	1,234	56,913	58,147
1933	32,514	12,712	13,288	1,135	58,514	59,649
1934	30,038	13,007	11,985	1,677	55,030	56,707
1935	28,640	13,910	10,691	1,409	53,241	54,650
1936	36,832	14,822	5,710	2,994	57,364	60,358
1937	45,788	12,622	3,147	1,661	61,557	63,218
1938	30,064	18,283	5,848	5,172	54,195	59,367
1939	30,355	21,753	6,241	3,085	58,349	61,434
1940	32,697	23,085	5,690	1,260	61,472	62,732
1941	41,806	18,127	2,862	1,120	62,795	63,916
1942	47,045	14,813	2,754	464	64,612	65,076
1943	44,938	16,219	4,283	367	65,440	65,807
1944	43,618	16,915	4,027	1,646	64,560	66,206
1945	44,209	17,774	3,352	726	65,335	66,061
1946	44,501	18,239	3,577	571	66,317	66,888
1947	49,874	15,033	1,722	653	66,629	67,282
1948	53,890	10,319	2,024	414	66,233	66,647

[1]Source: 1936 and earlier "Regional Planning, Part VI, Upper Rio Grande," National Resources Committee, Feb., 1938; 1937 to 1948 U. S. Department of the Interior, Bureau of Reclamation.

late as 1945 for around $8 per acre, exclusive of mineral rights. By 1948, the price of raw land had advanced to upward of $75 per acre.

Until about 1942, the cost of development—brush clearing, leveling, ditching and well construction—was approximately $80 per acre. Costs were higher in the more recent developments, averaging about $120 per acre. With land included, the investment approximates $150 per acre.

Present Development

During 1948, 193,000 acres were under irrigation in the Pecos Valley-Trans-Pecos area (Table 1). Approximately 50,000 additional acres were equipped for irrigation. Surface-water supplies along the Pecos River were in short supply during 1948. This factor, combined with the effect of an early killing frost on late planted cotton, resulted in crop failure or abandonment on nearly 16,000 acres of the irrigated land.

Surface water provided the sole source of supply for 120,000 acres. Meager surface-water supplies were supplemented by ground water in 6 of the 7 Pecos River projects, and to a small extent in the acreage irrigated from Comanche, Leon and San Pedro Springs near Fort Stockton. Combination water use, which is of recent origin, totaled 24,000 acres in 1948 (Table 1).

Ground water provided the sole source of supply for 49,000 acres in 1948. The acreage irrigated exclusively by ground water was concentrated largely in 5 centers of development. These were in Salt Flats, 3,080 acres; Hermosa Flats (Pecos area), 31,000 acres; Imperial, 10,500 acres; Bakersfield, 2,080 acres; and near Fort Stockton, 1,420 acres. A few wells were located outside these areas of main development.

Method of Diversion

A higher proportion of surface-water supplies in this area is gravity-diverted than in any other part of the State. Water supplies for 93 percent of the lands irrigated exclusively by surface water and 100 percent of the surface-water supplies used in combination with ground water, are obtained by gravity diversion. Pump diversion of surface water is confined largely to independent developments along the Rio Grande below Hudspeth County Water Improvement District No. 1.

A few flowing wells are found in the vicinity of Fort Stockton and Pecos, but the yield usually is so small that they are pumped.

Type of Farming

Cash-crop farming predominates. In a few cases, particularly in recent ground-water developments, irrigation farming and extensive ranching are combined in the same unit. Generally the ranch operators grow livestock exclusively and the farm operators produce crops, mainly cotton.

Number and Size of Farms

Irrigation was practiced on 2,284 different farm units in 1948 (suburban developments near El Paso containing 3,190 units of 2 acres or less are omitted from this total). In addition, 93 farms were equipped for irrigation but were not operated in 1948. Most of the idle farms were in Presidio County where irrigated acreage has recently declined. Farm sizes vary so widely both among individual districts, where surface waters are used, and between surface and ground-water irrigated areas that an area average would be misleading (Table 7).

Surface-water Irrigation

No distinction is made here between combination and surface-water uses, as the conditions pertaining to the acreage using both surface and ground water are more closely allied with surface-water irrigated areas than those using ground water. About three-fourths, or 144,000 acres, of the irrigated land and 94 percent of the irrigated farms used surface water in whole or in part during 1948. About 90 percent of this acreage, and 1,948 farms, were included in 11 organized districts. Independent developments accounted for about 15,000 acres and 161 farms (Table 7).

Ground-water Irrigation

Farms using ground water were considerably larger than most farms irrigated by surface water. This is to be expected, as the average well serves 140 acres, and the discharge from a single well is seldom shared unless family relationships are involved. Also, with raw land relatively cheap and construction costs of wells high, there are definite advantages in irrigating all the acreage that a single well will serve.

Irrigated land per farm in 1948 ranged from 20 acres where a well was shared to 1,440 acres. About 60 percent of the farms contained 200 to 480 acres of irrigated land per farm. Slightly more than a third were larger than 480 acres.

Irrigated Crops

Cotton and alfalfa are the irrigated crops of this area, occupying almost 91 percent of the harvested acres in 1948 (Table 2). Other crops such as forage sorghum, oats, barley, grain sorghum and some specialties are grown, but for the area as a whole these are relatively unimportant.

Cotton came to the Pecos Valley late in the 19th Century. According to Hutson, cotton was an established irrigated crop at Fort Stockton and Pecos in 1897.[46] It was not introduced into the El Paso area until later. Once ginning facilities were available, cotton rapidly replaced al-

[46]Hutson, William F., *op. cit.*

falfa and cereals. By 1922, cotton was the leading crop in the Pecos Valley and in the nearby developments. Two years later, it attained a similar position in the El Paso area, a position it has never relinquished (Table 6).

Until recently, cotton normally occupied about two-thirds of the irrigated land in the area. It occupied 77 percent in 1948. Actual or potential water shortages and favorable cotton prices resulted in increased acreages of cotton, almost 80 percent in the recently developed ground-water irrigated lands being planted to cotton in 1948.

Despite its high water requirements, alfalfa ranks second to cotton in acreage, largely because of the lack of a suitable alternative crop (Table 2). Actual or impending water shortages combined with favorable cotton prices of the past few years have reduced the acreage of alfalfa. In recent years, farmers have turned to commercial fertilizers of high nitrogen content for the fertilizing after-effects formerly realized from alfalfa.

Three-fourths of the alfalfa acreage in 1948 was located in the vicinity of El Paso, Fort Stockton and Balmorhea. Short water supplies along the Pecos River contributed to the decline in alfalfa acreages in the Pecos Valley area.

Yields

Some of the largest cotton yields in Texas are obtained in the El Paso Valley. For the area as a whole, cotton averaged more than a bale to the harvested acre. Wide differences in yield, however, occurred between different parts of the area.

Project crop yield reports compiled by the Bureau of Reclamation for the districts located in El Paso and Hudspeth Counties show average cotton yields of 1.65 and 1.24 bales per acre, respectively, for medium staple cotton in 1948. The highest yield reported was 3 bales per acre.

Cotton yields were lower in the Pecos Valley and adjacent areas, averaging about .7 bale per acre harvested. Top yields of slightly more than 2 bales per acre were reported in several cases, although a number of factors combined to restrict yields in the Pecos Valley during 1948. Water shortages reduced yields in those areas diverting

Table 7. Total acres irrigated, average per farm and tenure of operator, by type of irrigation enterprise organization and type of water use, Pecos Valley-Trans-Pecos area, 1948

Districts or areas	Common name	Acres irrigated (harvested)	No. of farms	Acres irrigated per farm	Class of Operator		Average water charge per acre
					Owner[1] (no.)	Tenant (no.)	
Surface-water irrigated areas[2]							
Organized districts							
El Paso Co. W. I. D. No. 1[3]	Elephant Butte project	66,233	1,462[4]	44	877	585	$7.40
Hudspeth Co. W. I. D. No. 1	Hudspeth project	17,060	92	185	92	.....	8.50[5]
Reeves Co. W. I. D. No. 1	Balmorhea project	7,144	90	79	48	42	3.25[5]
Reeves Co. W. I. D. No. 2[6]	Farmers Independent project.	2,800	20	140	13	7	2.25[7 8]
Loving Co. W. I. D. No. 1	Porterville project	500	7	71	7	.....	3.00[9]
Ward Co. I. D. No. 1[6 10]	Barstow project	8,000	66	121	51	15	3.47[8 9]
Ward Co. W. I. D. No. 2[6]	Grandfalls project	7,800	44	177	27	17	....[11]
Ward Co. W. I. D. No. 3[6]	Cedarvale project	3,000	22	136	19	3	3.00[7 8]
Pecos Co. W. I. D. No. 1[6]	Fort Stockton project	6,179	88	70	64	22	3.75[5]
Pecos Co. W. I. D. No. 2[6]	Imperial project	6,780	60	113	51	9	....[12]
Pecos Co. W. I. D. No. 3[6]	Zimmerman project	4,000	32	125	18	14	1.50[8 9]
Independent diversions		14,624	161	91	105	56	....[11]
Ground-water irrigated areas							
Salt Flats		3,080	10	308	7	3	....[11]
Hermosa Flats (Pecos area)		31,000	73	425	....[11]	....[11]	....[11]
Near Fort Stockton		1,420	10	142	10	.....	....[11]
Bakersfield		2,080	10	208	10	.....	....[11]
Imperial		10,500	33	318	....[11]	....[11]	....[11]
Scattered developments		1,100	4	275	4	.....	....[11]
Total		193,300	2,284	85	.....	.....	.....

[1]Includes managers and owner-additional operators.
[2]Includes combination water uses.
[3]W. I. D.—Water Improvement District.
[4]Exclusive of 3,190 units of 2 acres or less in size.
[5]Plus district ad valorem assessments.
[6]Surface-water supplies supplemented by ground-water in these districts.
[7]Plus district and Red Bluff district ad valorem assessments.
[8]Water charge applies to each acre for which water application is made. Net charge per acre will exceed this somewhat as irrigated acreage was less than the acreage of water application.
[9]Plus Red Bluff district assessment.
[10]I. D.—Irrigation district.
[11]Data not available.
[12]District and Red Bluff ad valorem assessments only in 1948.

from the Pecos River, while an earlier-than-usual killing frost damaged late-planted cotton on the newly developed ground-water areas.

Yields of alfalfa averaged slightly less than 4 tons per acre for the Trans-Pecos area in 1948. Like cotton, yields of alfalfa differed significantly, ranging from an average of 5 tons in the El Paso Valley area to about 2 tons per acre in the Pecos Valley. The highest yield reported in the El Paso Valley was 8 tons per acre. The highest yield, 9 tons per acre, in the area, however, was reported from near Fort Stockton.

AREA III: WEST CENTRAL TEXAS

The area included lies east of the Pecos River and southeast of the High Plains. Generally, it is bounded on the east by the Colorado River and by the Rio Grande Plain on the south (Figure 1).

It is an area of gently to strongly rolling or broken topography with a number of spring-fed perennial streams. Elevations range from a little under 750 feet in the southeast to about 3,000 feet in the northwest. Stream gradients are steep and most streams are deeply incised.

Ranching is the principal agricultural activity throughout most of the area. Except for the northeastern part, where farming is extensively practiced, most of the land under cultivation is in the narrow stream valleys.

Early Irrigation Development

Irrigation farming began with the San Saba Mission on the San Saba River about the middle of the 18th century, followed by developments near Del Rio shortly after the close of the Civil War. Surface water supplies were developed in the vicinity of San Angelo in the 1880's.

Irrigated acreage, especially at Del Rio and along the Colorado River, was considerably larger in the earlier days than at present. According to Hutson, 3,600 acres were irrigated from San Felipe Springs near Del Rio in 1897.[47] Rockwell reported 3,100 acres irrigated from the same source in 1914.[48] Only 805 acres were irrigated from San Felipe Springs in 1948. According to Rockwell, about 18,600 acres were irrigated along the Colorado River and tributaries above Austin in 1897.[49] Slightly more than 6,100 acres were irrigated in the same area in 1948.

Increases in irrigated land have occurred in parts of the area in recent years. Acreage at Brownwood has expanded since the construction there of the irrigation project. Ground-water developments in Lipan Flats near San Angelo brought new lands under irrigation. Other individual developments, both through construction of wells and independent diversions of surface water, occurred in recent years.

Present Extent of Development

More than 24,700 acres were equipped for irrigation in 1948. However, surface water was in such short supply, particularly in the Concho River, that only 19,200 acres were irrigated (Table 1). Most of the irrigated land is concentrated along the Concho, the San Saba and the Llano Rivers and along Pecan Bayou (Figure 5).

About 80 percent of this acreage was irrigated with surface-water supplies (Table 2). Of the lands included in organized irrigation enterprises, 6,463 acres were irrigated mostly by gravity flow; those in individual enterprises by pump diversion. Ground-water developments comprising 3,050 acres are located in the Concho River basin, a little more than 2,300 acres of which are in the vicinity of San Angelo.

Type of Farming

Most of the irrigation farming is complementary to livestock enterprises. The ground-water irrigated section near San Angelo is a cash-crop farming area in which cotton and grain sorghum predominate. Land irrigated from San Felipe Springs near Del Rio, which once was a cash-crop farming area, is now largely covered by suburban homesites. Part of the irrigated land at Brownwood is also in suburban developments.

Number and Size of Farms

The 19,200 acres irrigated in 1948 involved 438 farm units (Table 1). Irrigated acreage per farm ranged from 3 to 5 acres in the suburban developments at Del Rio and Brownwood to more than 500 acres in the open country. Farms on which irrigation is practiced range in size from small, wholly irrigated tracts in the suburban areas to parts of large ranches. There is a similar range in the proportion of cropland irrigated. Cultivated land in the suburban areas is wholly irrigated, while throughout the rest of the area, irrigated acreage usually constitutes less than half of the cultivated acreage per farm.

Irrigated Crops

Almost three-fourths of the harvested irrigated cropland in 1948 was in feed crops—forage sorghum, oats for hay or pasture, and alfalfa (Table 2). Cotton, which was once an important crop at Del Rio and in the irrigated land along the San Saba River, is no longer grown in this part of the area. Production of cotton in 1948 centered in the vicinity of San Angelo. Yields of irrigated cotton averaged about two-thirds of a bale per

[47] Hutson, William F., *op. cit.*, p. 56.
[48] Rockwell, W. L., *op. cit.*, p. 18.
[49] *ibid.*, p. 18.

acre, production being reduced generally by short water supplies.

Alfalfa is grown to some extent in most of the surface-water irrigated areas. Production centers, however, in the vicinity of Del Rio, Spring Creek and Brownwood where it occupies about one-third of the irrigated acreage. Yields of alfalfa reflected in part the short water supply situation that prevailed over much of the area during 1948. They averaged only 2.9 tons per acre. Some fields in the Concho River Valley were harvested by grazing, while others in the Brownwood area and along the Blanco River produced yields of 4 tons or more per acre.

Production of grain sorghum is concentrated largely in the northeastern part of the area. It is grown chiefly in combination with cotton, except near Brownwood and along the San Saba River where it is grown in combination with forage sorghum. Yields averaged about 38 bushels per acre with little variation between areas.

Small grains, largely oats, occupied about 14 percent of the acreage in 1948. They were grown in combination with forage sorghum, mostly in the lower valleys in the southern and eastern parts of the Edwards Plateau. Corn, orchards, nurseries, truck and other miscellaneous crops of small acreage occupied less than 7 percent of the irrigated acreage in 1948.

AREA IV: RIO GRANDE PLAIN

The Rio Grande Plain extends from the Balcones escarpment south to the Lower Rio Grande Valley and east to about the Guadalupe River (Figure 5). It is a broad plain sloping to the south and east. In the northern and northeastern parts and in a narrow border adjacent to the Rio Grande, the topography ranges from rolling to strongly rolling. Topography in the west, central and southern parts is gently undulating; that along the coast, particularly in the vicinity of Corpus Christi, is flat. Elevations range from near sea level to about 1,000 feet in the northwest. About two-thirds of the area has an elevation of less than 500 feet.

Annual rainfall ranges from around 22 inches in the extreme west to 35 inches in the east. Effectiveness of precipitation, however, is lessened by the torrential nature of its occurrence and the high rates of evaporation. Seasonal distribution also reduces its effectiveness for crop production. Normally the heaviest rainfall occurs in two periods—May-June and September-October.

Frost-free seasons are long, averaging about 260 days in the north to 300 days in the south. In Zapata, Webb, Maverick, Uvalde, Zavala and Dimmit Counties, where most of the irrigated lands are located, the frost-free season averages around 280 days.

Irrigation Development

Irrigation farming had its inception with the founding of the missions at San Antonio early in the 18th Century. Anglo-American settlement of the area came mostly after the Civil War. Irrigation was developed on the Leona River in 1876, other developments followed mainly after construction of the Southern Pacific Railroad. According to Hutson, irrigation was being practiced to some extent in most parts of the area by 1897.[50]

Early irrigation efforts utilized surface water, but in the late 1890's following the discovery of ground waters under artesian pressure some of the wells were put to use. Some 500 acres in Zavala County and 250 acres near San Antonio were irrigated by water from these sources in 1897.[51] Scattered development of artesian wells followed, and by 1904 artesian sources were being tapped throughout most of the present area of development (Figure 5).

Most of the development came after railroads were constructed in 1909-11. Once rail transportation was available, irrigated acreage expanded rapidly until about 1917, slowed or ceased altogether during World War I and expanded again during the 1920's. Construction of wells during the 1930's consisted largely of replacements with little or no expansion in irrigated lands. Groundwater irrigated acreage in Uvalde, Zavala and Dimmit Counties has expanded since 1940, and particularly since 1945. Some new well installations were made outside the Uvalde, Zavala and Dimmit County area in recent years, but in most cases these constitute replacements or shifts in place of use, and irrigated acreage remains about the same.

Surface-water irrigation along the portion of the Rio Grande that is included in this area began late in the 19th Century. Expansion, however, was slow and by 1919 only a little more than 10,000 acres were irrigated along this stretch of the river. Slow development continued through 1939 when 22,000 acres were irrigated. Irrigated acreage has expanded rapidly since 1939, reaching 58,000 acres in 1948. Other surface-water irrigated lands along the Nueces and Medina Rivers have not experienced similar expansion, and the acreage included in these projects has remained stable or declined.

Present Extent of Development

Approximately 187,000 acres were equipped for irrigation in this area in 1948, but surface-water supplies were so short that only 150,000 acres were irrigated (Table 1). Most of the idle lands equipped for irrigation were in the Bexar-Medina-Atascosa Counties Water Improvement District No. 1 near San Antonio.

[50] Hutson, William F., *op. cit.*, pp. 41-59.

[51] *Ibid.*, p. 51.

More than half (85,000 acres) of the irrigated lands were supplied with surface water in 1948 (see Figure 5 for location). Surface-water supplies for the 37,000 acres irrigated at Eagle Pass and in the Bexar-Medina-Atascosa Counties Water Improvement District No. 1 were obtained by gravity diversion. Water supplies for the other surface-water irrigated lands were pump diverted.

Ground waters were used on 66,000 acres and in combination with surface water on 260 acres. Although a large part of the wells in this area tap water under artesian pressure, flowing wells provide water for only a small part of the irrigated lands. Many of the wells near San Antonio and Poteet are flowing wells, especially those at lower elevations, but the yield is generally so small that pumping is necessary.

Type of Farming

Although a considerable acreage of new farmland was cleared for dryland farming in recent years, cattle ranching remains the principal agricultural activity. Irrigation farming centers around 2 main types of enterprise, production of commercial truck crops and diversified farming. Some vegetables may be produced, depending on the location in the area, but most diversified farming operations center on the production of small grain, Sudan grass for pasture, and grain and forage sorghum for livestock feed. Most of the isolated irrigation developments are on large ranches where water is used principally for pasture and the production of feed crops.

Most of the cultivated land that lies to the west of the line denoting the boundary between the sub-humid and semi-arid regions of the State is irrigated (Figure 5). This includes most of the cultivated lands of Zapata, Webb and Maverick Counties and those west of the Nueces River in Dimmit, Zavala and Uvalde Counties. Both irrigation and dry farming are practiced east of this line. Irrigation is used for the production of truck crops, pasture and feed crops. It is seldom used on such crops as cotton, grain sorghum and corn.

Number and Size of Farms

Irrigation was practiced on 2,027 farms and ranches in 1948.[52] Acreage per farm and the size of farm or ranch on which irrigation was practiced differed widely in all parts of the area, depending on the type of farming involved. Many of the operating units are small in the market gardening operations near San Antonio and Poteet. Other units in the same vicinity are larger, particularly those engaged in production of truck crops. Commercial vegetable farms in Dimmit and Zavala Counties and along the Rio Grande near Laredo and Eagle Pass range in size from small 3 to 5-acre tracts to large corporate enterprises that contain more than 1,000 acres. Most commercial truck farms, however, contain 25 to 75 acres. Diversified farms are larger; ordinarily they contain 120 to 160 acres of irrigated land.

Irrigated Crops

The long growing season and relatively mild winters encourage almost year-round crop production. Drouth and high summer temperatures tend to divide the growing season throughout the western two-thirds of the area. This has led to the adoption of short season crops or crops that mature before the impact of hot weather. It also has encouraged an intensive type of agriculture in which two crops are frequently harvested from the same acreage each season.

Commercial production of truck crops is the leading farm enterprise under irrigation (Table 2). The practice centers in the vicinity of Laredo and Eagle Pass and in Dimmit and Zavala Counties. Some vegetables are grown in the other irrigated areas also, but the acreage is small. Further east, in the vicinity of Corpus Christi, commercial truck crops are grown without irrigation. Commercial truck and market garden crops near San Antonio and Poteet are irrigated.

Irrigated pastures occupied slightly less than 40,000 acres in 1948, ranking second in acreage to commercial truck crops. In contrast to vegetables, which were among the first irrigated crops, it is only in recent years that irrigation of pastures became important. Oats, sweetclovers and Sudan often are used for temporary pasture, while permanent pastures involve both improved and native grasses.

Grain sorghum ranked third among irrigated crops. Production centered in the western part of the area—Zapata, Webb, Maverick, Dimmit, Zavala and Uvalde Counties—whereas forage sorghum was grown throughout the area. Yields of grain sorghum averaged about 38 bushels per acre, about the same as those in the West Central Texas area to the north. Forage sorghum averaged slightly under 2 tons per acre, reflecting in part the short water supplies and the extensive type of agriculture under which it is commonly grown.

Cotton occupied approximately 10 percent of the irrigated cropland in 1948. Ordinarily cotton is not an important irrigated crop in the area, but high postwar prices led to increased cotton plantings. Production of irrigated cotton centered in

[52]The number and size of farms where production of commercial vegetables is involved varies with the time of year in which the count is made. In the commercial vegetable-producing areas, the land is commonly cash-leased for the production of a single vegetable crop. Because of this, an individual tract may be operated by 2 or perhaps 3 operators in a single year. Acreage handled by an individual may vary widely in different parts of the year, depending on the crop and on individual circumstances. Some landholders, not necessarily owners, do little or no farming themselves, but lease their holdings to others for the production of a single vegetable crop. Inasmuch as this inventory was conducted in June, the number of farms reported includes these base units as individual units rather than the total number of operators who might have been involved during the 1948 crop season.

the same parts of the area where grain sorghum is grown. Irrigated cotton averaged slightly less than half a bale per acre in 1948, the lowest average yield for cotton under irrigation in any part of the State. Other irrigated crops such as citrus, alfalfa, peanuts, flax, corn for grain, and nurseries occupied less than 5 percent of the irrigated acreage harvested in 1948.

AREA V: LOWER RIO GRANDE VALLEY

For purposes of this publication, the Lower Rio Grande Valley area is considered to be the 4 southernmost counties of Texas. The irrigated area, most of which is contiguous, constitutes the largest single concentration of irrigated land in the State. It is also the most intricately organized, densely settled and intensively farmed area in Texas. Because of its dependence on vegetable crops and citrus, the economy of the Lower Valley is especially sensitive to changes in national employment and income levels. Adverse or favorable production situations in Florida or California, both of which are competitive areas, are also quickly reflected in prices paid for Lower Valley commodities.

With the exception of a strongly rolling area bordering the Rio Grande in Starr County, the area has a smooth to gently undulating topography. Most of the Lower Valley, particularly the irrigated part, is less than 250 feet above sea level. Undeveloped lands, except for the prairies near the coast, are heavily brush-covered.

The climate of the Lower Valley is semi-tropical. Annual precipitation, much of which occurs as torrential downpours, ranges from about 18 inches in the west to a little more than 26 inches near the coast. It is usually concentrated in 2 periods, late spring and early fall. Frost-free seasons are long, ranging from an average of 310 days in the higher western part to 330 days at Brownsville.

Mild temperatures, a long growing season and the control of moisture provided through irrigation permit a wide range of crops. Despite this favorable combination of physical factors, the Lower Rio Grande Valley is not without production hazards. Among the production hazards are floods, torrential rainfall, rising water levels, insect or pest infestations, occasional tropical hurricanes and frost.

Irrigation Development

Anglo-American settlement in the Lower Valley began about 1846 when the city of Brownsville was established. Irrigation farming began in 1876, but little progress was made until a railroad was built into the Lower Valley in 1904. Private land and water companies became active in the area shortly thereafter. The year 1907 marked the beginning of a period of irrigation expansion that continued until the effects of the depression of the 1920's reached the area (Table 8). The acreage declined after 1929 and did not fully recover until 1940. Year-to-year variations in irrigated acreage during the 1930-39 period to a considerable extent reflect fluctuations in general economic activity. Irrigated acreage declined sharply under the influence of above-normal and well distributed precipitation in 1941-42. Since 1942, however, the acreage has expanded at an average rate of about 37,000 acres a year.

Table 8. Acres irrigated, Lower Rio Grande Valley, 1901-48[1]

Year	Acres irrigated	Year	Acres irrigated	Year	Acres irrigated
1901...	500	1917...	110,600	1933...	271,900
1902...	1,200	1918...	142,500	1934...	294,000
1903...	3,400	1919...	181,200	1935...	327,000
1904...	6,900	1920...	195,600	1936...	358,000
1905...	3,200	1921...	204,500	1937...	321,000
1906...	3,500	1922...	215,600	1938...	270,400
1907...	5,100	1923...	237,400	1939...	346,074
1908...	13,300	1924...	268,100	1940...	393,439
1909...	21,800	1925...	298,500	1941...	259,985
1910...	33,700	1926...	327,800	1942...	370,769
1911...	53,100	1927...	342,800	1943...	459,594
1912...	65,700	1928...	354,150	1944...	469,818
1913...	74,200	1929...	371,000	1945...	504,430
1914...	70,900	1930...	329,550	1946...	535,695
1915...	87,000	1931...	257,800	1947...	556,678
1916...	95,400	1932...	261,300	1948...	592,100

[1]Irrigated acreage 1901-33 from "Investigations in the Lower Rio Grande Valley for Farm Credit Administration," Division of Irrigation, Bureau of Agricultural Engineering, USDA, 1933.
Irrigated acreage 1934-47 from Water Bulletins, International Boundary and Water Commission.
Irrigated acreage 1948 from International Boundary and Water Commission, American Section, plus U. S. Geological Survey estimates of ground-water development from sources not contributing to Rio Grande stream flow, unpublished.

Private land and water companies were responsible for the expansion of irrigation after 1907. The following narrative report of their early activities is carried in a recent report by the Bureau of Reclamation:

> Numerous companies were soon formed for the development and sale of irrigated land. For a number of years the emphasis was on the sale of land for vegetable production but later the promoters subdivided the land into small tracts and planted it to citrus orchards. The first plantings of citrus were made about 1907 with commercial production starting about 1917. Great energy and ingenuity were shown in the sales campaigns of the land companies. They brought many prospective buyers to the valley from northern states. The mild weather, flourishing citrus groves, and profusion of flowers in mid-winter proved irresistible to many people and land was usually sold at inflated prices.[53]

The era of land and water company development was short-lived. Many of the companies were bankrupt by 1915 and unable to continue. Beginning in 1914, farmers organized irrigation districts, issued bonds and took over the com-

[53]"Plan for Development; Valley Gravity Project, Rio Grande (Lower) Basin, Texas," Bureau of Reclamation, U. S. Department of Interior, Dec., 1948.

panies' interests. Increases in irrigated acreage following this came mostly through expansion in existing districts and new district organizations. Settlers or purchasers, however, were recruited from the same areas and in about the same way as those in the earlier developments. One of the most striking features of Lower Rio Grande Valley development is the number of out-of-state people it has attracted, particularly people from the Northern States.

Present Development

During 1948, 592,000 acres were irrigated from all sources in the Lower Rio Grande Valley, amounting to more than 20 percent of the total irrigated acreage in Texas (Table 1). Water supplies from the Rio Grande were used to irrigate 587,000 acres while ground waters were used on approximately 5,000 acres.

All water supplies used in the Lower Valley area are obtained by pumping. Water is diverted from the Rio Grande by pumps, and it is frequently pumped once or twice before it reaches its destination. In 1945, according to the Bureau of Reclamation, about 54 percent of the Lower Valley Area was served by first lift pumps, 39 percent by second lift pumps, about 7 percent by third lift pumps, and a little less than 1 percent by fourth lift pumps.

Organization for Irrigation Purposes

Eighty-four percent of the irrigated lands of the Lower Rio Grande Valley is included in some form of group organization for providing water. Irrigation districts, which were formed to take over the interests of the bankrupt land and water companies, are no longer active in the Valley. These have been reorganized as State laws were amended, to water improvement districts or water control and improvement districts. There were 14 water improvement districts in 1948, of which 13 were active and 1 in the process of being reactivated, 14 water control and improvement districts and 1 water company. The last-named was the only early venture in commercial development to survive.

Number and Size of Irrigated Farms

Irrigation was practiced on 15,000 farms in the area in 1948, or 50 percent of the irrigated farms in Texas (Table 1).[54] More than 86 percent, or 13,000 of the irrigated farms were included in organized enterprises. Operators who buy or divert their water supplies independently numbered slightly more than 2,000.

The average-sized operating unit in the Lower Rio Grande Valley in 1948 contained about 40 acres of irrigated land, with those in organized districts averaging a little less than the ones classed as independents. Average sizes, however, tend to obscure the complexity and range in farm size, as units vary widely in all parts of the Valley, ranging from a large number of small tracts that contain only an acre or two to large corporate holdings of several thousand acres. Large or small farms are not peculiar to any part of the Valley. They tend rather to be intermingled. On the whole, the situation as to farm size is so complex that it would be misleading to refer to a particular size of farm as "typical."

Early colonization efforts and the effects of intensive real estate promotions, aided by the attractiveness of the Lower Valley to out-of-state people, are indicated by the large number of non-resident landowners. Bureau of Reclamation tabulations in 1945 showed that 43 percent of the individual landowners within organized districts were not residents of the Lower Valley Area.

Indications are that the situation has changed somewhat since these tabulations were made. Normally, the Lower Valley real estate market is rather active, particularly during periods of high income. The years since 1945 have not been exceptions; irrigated acreage has increased almost 100,000 acres, while improved lands have been further subdivided and intensive real estate promotions carried out. Comparison of the 1945 Bureau of Reclamation count with the number of non-resident owners polled by the individual districts in determining landowner sentiment toward proposed constructions, indicates that the proportion of non-resident landowners is somewhat higher now than in 1945.

Generally, non-resident holdings are smaller than resident-owned tracts. This is evident in the 1945 inventory by the Bureau of Reclamation, which showed that non-resident landowners constituted 43 percent of all owners but held only 30 percent of the land within organized irrigation districts. A sample inventory conducted by the same organization in 1945 showed that 45 percent of the ownership tracts and 86 percent of the farms containing 40 acres or less were owned by non-residents. The proportion of non-resident ownership tracts declined sharply in the size range above 40 acres.

Type of Farming

The once predominant cattle industry declined as irrigation expanded, and recent land clearing for dryland production of cotton reduced it still more. Production of cattle has never been important in the irrigated agriculture of the Lower Valley. Rice and sugarcane were the principal irrigated crops until they were replaced by vegetables in the expansion after 1904 following the construction of the railroad. Citrus and cotton were introduced shortly thereafter, and they have gained in importance through the years. The present principal crops were firmly established by 1920, and an intensive commercial type of

[54] Caretaker organizations are included as individual farm units.

farming emerged. Operations since have become more intensive and commercialized, and today they rival those practiced in the intensively farmed semi-tropical areas of California and Florida.

Irrigated Crops

Although the Valley produces a wide variety of crops, cotton, citrus and winter vegetables are the ones of major dependence. They occupied about 94 percent of the irrigated acreage in 1948 (Table 2). Crop sequences and practices employed in Lower Valley agriculture have been described by the Bureau of Reclamation as follows:

> Cropping practices include an extensive system of double cropping of practically all vegetables. There is also some double cropping of vegetables with non-bearing trees. . . . Forage crops are important in the dryland areas of the Project but are not grown extensively in the irrigated area. Grapefruit has been the principal citrus crop heretofore, with oranges constituting a smaller part of the crop, the ratio of the two being five to one. However, the situation is changing with new plantings and the future citrus production of the Valley will doubtless have a much larger proportion of oranges. A wide variety of vegetables is grown in the Valley, with climatic conditions permitting production of a winter crop which usually finds a ready market.[55]

Cotton was the most extensively grown crop in 1948, occupying almost half of the total harvested acres (Table 2). Excluding the land planted to citrus, only a small part of which is available for other crops, cotton was planted on 60 percent of the irrigated lands. Cotton is well adapted to double cropping with vegetables. It is planted early in the spring or late winter and is usually harvested by September 1. Pink bollworm control regulations require that all cotton or cotton residues be disposed of by early September.

Yields of irrigated cotton in the Lower Valley have increased in recent years. This has been attributed to the beneficial effects of the pink bollworm program which, although designed primarily to control this pest, also reduced damage from other insects. Some irrigated cotton produced a little more than 2 bales per acre in 1948, although the average was slightly less than three-fourths of a bale.

Citrus, the crop for which the Lower Valley is noted, occupied 167,000 acres in 1948, of which 121,000 acres supported trees of bearing age. Citrus culture is largely concentrated in the higher northwestern part of the area, having been on the decline in the middle and eastern parts for a number of years.

According to the most recent citrus census, 62 percent of the citrus trees were grapefruit, 35 percent were orange and slightly more than 1 percent were lemon.[56] Tangerine, lime and other citrus trees constituted less than 2 percent of the total.

Non-resident ownership of land in citrus is particularly high. This factor, combined with provisions in the original sales contract wherein the developers cared for the citrus trees until they were of bearing age, led to the establishment of citrus grove management services, locally known as "caretakers." The number of "caretakers," both individuals and organizations, has increased sharply in recent years. Some of these operations are large, handling 3 to 5 thousand acres of trees. Generally, they provide all labor required in irrigating, spraying, dusting, fertilizing and grove maintenance for a fixed fee per acre. The landowner pays for all water, fertilizer, insecticides and pruning. "Caretakers" usually market the fruit, unless the grove owner belongs to a cooperative marketing association.

Commercial truck crops were grown in 1948 on 163,000 acres, or about 26 percent of the total harvested acres. Spring and fall tomatoes, cabbage, carrots, beets, potatoes and green corn were the principal truck crops. There were a number of others, such as green beans, peppers, eggplants and radishes, but production from these is usually in much smaller quantities than that of the principal truck crops.

Grain sorghum, forage sorghum, alfalfa and corn are irrigated crops of small importance in Lower Valley agriculture. Their combined acreage in 1948 amounted to 38,000 acres, or 6 percent of the total harvested acres.

Water Costs

Water charges levied within the individual districts are among the highest, if not the highest, in Texas. Methods of calculating the per-acre cost of water, like many other features of Lower Valley agriculture, are complicated. Each acre or tract has its own individual cost, depending on the district in which it is located, assessed valuation, way in which water is applied and the number of times it is watered. Irrigation districts generally levy 3 kinds or types of charges: flat rate, toll charge and bond tax.

The *flat rate* is a charge per irrigable acre which is levied to maintain the district, and it is collected whether or not water is used. Rising material and labor costs have caused flat rate charges to be increased. They ranged from $1.00 to $6.60 per acre in individual districts in 1948, with most districts charging $3.00 or more per acre.

The *toll charge* is a per-acre service charge payable in advance each time water is delivered. Rising labor costs have also caused some districts to increase toll charges. These charges ranged from 75 cents to $3.00 per acre in individual districts, with most districts charging $1.50 to $2.00.

[55] "Plan for Development; Valley Gravity Project, Rio Grande (Lower) Basin, Texas," *op. cit.*

[56] "Citrus Census of the Lower Rio Grande Valley of Texas as of July 1, 1947," Bureau of Entomology and Plant Quarantine, USDA, Harlingen, Texas.

Two rates are charged in some districts, depending on whether the land is flood or sprinkler-irrigated. Generally, the toll charge is 50 cents per acre less where sprinklers are used. The toll charge may not appear to be significant, but it should be noted that it applies each time water is delivered, a matter of 6 times in some districts during 1948.

The *bond tax* is an ad valorem levy, the revenue from which is used to amortize bonded indebtedness. Two of the districts have retired their indebtedness and do not levy the bond tax. In the others, the levy ranges from 50 cents to $5.00 per $100 valuation. Average district bond taxes per acre range from 29 cents to $7.77, with most districts averaging $3.00 or more.

In addition to these regular charges, some districts levy special flat rate charges. One district made a special assessment of $10 per irrigable acre in 1948. Special flat rates levied by other districts were somewhat lower than this. Generally, the special flat rate is necessary when district officials decide to pay for needed construction during a period of high prices, rather than adding to an indebtedness which might have to be paid in less favorable times.

Other Public Organizations

The situation is further complicated by a number of other publicly-organized districts, all with taxing authority. In addition to the foregoing charges levied by the irrigation districts, a large part of the irrigated lands is subject to ad valorem taxes levied by one or more special districts—road, drainage and navigation. Inasmuch as these special districts include most of the irrigated lands, it is possible for an individual tract to be subject to ad valorem taxes levied by 7 different public organizations—state, county, school, irrigation, road, drainage and navigation district.

The Lower Valley gravity project plans, prepared by the Bureau of Reclamation, are designed to alleviate 2 of the more pressing Valley needs, improvement of water supplies and drainage. Water supplies are now obtained from the unregulated flow of the Rio Grande. In the absence of storage facilities, much of the water, especially flood flows, escapes unused to the Gulf of Mexico and leaves the area short of water at critical times.

AREA VI: COAST PRAIRIE

This area includes the rice-growing part of the State. Most of the rice is grown in a belt of prairie land 40 to 100 miles wide which lies along the coast between the Guadalupe and Sabine Rivers. Within recent years, however, a small acreage has been developed along the Trinity River in Houston and Polk Counties. As delineated in Figure 5, the new areas of development are not included in the Coast Prairie area. The acreage of rice, however, is included in the totals for the area.

The Coast Prairie is a low, almost flat prairie, heavily covered with grass. Timber and bush cover, as well as minor topographic variations, are confined chiefly to the bayous and other shallow drainage ways.

Climatically, the area is well suited for the production of rice. The growing season is long, ranging from around 300 days in the southern part to about 270 days in the east near Beaumont. Annual rainfall ranges from about 35 inches in the south to 50 inches in the east, and about 60 percent occurs during the growing season. Nearness of the area to the Gulf, combined with high precipitation, results in a warm, humid atmosphere. September hurricanes sweeping in from the Gulf damage late rice in some parts of the area almost every year.

Irrigation Development

According to Haskell, the first irrigation of rice in Texas was in 1895 in Jefferson County.[57] Rice production spread rapidly thereafter, and by 1901 the crop was being grown in various places from Orange to Brownsville. The period of expansion continued until 1913, when 303,000 acres were grown.[58] Low prices for rice in 1913 caused a decline in acreage, the first since irrigated rice production began in 1895. The acreage irrigated did not reach 1913 levels again until the price situation improved in the 1940's (Table 9).

Present Development

Favorable war and postwar prices for rice, plus cost reductions from combining and drying, led to an expansion of the Texas rice industry. Development accelerated at the start of the war, leveled off during the war years, and expanded sharply once the war was over (Table 9).

Rice was grown on 525,300 acres in 1948, as compared with 269,000 acres in 1939. Total irrigated acreage in the Coast Prairie was 525,420; a very small acreage, 120, of the total was in pasture and vegetables (Tables 1 and 2).

Type of Water Used

Surface-water supplies, pump diverted from the streams and bayous, were used on 393,000 acres. Pumped ground water was used on 131,000 acres and both surface and ground water were used on 800 acres. A number of operators, west and south of the Trinity River, used both surface and ground water, but the 2 types were seldom used on the same tract of land.

Compilation of annual reports filed by the various holders of surface-water permits indicates

[57] Haskell, C. G., *op. cit.*

[58] *Ibid.*

Table 9. Rice acreage and production, Coast Prairie of Texas, 1933-48[1]

Year	Harvested acreage	Harvested yield per acre	Production
	1,000 acres	*Bushels*	*1,000 bushels*
1933	148	49.6	7,341
1934	148	49.8	7,370
1935	167	52.0	8,684
1936	204	52.0	10,608
1937	261	50.0	13,050
1938	268	51.0	13,668
1939	269	56.4	15,172
1940	291	57.2	16,645
1941	305[2]	38.0	11,590
1942	370[2]	43.0	15,910
1943	388[2]	43.0	16,684
1944	392	44.5	17,444
1945	400	45.0	18,000
1946	412	43.0	17,716
1947	474	45.0	21,330
1948	526	46.5	24,459

[1]Estimates, Bureau of Agricultural Economics.
[2]Planted and harvested acreage the same except in 1941, 1942 and 1943.

that the acreage irrigated by surface water has increased since 1939. Two new group enterprises were established and older enterprises expanded their facilities. A large part of the increase since 1939, however, came through ground-water developments, particularly during 1946, 1947 and 1948.

Organization for Irrigation Purposes

More than 68 percent of the irrigated lands was included in some form of group enterprise for delivering water. Almost 91 percent of the lands irrigated by surface water was included in group enterprises. The proportion of the acreage served by independent and organized enterprises in 1948 was about the same as that reported in 1913. According to Haskell, 31 percent of the 1913 rice acreage was served by independent diversions or wells, while 69 percent was served by group enterprises.[59]

In contrast with other parts of the State where commercial enterprises have been replaced by public corporations, the commercial water company type of organization predominates in the Coast Prairie.[60] The area had 25 active, organized irrigation enterprises in 1948, of which 19 were water or canal companies, 2 were conservation and reclamation districts, 1 a valley authority, and 3 were classed as other organized enterprises. The water improvement district and the water control improvement district forms of organization, which predominate in other parts of the State where organized enterprises are used, are not found in the Coast Prairie. The 19 water and canal companies provided water for 252,000 acres in 1948, or 70 percent of the acres irrigated through organized enterprises.

Number and Size of Farms

The 525,000 acres irrigated were included in 1,942 farms, 1,940 of which were rice farms (Table 1).[61] About 70 percent of the farms were operated in organized irrigation enterprises; of those so included, 68 percent were in commercial enterprises.

Acres of rice per farm ranged from 30 to more than 3,100, with an over-all average of 270 acres per farm. Average acreage irrigated was much the same for both surface and ground-water irrigated farms. The 457 farms using ground water alone averaged 287 irrigated acres, while the 1,481 farms using surface water averaged 265 acres. Two farms containing a total of 800 acres of rice used both types of water.

Although rice is normally grown on the same land only once in every 3 to 5 years, farm sizes and acreage of rice per farm are generally the same. This results from the type of farming commonly followed.

Type of Farming and Tenure

Two types of farming are practiced in the rice-growing area of the Coast Prairie—rice growing and cattle ranching. Generally, the practices are not combined under one operator. One group of operators grows rice, another cattle.

Owner-operatorship, as commonly construed, is not extensive in rice production. Indications are that a little less than 25 percent of the rice farms are owner-operated. Rental or leasing arrangements vary widely, particularly where sub-tenancy is involved. Often rice is grown under a share lease in which the landholder provides land, water and seed for half of the rice crop.

Generally, the rice grower operates under a share lease agreement, growing rice only and shifting to a different tract each year. Rice lands not in rice are utilized by cattlemen who may or may not be rice growers themselves.

Favorable prices for rice during the war and postwar years led some operators to shorten the rotation period. The extent of this practice, which usually results in lowered yields, has not been reported. Yields per acre, as reported in Table 9, suggest that it is not extensive, or if it is extensively practiced, the effect has been obscured by the higher yields obtained on newly developed lands.

[59]*Ibid.*

[60]A definition of the various types of organized enterprises is given under the heading "Organization for irrigation purposes," Part I of this report.

[61]Farmers in this case are individual operators, that is, the men who grow rice. Frequently, the operator is a subtenant operating under a share lease arrangement with a tenant who holds a long-time cash, share, or cash and share contract with the landowner.

Water Costs

Eight of the water or canal companies delivered water for a share of the crop.[62] When water alone was furnished the charge was one-fifth of the crop, but when land, water and seed were provided the share amounted to half of the crop. One enterprise delivered water for a fifth of the crop, or $9 per acre. Charges levied by 10 of the water or canal companies ranged from $11 to $12 per acre irrigated.

Cooperative enterprises charged $12.50 per acre irrigated, while publicly organized enterprises had the lowest assessment per acre among all the organized enterprises, ranging from $7.05 charged by the valley authority to $8.18 in one of the conservation and navigation districts.

AREA VII: OTHER

This area covers all of the State not included in a previously described area (see Figure 1 for area delineation). Generally, irrigation farming is confined to the stream valleys, and crops, except for some specialization near Wichita Falls, are much the same as those grown without irrigation.

Irrigation farming has been practiced from time to time in different parts of the area for more than 50 years, and indications are that it was more widely practiced in the early days than it is at present. A number of small installations, particularly along the Brazos River, were reported in papers relating to irrigation practiced in 1898, 1902, 1908 and 1913.[63]

Present Development

Less than 20,000 acres were irrigated in 1948 in this part of Texas, and of this total almost 97 percent was in the project at Wichita Falls (Table 1). The remainder, 550 acres, was in small isolated developments (see Figure 5 for locations).

Including the large number of small suburban holdings in the Wichita Falls project, there were 724 irrigated farms in the area. Inasmuch as 97 percent of the irrigated lands and nearly 100 percent of the farms on which irrigation was practiced were located in the project at Wichita Falls, it seems advisable to separate the discussion at this point, and to treat the isolated developments and the project area separately.

Isolated developments. Irrigated lands in isolated developments totaled only 597 acres in 1948. This acreage was included in 9 farms, 4 of which used surface water on 387 acres while 5 used ground water from 5 wells on a total of 210 acres. Irrigated acreage per farm ranged from 20 to 250 acres and, with one exception, comprised only a small part of the cultivated acreage on farms where it was practiced. Cotton, alfalfa and corn were the crops irrigated in 1948.

Wichita Falls project. This project, which obtains water from the Wichita River, occupies the bottom lands along the river in Wichita County. Its construction followed almost 30 years of agitation which began in the 1890's and ended in 1924 when the project was completed.

Irrigation was practiced in the vicinity as early as 1900, but it was not until the first year of project operation in 1925 that it became extensive. A total of 20,000 acres were irrigated during that year. It expanded thereafter, reaching a peak of 33,000 acres in 1935, but it has been on the decline since that time (Table 10).

In this area, where the rainfall approaches 29 inches annually, the need for irrigation is less than in most other parts of the State where irrigation is practiced.

Irrigation farming in the Wichita Falls project has not been entirely successful for a number of

[62]Data on water costs obtained from certified filings, State Board of Water Engineers, Austin, Texas.

[63]Hutson, William F., *op. cit.*, among others.

Table 10. Acreage irrigated, by crops, Wichita Valley, Texas, 1933-48[1]

Year	Acres irrigated	Irrigated crops						
		Cotton	Grain sorghum	Small grain	Legumes	Pasture	Corn	Miscellaneous
1933	30,501	17,061	6,187	2,935	292	649	1,888	1,489
1934	30,301	13,161	7,496	4,401	271	1,591	1,494	1,887
1935	33,147	13,024	8,547	5,736	304	2,171	876	2,489
1936	32,859	15,125	6,841	4,802	398	1,650	693	2,750
1937	28,613	17,219	4,671	2,486	458	1,124	468	2,187
1938	26,089	8,101	10,026	3,675	695	1,496	540	1,556
1939	28,814	7,953	11,458	4,474	1,023	1,425	482	1,999
1940	22,862	7,724	8,536	2,825	1,202	1,099	303	1,173
1941	15,256	6,854	5,946	388	973	560	285	250
1942	17,172	7,088	6,842	514	857	637	814	420
1943	23,000	8,166	8,216	702	555	3,076	1,157	1,128
1944	18,078	6,411	6,748	1,487	239	1,807	846	540
1945	11,049	3,499	3,981	928	160	1,882	257	342
1946	17,117	5,516	4,572	2,577	422	3,132	478	420
1947	14,273	5,691	3,265	2,101	782	1,775	321	338
1948	19,183	6,721	3,594	2,940	1,907	2,584	180	1,257

[1]Compiled from annual report of Wichita County Water Improvement Districts No. 1 and No. 2.

reasons, some of them which stem from unanticipated physical deficiencies. Part of the soils was not suited for irrigation and this, combined with the salt content of the water, led to drainage and salt problems. Water supplies, unlike those in most other irrigated areas of the State, are ample.

Agriculture has been further inhibited by oil production and urban encroachments. Much of the area is in a producing oil field which has experienced two boom periods since the project was completed. Consequently, land ownership and land values are more likely to be influenced by mineral values than by agricultural possibilities.

Many farmers, especially those engaged in part-time farming, are most interested in and more dependent on non-agricultural activities than they are in farming. In addition to the part-time farms, some of which are 50 or 60 acres in size, a large number of rural residences are in the irrigated areas.

There were 715 farms and 19,000 irrigated acres in the Wichita Falls project in 1948. The average size of farm in the project was about 27 acres, but farms range in size from less than 1 acre in some of the truck farms near Wichita Falls to more than 600 acres. About 40 percent were less than 10 acres in size.

Cotton, grain sorghum and small grains regularly occupy three-fourths or more of the irrigated acreage. Their importance has declined somewhat in recent years, being replaced by irrigated pasture crops (Table 10). Some alfalfa and clovers are grown but the acreage usually is not extensive.

Yields of irrigated crops average about 30 percent higher than yields from dryland crops. Production hazards include cotton root rot, birds, noxious weeds and adverse weather conditions. The 1948 crop season was rather favorable, with irrigated cotton averaging about three-fourths bale per acre, or about 50 percent higher than usual. Yields of grain sorghum at 30 bushels per acre and of forage sorghum at nearly 2.5 tons per acre, were also above average.

Water costs are among the lowest in Texas. District 1, which includes the city of Wichita Falls, levies an ad valorem tax with rates set annually by the board of directors. In addition, a service charge of $2.00 per acre is assessed when water is used.

District 2, which includes most of the irrigated lands, assesses according to the benefits received. The present assessments are $2.00 and 3 cents per acre per annum for irrigable and non-irrigable lands, respectively. These charges apply whether water is used or not. District 2 has long taken an active interest in promoting better drainage, cropping and water use practices. The district now has an active improvement program underway.

ACKNOWLEDGMENTS

Data presented in this report were obtained mostly from secondary sources, many of them unpublished. Unless otherwise indicated, all tables and charts relating to State and area totals represent the contribution of a number of agencies and individuals.

Data regarding surface-water irrigated lands, within the various types of organized enterprises, were obtained mostly from officials of the organizations concerned. Information pertaining to individual enterprises using either surface or ground water were obtained from county offices of agencies having knowledge of the particular operation, published and unpublished data of state and federal agencies, or the individuals concerned.

Field representatives of the following agencies provided data for this study:

U. S. Department of Agriculture—Bureau of Agricultural Economics, Office of State Agricultural Statistician; Bureau of Plant Industry, Soils and Agricultural Engineering; Extension Service; Production and Marketing Administration; and Soil Conservation Service.

U. S. Department of Interior—Geological Survey and Bureau of Reclamation.

U. S. Department of State—International Boundary and Water Commission.

State (Texas) Board of Water Engineers.

State (Texas) Department of Agriculture—Office of Pink Bollworm Control.

Texas A&M College System—Departments of Agricultural Engineering, Agronomy and Horticulture.

Various county and school district tax assessors.

Particular credit is due officials of the various irrigation districts and county administrative officers of the Production and Marketing Administration.

APPENDIX

Appendix Table 1. Irrigated acres, crops and land use, by type-of-farming areas, Texas, 1948

Area no.[1]	Acres irrigated	Irrigated crops										
		Cotton[2]	Grain sorghum[2]	Wheat[2]	Alfalfa[2]	Rice[2]	Truck crops[2]	Citrus[2]	Forage sorghum[2]	Pasture	Miscellaneous[2 3]	Crop failure
1	829,100	120,700	380,800	261,900	39,400	.....	6,100	.....	8,500	13,200	6,100	[4]
3	543,300	353,000	135,000	5,000	16,500	.....	2,800	.....	15,200	8,700	7,700	2,000
4	22,200	8,100	4,200	1,700	1,900	.....	.....	.....	900	2,600	2,800	[4]
5	119,200	75,800	4,200	.....	10,900	.....	.....	.....	7,000	600	5,300	15,100
6	83,700	67,400	.....	.....	14,700	.....	.....	.....	.....	.....	2,700	[4]
7	12,200	2,300	1,300	.....	1,500	.....	.....	.....	4,000	700	1,700	700
8	159,800	22,400	23,600	.....	200	.....	72,600	1,400	16,600	39,800	6,500	[4]
9	583,300	289,700	16,800	.....	4,000	.....	161,800	121,100[5]	10,700	20,000	3,500	[4]
10	2,000	.....	.....	.....	.....	.....	1,900	.....	.....	100	.....	[4]
12	4,500	.....	700	.....	1,500	.....	.....	.....	400	300	1,600	[4]
14	300	100	.....	.....	100	.....	.....	.....	.....	.....	100	[4]
16	1,100	.....	.....	.....	.....	1,100	.....	.....	.....	.....	.....	[4]
18	524,300	.....	.....	.....	.....	524,200	.....	.....	.....	100	.....	[4]
Total	2,885,000[6]	939,500	566,600	268,600	90,700	525,300	245,200	122,500	63,300	86,100	38,000	17,800

[1]Areas named and described as follows in "A Description of the Agriculture and Type-of-Farming Areas in Texas," Texas Agricultural Experiment Station Bulletin 544:

1—Panhandle Wheat area
3—High Plains Cotton area
4—Low Rolling Plains area
5—High Plains and Trans-Pecos Cattle Grazing area
6—Upper Rio Grande Valley Irrigated area
7—Edwards Plateau Grazing area
8—Rio Grande Plains area
9—Lower Rio Grande area
10—Corpus Christi Cotton area
12—Western Cross Timbers Farming area
14—Blackland Prairie
16—Piney Woods Lumbering area
18—Coast Prairie area

[2]Acres harvested only, entries rounded to nearest 100 acres.

[3]Includes corn, oats, barley, sugar beets, field peas, dry beans, market garden crops, flax and other crops of small acreages.

[4]None reported.

[5]Net citrus acreage 167,300—121,100 acres in trees of bearing age, 18,500 acres in young trees not double-cropped, 27,700 acres in trees not of bearing age interplanted to other crops.

[6]Because of double cropping practices, principally in areas 8 and 9, the acres listed for the various crops and uses exceed the total acres irrigated.

Appendix Table 2. Acres irrigated, by type of water used and drainage basins, Texas, 1948

Drainage basin[1]	Type of water used			
	Surface[2]	Ground[3]	Combination[2 3]	Total
Rio Grande—direct	739,400	5,400	200	745,000
Pecos River	29,200	46,100	24,200	99,500
Total Rio Grande	768,600	51,500	24,400	844,500
Sacramento-Salt Lakes (closed basin)	.....	3,100	.....	3,100
Total Rio Grande drainage basin	(768,600)	(54,600)	(24,400)	(847,600)
Baffins Bay	.....	1,900	.....	1,900
Nueces River basin	22,100	56,100	300	78,500
Guadalupe River—direct	24,700	57,500[4]	800	83,000
San Antonio River	5,100[5]	7,500	.....	12,600
Total Guadalupe River basin	29,800	65,000	800	95,600
Colorado River—direct	119,800	31,100	.....	150,900
Llano River	400	.....	.....	400
San Saba River[6]	2,400	200	.....	2,600
Pecan Bayou[6]	4,500	.....	.....	4,500
Concho River[6]	3,100	3,200	.....	6,300
Total Colorado River basin	130,200	34,500	.....	164,700
Brazos River basin	85,300	924,200	.....	1,009,500
San Jacinto River basin	7,400	29,900	.....	37,300
Trinity River basin	78,600	600	.....	79,200
Sabine River—direct	9,700	400	.....	10,100
Neches River	68,700	1,500	.....	70,200
Total Sabine River basin	78,400	1,900	.....	80,300
Total Gulf of Mexico other than Mississippi River and Rio Grande	(431,800)	(1,114,100)	(1,100)	(1,547,000)
Canadian River—direct	.....	.....	.....	.....
Mustang Creek (Rita Blanca)	.....	6,300	.....	6,300
North Canadian River	.....	3,700	.....	3,700
Total Canadian River	.....	10,000	.....	10,000
Red River basin	19,300	460,800	.....	480,100
Total Mississippi River, exclusive of Missouri River basin	(19,300)	(470,800)	.....	(490,100)
Grand total, Texas[7]	1,219,700	1,639,500	25,500	2,884,700

[1]As delineated and named in 16th Census, 1940, "Irrigation of Agricultural Lands," Texas portion of interstate and international basins only.
[2]Acreage tabulation according to source of water supply. All acreage listed not necessarily within individual drainage basin.
[3]Ground-water irrigated acreage located within drainage basin boundaries.
[4]Includes coastal drainage areas lying between Guadalupe basin and Tres Palacios River.
[5]Includes Bexar-Medina-Atascosa Water Improvement District No. 1.
[6]Data for these basins included in "Colorado River—direct" in 1940 Census.
[7]Grand total is sum of totals in parentheses.