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AN ECONOMIC LAND CLASSIFICATION OF THE IRRIGATED CROPLAND IN THE PECOS RIVER BASIN, NEW MEXICO

WATER RESOURCES RESEARCH INSTITUTE

IN COOPERATION WITH

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PUBLICATIONS

This report is one of a series in the project entitled "A Comprehensive Water Resources Analysis of a Typical Overdrawn Basin in an Irrigated Semiarid Area—Pecos River Basin, New Mexico."

Others published are:

Report 8— *Quantitative Water Resource Basin Planning: An Analysis of the Pecos River Basin, New Mexico*, by Ralph C. d'Arge.

Report 9— *Economic Feasibility of Increasing Pecos Basin Water Supplies Through Reduction of Evaporation and Evapotranspiration*, by William C. Hughes.

Other reports covering the hydrology, geology, systems analysis, and a summary of this study are yet to be published.

AN ECONOMIC CLASSIFICATION OF THE IRRIGATED CROPLAND IN THE PECOS RIVER BASIN, NEW MEXICO

ABSTRACT

Farmers in the desert southwest are continually facing problems of allocation of water, their most vital resource. Demands that are larger than supplies have resulted in the need for a well planned future regarding the use of water if economic agricultural development is to continue. For effective long-range plans to be made there is a need for factual information regarding existing conditions in order to project into the future.

The central objective of this study of the Pecos River Basin, New Mexico, was to furnish information concerning the geographic location of irrigated cropland with soil and water problems that were considered to affect income expectancies. The Cornell system of economic land classification was used to delineate those areas having slight, moderate, or severe limitations with respect to soil and water quality and/or quantity.

Soil and water maps and reports, results of previous farm management studies, and an extensive field survey, were combined to construct economic classification maps of the basin. Differences in areas were reflected on the map by use of a color scheme. Lands with slight limitations were referred to as Economic Class I and were colored black, those with moderate limitations or Economic Class II were colored dark gray, and those with severe limitations in Economic Class III were shown in light gray. Results of this study indicated that about 31 percent of the irrigated cropland of the Pecos River Basin had only slight limitations, 43 percent had moderate limitations, and only about 16 percent was severely limited with respect to income expectancies. The remaining 10 percent of the irrigated cropland was not classified.

Income expectancies measured in terms of net returns to land and management were estimated to be greater than $100 per cultivated acre for Economic Class I land, between $100 and $35 per cultivated acre for Economic Class II land, and less than $35 per cultivated acre for Economic Class III land.

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This study was part of an interdisciplinary-interuniversity research project entitled "A Comprehensive Water Resources Analysis of a Typical Overdrawn Basin in an Irrigated Semiarid Area–Pecos River Basin, New Mexico." The principal investigators were Charles E. Jacobs, hydrologist, and William K. Sumners, geologist, New Mexico Institute of Mining and Technology; Ralph d'Arge, economist, and W. H. Ellis, professor of law, University of New Mexico; and the following persons from New Mexico State University: John W. Hernandez, civil engineer; Arden Baltensperger, agronomist; Harold Dregne, soils scientist; George R. Dawson and Robert R. Lansford, agricultural economists. H. R. Stucky, Director of the New Mexico Water Resources Research Institute, New Mexico State University, served as the coordinator of all phases of the project.

Numerous other groups and individuals aided in the study. Special appreciation is expressed to the following: U. S. Soil Conservation Service, U. S. Geological Survey, State Engineer Office, Pecos Valley Artesian Conservancy District, Agricultural Stabilization and Conservation Service, and the New Mexico Extension County Agents in San Miguel, Guadalupe, DeBaca, Chaves, and Eddy Counties.

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Robert R. Lansford, Edwin T. Garnett, and Bobby J. Creel[1]

Chapter 1

INTRODUCTION

The Pecos River Basin in New Mexico probably presents a greater aggregation of problems associated with land and water use than most other irrigated basins in the western United States. These problems involve both quantity and quality of water. Salinity encroachment is of particular concern in certain areas of the basin where there is an abundance of productive land whose development is limited by the availability of water of satisfactory quality (29). In other areas of the basin an ample supply of irrigation water is available but the availability of irrigable land is limited.

Crop production and farm income may be seriously affected by the combinations of soil and water, depending upon the degree of limitation posed by any particular combination of these variables. This fact has been recognized, but has received little attention in research because knowledge was lacking as to the exact location and degree of limitation of the variables. The primary objective of this study was to delineate those areas in the basin having similar combinations of soil and water quantity and/or quality.

Irrigation throughout the Pecos River Basin in 1967 diverted about 613,744 acre-feet, of which 392,844 acre-feet were from ground-water sources and 225,978 from surface water sources. Consumptive use in the Pecos River Basin was estimated at 368,600 acre-feet annually, of which 241,000 acre-feet were from ground-water sources, and 127,200 from surface water sources for 1960-1964 (38).

Use of underground water exceeds the rate of natural recharge in certain areas of the basin; therefore, a ground-water mining condition exists. The rate at which use exceeds recharge into the Roswell Artesian Basin, for example, is as follows: the natural recharge of ground-water aquifers is about 265,000 acre-feet, of which about 115,000 acre-feet are naturally discharged. A balance of 150,000 acre-feet remains available for consumptive use (36, p. 80). The estimated total pumpage from this area for 1960-1964 was between 400,000 and 430,000 acre-feet per year, of which about 270,000 acre-feet were consumed and the remainder were returned to the underground aquifers. The consumptive use exceeds available recharge by about 120,000 acre-feet annually (36, p. 80).

Extensive pumping of water for both irrigation and municipal purposes in the Roswell area has reduced the pressure of the fresh water in the upper aquifers, allowing the intrusion of salt water into the fresh water. Thus a deterioration of the quality of the ground water has occurred. Water in some areas of the basin contains in excess of 35,000 parts per million (ppm) of dissolved solids. Fresh water is considered to have less than 1,000 ppm; saline water from 1,000 to 35,000 ppm; and brine waters more than 35,000 ppm (20, p. 63).

Some of the more pressing questions in the management of the basin's water resource include the following: 1) How may land and water quality and/or quantity be optimally combined? 2) Will a policy change be necessary, and if so, how should it be administered? 3) What should be the priorities of remedial means to withdrawals of ground water from the basin?

Production on the irrigated cropland in the basin is greatly influenced by soil type and water quality and/or quantity. Different combinations of these characteristics in farming areas within the basin directly influence the income that may be expected. If income from crop production is to be sustained over time, adjustments must be made to overcome the present rate of depletion of the water resource.

The specific objective of this study was to develop an economic classification of the irrigated cropland in the basin. The classification was based on the relationship between the independent variables—soil and water quality and/or quantity—and the dependent variables—crop yields and farm income—in the different farming areas of the basin. The classification should be useful in making policy decisions concerning adjustments to maximize economic returns to the basin over time. Knowing the geographic location of combinations of the above mentioned variables may prove useful to those interested in engaging in agricultural production in the basin, or in deciding whether to expand existing operations in certain areas, and to provide information for developmental committees, county extension agents, vocational agriculture instructors, Soil Conservation Service and United States Geological Survey personnel, and the New Mexico State Engineer.

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Definition of Terms

To avoid frequent lengthy descriptions, certain terms are used throughout this report. Reference to the following nontechnical working definitions may facilitate a better understanding of the discussion.

Irrigated cropland: Land on which water is artificially applied for the production of agricultural products and/or on which the owner has the physical facilities and legal right to engage in such practices.

Water-right acreage: As used in this report, irrigated cropland on which the owner has the legal right to apply irrigation water as defined by adjudication, and unadjudicated cropland that has been farmed in the preceding five years.

Cultivated land: Irrigated cropland to which cultural practices were actively applied during the preceding two years including the year in which this study was conducted. (Includes cropped, fallow, and diverted.)

Cropped acreage: Irrigated cropland on which crops were growing at the time the field survey was conducted.

Out of production: Irrigated cropland not actively farmed for two consecutive years or on which water rights had been removed.

Unreported: Cropland not observed during the field survey or unreported due to planimeter error.

Water quality: Suitability of water for crop production as indicated by parts per million of chlorides in the water.

Water quantity: The extent of decline in ground-water level or amount of surface irrigation water available.

Limitation: A deficiency existing in one or more of the variables (soil and water quality and/or quantity and economic indicators) which may be expected to restrict crop yields and farm income from the maximum level.

Procedure

The procedure for the study was based on the Cornell system of economic land classification (6). Generally, the Cornell system consists of a grouping of individual farm units on the basis of information concerning the physical description of soil, climate, topography, type of farm, size of farm, and results of farm-management studies. The grouping of individual units is then reflected as a categorical classification of income expectancies. Geographically localized differences in income expectancies are portrayed on a map, using a different color for each class.

In this study a descriptive analysis was used to make an economic classification of the irrigated cropland in the Pecos River Basin of New Mexico. The purpose of the analysis was to relate the independent variables—soil and water quality and water quantity—to the dependent variables—crop yields and expected farm income—in the different areas of the basin.

Data Collection and Assembly

A ground reconnaissance was made of the basin at the outset of the study (August 1966), which included observations of condition of growing crops, farm improvements, cultural practices, size of farms, and other economic indicators. Contacts were made in different areas of the basin to obtain data pertaining to the above-mentioned economic indicators as well as soil and water quality and quantity. Data were obtained from Agricultural Stabilization Conservation (ASC), Soil Conservation Service (SCS), U. S. Geological Survey (USGS), State Engineer Office (SEO), New Mexico Extension Service (county agents), and the New Mexico Agricultural Experiment Station, Southeastern Branch, at Artesia. The reconnaissance also served to acquaint the above agencies with the purposes of the study and to facilitate stronger communications for further work.

Soil Data

A base map was drawn showing the location of the irrigated cropland acreage in the basin, using a scale of one inch to two miles. Soils with the same characteristics were designated on the map by means of SCS soil survey symbols. A further designation was made according to the SCS capability classification for each of the different soils. It was considered desirable for purposes of this study to group the soils in such a way as to reflect differences in productivity, managerial requirements, and responsiveness to intensive cultural practices. After consultation with SCS personnel and county agents, and interviewing farmers in the basin, the soils were assigned to one of three groups depending on the degree of limitation of the above characteristics. A productivity index was used to reflect 100-percent expected yields of eight major crops produced on these different soils. Group I soils were considered to be those with only slight, if any, limitations; Group II, those with moderate limitations; and Group III, those with severe limitations. Such a grouping was considered to reflect the long-run economic potential of different soils in the basin. This grouping was then represented on a three-color map with the darkest color indicating Group I soils, the medium color Group II, and the lightest color Group III. A detailed description of the soils is given in the Appendix.

Water Data

Technical reports and maps from SEO and USGS were used to provide basic data concerning irrigation water source, use, quality, legal requirements, and irrigated acreage (1, 3, 4, 22, 24, 28, 30, 32).

State Engineer and USGS maps were used to determine the source of irrigation water and define the boundaries of different land areas according to source of water. These maps also showed the location of points of diversion in the basin. Source of irrigation water was considered to be important to the economic classification both from the standpoint of cost of diversion and dependability of the source.

Data pertaining to water diversion were obtained from SEO pumping records for the Roswell Artesian Basin for 1967 (22) and from estimates of USGS, SCS, county agents, and farmers for other pump areas. Surface water diversion records were obtained from the watermaster at Roswell, Carlsbad Irrigation District, and Ft. Sumner Irrigation District (1). These data were in the form of maps and tables showing the location of the right, acre-feet diverted, and total water-right acres to which the irrigation water was applied.

Mower (28) made a study of the pumpage in the Roswell Artesian Basin in 1960. His report, which gave a breakdown of water diversion, crop acreages, and a description of the geology and legal aspects of irrigation water in the Roswell Artesian Basin, was used as a guide to part of the research in this study.

Quality of irrigation water is as important as quantity to farmers in most of the Roswell Artesian and Carlsbad Basins, and is becoming more important in the Ft. Sumner Basin. When water of inferior quality is used for irrigation, crop selection is restricted either to salt-tolerant crops such as cotton and barley or moderately salt-sensitive crops such as alfalfa and most vegetables, with frequent heavy irrigations (8, p. 98). In either case certain inefficiencies may exist which directly affect income expectancies under such circumstances.

There are several ways to determine the quality of irrigation water. Among these are 1) measuring the degree of acidity or alkalinity (pH) of the waters, 2) weighing the salt content of a specific amount of water (total dissolved solids), 3) determining electrical conductivity of a unit quantity of water, 4) calculating the percentage of sodium of the cations present, 5) determining residual sodium carbonate, and 6) calculating the sodium adsorption ratio (9, p. 7). Another measure of water quality is that indicated by parts per million of chlorides in irrigation water.

In addition to its effect on the salinity of the soil solution, the chloride ion has a directly toxic effect on some crops common to the basin. Results of a water quality study conducted in New Mexico by Dregne and Maker (9) indicated that, next to sulfate, which has no special harmful effects on soils or plants, chloride is the most common ion in well waters. The chloride exceeds the sulfate ion in total concentration in many of the waters used for irrigation in the Roswell Artesian Basin.

Irrigation water quality data used in this study were obtained from various USGS and SEO maps and reports. Most of these data were in terms of parts per million (ppm) of chlorides and a limited amount of data were in terms of ppm of total dissolved solids; therefore, it was considered desirable to use ppm chlorides to indicate differences in water quality in the Roswell Artesian and Carlsbad Basins.

After checking crop yield data and interviewing farmers throughout the basin, especially in those areas with poor water quality, the following classification scheme was considered to be reliable for purposes of this study. On the basis of ppm chloride, irrigation water was categorized into one of three classes. Class I water (0-1,000 ppm chloride) was considered suitable for most crops under most conditions. Class II water (1,000-2,000 ppm chloride) was considered satisfactory for most crops if proper management practices were used. Class III water (above 2,000 ppm chloride) was considered suitable as a supplemental source of water if the primary source was of better quality. Otherwise, the use of Class III water for irrigation severely restricts crop selection and yields and thereby income expectancies (table 1).

Table 1. Quality classes for irrigation waters in the Pecos River Basin, New Mexico.

Class	Chloride Content
	(ppm)
I	0–1,000
II	1,000–2,000
III	above 2,000

Using data from the USGS and SEO, maps were constructed to show geographically localized differences in water quality in the basin, by means of isochlor lines beginning with 500 ppm and increasing by units of 500 up to 3,500 ppm.

Quantity of water was used primarily to refer to changes in the ground-water level in the basin and availability of an adequate supply of surface water for crop production. Changes in ground-water levels were determined from USGS and SEO reports. These data are computed by periodic measurements of observation wells located throughout the basin. Annual measurements of water levels in these wells are made in winter, usually several months after the peak of the irrigation season, which allows wells to recover from the local effects of sustained large-scale withdrawals from the ground-water reservoir (4, p. 3). This may not be a "true" measure of the quantity of water available in an area but, according to Busch and Hudson (4, p. 3), ". . . water levels serve as a good index of the amount of ground water in storage, after the summer's pumping has ceased." Further results of the study by Busch and Hudson indicate that water levels declined as much as 53 feet in the Roswell Basin during 1961-1965 (4, p. 1).

According to Jackson (26, p. 7), "... the availability of water and cost of getting it to the land are key determinants of success or failure of farming enterprises in the area.... Lowering of the water level has made it necessary for many farmers to lower their pump settings, and in many cases, to install larger power units on their wells." Jackson lists the variable flow of the Pecos River and the declining water level as two of the main uncertainties that are of concern to farmers in the basin (26, p. 9).

Spiegel (37, p. 23) lists water-level decline in the San Andres formation as one of the causes of lateral intrusion of saline water into fresh-water areas.

Water-level decline, for purposes of this study, was considered to be an indicator of the long-run economic potential of an area with regard to reliability of the source of irrigation water as well as the effect it might have upon the quality of the source. Using water-level decline as a basis for reference, a water quantity classification was devised to reflect the degree of limitation posed by this variable.

Data on the amount of surface irrigation water available for irrigation for the 10 years preceding the study were obtained from the Ft. Sumner and Carlsbad Irrigation District Offices. Information on the availability of surface irrigation water in the Upper Pecos River Basin was obtained by interviews with personnel of SCS, SEO, county extension offices, and farmers. A reliable source and adequate amount of surface water for agricultural crop production were considered to be indicators of the long-run economic potential of an area.

The classification reported in table 2 is based on three water quantity classifications. Class I indicates only minor limitations regarding income expectancies as they are reflected by not receiving maximum economic yields from surface water and by increased pumping costs due to increased depth of lift with pumped water. Class II indicates the possible necessity of leaving parts of farms fallow or suffering reduced yields with surface water, and the possible need to lower pumps, and in some areas, thereby increasing the likelihood of encroachment of saline water into ground-water aquifers. Class III reflects the probability of both leaving parts of farms fallow and experiencing reduced yields with surface water, and the necessity of lowering pumps, installing larger power units, or greatly enhancing the potential encroachment of saline waters into the ground-water aquifers.

Source of irrigation water and changes in ground-water levels in the basin for 1961-1966 were described on maps according to the source from which ground water was diverted. These maps were derived from interpretations of basic data obtained from the USGS and SEO.

Other Data

Historical data regarding cropping patterns, crop acreages, yields, farm size, and farm yields were obtained from ASC, agricultural extension service, New Mexico Crop Reporting Service, and agricultural experiment station records. This information was used to update and, in some cases, supplement previous farm management studies made in the different areas of the basin. Climatic data such as rainfall, temperature, and length of growing season were assembled from weather bureau publications (39) for the six reporting stations in the basin—Las Vegas, Santa Rosa, Fort Sumner, Roswell, Artesia, and Carlsbad.

A recent study conducted in the Roswell Artesian Basin by Garnett and Lansford (10) was used to determine differences in net returns to land and management per acre resulting from the interaction of soil and water quality and the rate of irrigation water application. This study involved the compilation of budgets for five different crops using eight different levels of water quality on the three different soil productivity groups with varying rates of irrigation water application for each crop. Net returns to land and management for cotton ranged from a high of $285.72 per acre on land with no limitations to a negative $56.22 per acre on land with severe limitations. Relatively high net returns resulted from the production of alfalfa hay on land with only slight, if any, limitations but declined rapidly with increased salinity levels and decreased irrigation water application. Cotton and barley yields were less severely affected by changes in water quality than were any of the other three crops (alfalfa, grain sorghum, and forages) considered in the study. These budgets were also applied to the Carlsbad Basin.

Enterprise budgets were constructed for the more important crops in the Fort Sumner and Upper Pecos River Basins. No attempt was made to determine the effects on yield of different levels of irrigation water applications, on the assumption that yield responses would be similar to those in the Roswell Artesian Basin.

Farm size was considered to be one of the more important variables. Results of farm management studies conducted in the Roswell Artesian and Carlsbad Basins indicate that, as farm size increases from 20 to 40 acres, net income increases six-fold; from 40 to 80 acres, net income doubles; from 80 to 160 acres, an increase of 3.5 times results; from 160 to 320 acres the increase is 1.8 times and from 320 to 640 acres the increase is proportional, or approximately twofold (26, pp. 183-184).

Table 2. Quantity classes for irrigation waters in the Pecos River Basin, New Mexico.

Class	Surface Irrigation Available per Year	Water Level Decline 1961-1966
	(acre-feet per acre)	(feet)
I	3 or more	less than 20
II	2 to 3	20 to 30
III	less than 2	greater than 30

Scott (33) used size of business, labor efficiency, and combinations of enterprises as indicators of farm returns in conducting an economic land classification study in Livingston County, New York. A similar study was made by Nolan (31), in an effort to classify farms on the basis of economic productivity and to determine the full significance of differences in economic productivity among land classes.

An economic indicator check-list was compiled for use during the field reconnaissance, to indicate differences in factors such as repair of farmstead, repair of equipment, type of irrigation system, and condition of growing crops within areas of the basin.

Relationship of Independent Variables

The different water maps and the soil map were superimposed, to determine the relationship among the independent variables for each area and thereby for the basin as a whole. The soil-productivity map and the water-quality map were combined to show the relationship of these two variables. The irrigation-water-source map was combined with the change in ground-water levels in the shallow aquifer and the artesian aquifer to show the relationship of source to water level. The combined effect of these maps superimposed one on the other was then used to delineate those areas in the basin with either slight, moderate, or severe limitations of the independent variables, soil and water.

Land areas were designated as being in Economic Class I, II, or III for the preliminary classification on the basis of the criteria reported in table 3. These criteria represent an "ideal" classification. Where the particular combinations of these variables did not result in an ideal designation, a plus or minus was used to locate areas requiring special consideration regarding the final classification. The above procedure was used to construct a preliminary economic land-classification map prior to the field survey.

Field Survey

All previously gathered data were used in making the field survey, which was conducted during the summers of 1966 and 1967. The Upper Pecos River and Fort Sumner Basins were surveyed in 1966 and the Roswell Artesian and Carlsbad Basins in 1967. The latter survey was conducted from two approaches, aerial reconnaissance and ground survey, and the upper Pecos River and Fort Sumner Basins were surveyed only from the ground.

In the aerial reconnaissance, two flights were made over the basin, the first flight immediately preceding the ground survey. During the flight different farms and areas were located by means of ASC aerial photos. Points were numbered on the photos and notes were made with reference to these numbers, describing the buildings, fields, crops, livestock, and evidence of problems concerning soil and water quality. A 35mm camera was used to photograph representative portions of each area, as well as any portions appearing to have unusual problems concerning soil and water. Such areas were noted for special consideration during the ground survey.

A crew, traveling in a stationwagon equipped with a map cabinet, file case, and tape recorder, made the field examination by driving each area in the basin in not more than one-mile intervals. One man followed the route on aerial photos[2] and designated which crops were being grown on every field in each area. Points were numbered on the airphotos and all notes were referenced accordingly to permit an interwoven record. The driver made verbal notes on the tape recorder describing the fields, crops, buildings, irrigation systems, implement size and age, and management practices, and any other pertinent characteristics of the farms. The third man was responsible for recording observations as to the economic indicators on the check list. The 35mm camera was used to record differences in the economic indicators on colored slides.

[2]ASCS aerial photos for 1964. Scale: 8 inches equal 1 mile in the Roswell Artesian and Carlsbad Basins; 4 inches equal 1 mile in the Upper Pecos River and Fort Sumner Basins.

Table 3. Criteria for determining land classification designation, Pecos River Basin, New Mexico.

Soil Productivity		Water Quality		Water Quantity			Preliminary
Group	Class	Measure	Class	Surface	Ground	Class	Classification
		(ppm chloride)		(acre-feet/acre)	(decline in feet)		
I	1	less than 1,000	1	3 or more acre-feet per acre	less than 20	1	I
II	2	1,000 to 2,000	2	2 to 3 acre-feet per acre	20 to 30	2	II
III	3	greater than 2,000	3	less than 2 acre-feet per acre	greater than 30	3	III

Following the ground survey, a second aerial reconnaissance was made, using the same procedure described for the first flight, to check small isolated areas not easily accessible to the ground reconnaissance, and to note any apparent changes in areas since the first flight. The Upper Pecos River Basin was not flown, however, and only two men conducted the survey. Also in the Upper Pecos River Basin 35 mm slides were not made.

Data Tabulation

Data used to make the preliminary classification, as well as those resulting from the field survey, were coded and placed on punch cards for computer analysis. A computer program was written to group farm areas according to the degree of limitation of the independent variables and the economic indicators. The farm areas were identified by the numbered points on the aerial photographs. Results of this analysis were compared with budget information regarding effects of water application and soil and water quality on farm income and costs and returns by farm size for the basin, to determine the categorical classification of the irrigated cropland in the basin. The preliminary economic classification map was revised to reflect any changes that might have resulted from these tabulations.

Rechecking

It was not uncommon for certain land areas in the basin to appear as marginal to one category or another. When possible the colored slides made during the field survey were used to verify decisions regarding the category into which such lands should be placed. In other cases it was necessary to make field rechecks of such areas. This was a general reexamination and usually included areas widely separated in the basin. County agents, farmers, and SCS, ASC, and SEO personnel were contacted in order to further verify decisions made regarding each of the areas in question.

The Economic Land-Classification Map

The final economic land-classification map was prepared on the basis of tabulations resulting from the combination of all above-described procedures. The basis for this map was determined primarily by the combinations of the independent variables, soil and water quality and/or quantity, modified by the economic indicators and budget information relevant to the area. The final map was prepared in three colors. Areas with only slight limitations were colored black, areas with moderate limitations were colored medium gray, and areas with severe limitations were colored light gray.

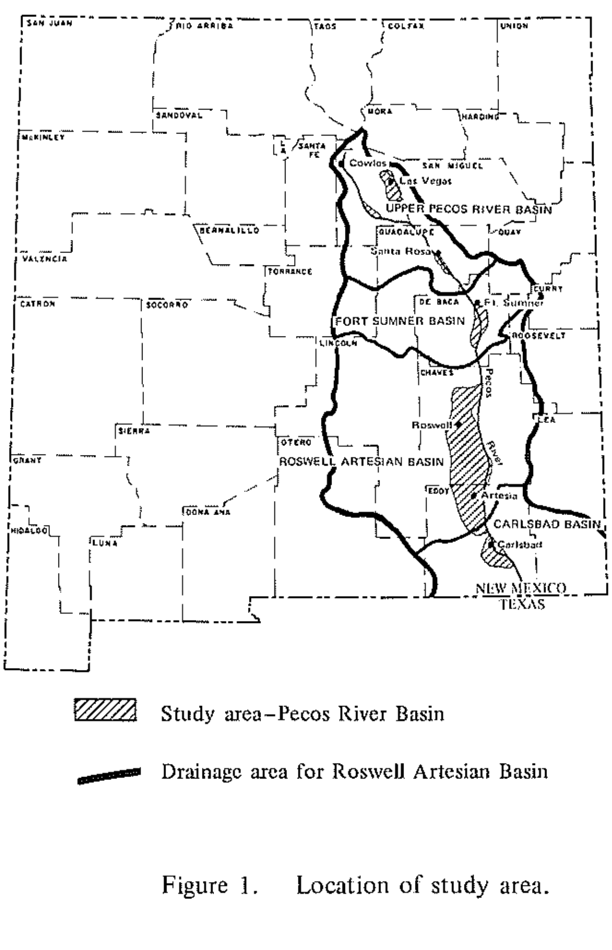
Chapter 2

GENERAL DESCRIPTION OF THE PECOS RIVER BASIN OF NEW MEXICO

The Pecos River Basin is located along the Pecos River in eastern New Mexico, extending from near Cowles in San Miguel County to the New Mexico-Texas state line below Carlsbad in Eddy County (figure 1). The Pecos Basin is bounded on the east by the Caprock escarpment, formed by erosion, which rises several hundred feet above the valley terrain. This west-facing wall runs northward along the eastern border of Chaves and Roosevelt Counties, then turns northeastward through Guadalupe County and merges with the foothills of the Sangre de Cristo Mountains in San Miguel County. On the west, the Pecos Basin is bounded by a north-south series of mountain ranges composed of the Jicarillas, Capitans, Sierra Blancas, Sacramentos, and Guadalupes (25, p. 29).

The Pecos River flows approximately 500 miles through the state in a southeasterly direction, passing the six major population centers of Las Vegas, Santa Rosa, Fort Sumner, Roswell, Artesia, and Carlsbad. The Pecos River Basin is comprised of approximately 26,000 square miles, roughly a fifth of the state's total area (4, p. 29). It includes most of Guadalupe, De Baca, Lincoln, Chaves, and Eddy Counties and parts of San Miguel, Santa Fe, Torrance, Mora, Quay, Curry, Roosevelt, Otero, and Lea Counties (figure 1). The principal irrigated cropland areas, however, are located in a narrow belt along the Pecos River, varying from less than one to 20 miles in width. These areas are located in San Miguel, Guadalupe, De Baca, Chaves, and Eddy Counties. Almost 90 percent of the 430 square miles of irrigated cropland is located in Chaves and Eddy Counties.

In order to establish a more consistent basis for reference, the Pecos River Basin was divided into four sub-basins: the Upper Pecos River Basin, the Fort Sumner Basin, the Roswell Artesian Basin, and the Carlsbad Basin (figure 1).



Study area–Pecos River Basin

Drainage area for Roswell Artesian Basin

Figure 1. Location of study area.

Topography and Climate

The Pecos River originates in the Sangre de Cristo Mountains on the South Truchas Peak, which is the second highest point in New Mexico with an elevation of 13,102 feet above mean sea level. The lowest elevation in New Mexico, 2,840 feet, is at the point where the Pecos River leaves the state. The river drops rapidly in its headwaters, and then gradually through the widening, north-to-south-sloping valley (25, p. 29). The basin drains into the Pecos River which flows along the eastern edge. Numerous tributaries flow into the river from the west, and only a few from the east.

The climate of the Pecos River Basin is predominantly semiarid, characterized by rapid temperature changes, marked temperature extremes, and wide daily and annual temperature ranges. Small portions have mountain climate, making them cooler throughout the year than the adjacent lowlands. Temperatures are generally mild, increasing in an irregular pattern from north to south in response to latitudinal and elevation changes. Winters are usually mild and dry in the southern portion of the basin, but heavy snows and extremely cold temperatures have been experienced throughout the basin.

Because of the high plateaus or mesas, mountain ranges, canyons, and valleys, there are great variations in climate over short distances. Precipitation generally increases with elevation. Although much of the Pecos River Basin receives an average annual precipitation of about 12 inches, it increases to about 24 inches in the higher elevations and may be as low as four inches in the southern elevations (39). The gradual upward slope of the basin from southeast to northwest plays a very important role in the weather and climate of the area. The tropical maritime air entering the basin from the southeast to south and the orographic lifting of this air as it flows upward over the valley floor toward the mountains to the north and west produces the frequent showers and thunderstorms of the rainy season (25, p. 31). Occasionally these thundershowers occurring from May to September are accompanied by high winds and hail and may cause flooding and severe damage to crops and property. Due to high temperatures and low relative humidity, rainfall is quickly evaporated and transpired.

The growing season usually begins in early April in the southern portion of the basin, and lasts about 200 days until late October. In the northern areas of the basin the growing season does not begin until late May or early June and lasts about 130 days until early October (39).

Soils

The soils in the basin consist primarily of alluvial deposits originating from limestone, gypsum, and sandstone. Most of the soils have been developed on smooth alluvial fans, are comparatively deep and friable, and are adapted to a wide variety of crops. The principal soil types vary in texture from clay loam to a fine sandy loam. Poor natural drainage in some sections results in a high degree of salinity. Soils in the basin are usually deficient in organic matter, available nitrogen, and phosphorus. Further discussion of soils is presented in the sections dealing with individual sub-basins and in the Appendix.

Water Resources

The Pecos River Basin of New Mexico has two basic sources of diversion of irrigation water—surface and ground. Surface water has been in use since 1540 in the Upper Pecos River Basin, since 1863 in the Fort Sumner Basin, the early 1870's in the Roswell Artesian Basin, and the 1880's in the Carlsbad Basin (29). The Pecos River is the major source of surface irrigation water for the Pecos River Basin with minor quantities coming from tributaries to the Pecos River, the more important being the Gallinas River in San Miguel County, Rio Hondo and Rio Felix in Chaves County, and Rio Penasco and Black River in Eddy County.

Surface water supplies about 99 percent of the irrigation water in the Upper Pecos River Basin. Most of this water is diverted from the Pecos River with small amounts diverted from the Gallinas River and Tecolote and Cow Creeks. There are 21 irrigation systems in the Upper Pecos River Basin. The water is diverted from the river or stream by a small diversion dam to irrigation ditches and is allotted to each farm operator on a share

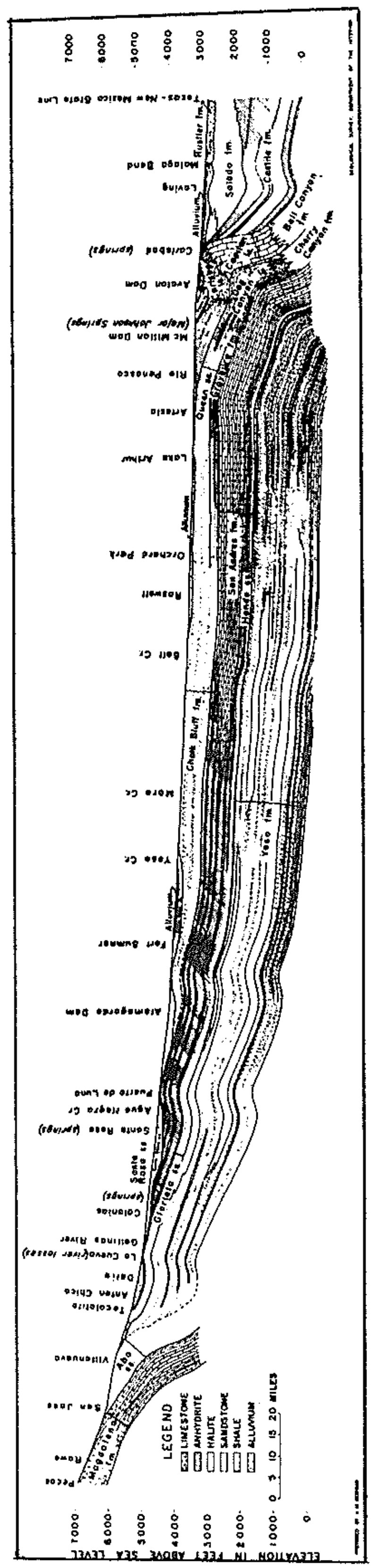


Figure 2. Geologic cross section along the Pecos River from Pecos, New Mexico, to the New Mexico-Texas line.

Source: National Resources Planning Board, Pecos River Joint Investigation (Report of the Participating Agencies), Washington, D. C., June 1942.

basis according to the number of irrigated acres owned.

Surface water supplies over 80 percent of the irrigation water in the Fort Sumner Basin. This water is diverted from the Pecos River and temporarily stored in the Alamogordo Reservoir. Irrigation water is released from Alamogordo Reservoir and is diverted from the Pecos River by the Fort Sumner Diversion Dam to a canal system more than 16 miles long.

The Hagerman Canal supplies a major portion of the surface water in the Roswell Artesian Basin. The canal, which has been in use since 1879 and has a decreed right of 9,026 acres, receives water from a combination of return flow from irrigation, and water from the Berrendo Creek, North Spring, Rio Hondo, and South Spring Creeks, as well as supplemental water from four artesian wells, five shallow wells, and several tile drainage systems.

Approximately 6,172 acres have surface irrigation water rights from the Pecos River, from which the water is diverted by means of pumps. Surface water accounts for about 6 percent of the total water diverted for irrigation purposes in the Roswell Artesian Basin.

Surface water supplies over 80 percent of irrigation water in the Carlsbad Basin and is diverted from the Pecos and Black Rivers. Alamogordo Reservoir north of Fort Sumner was constructed as a storage reservoir by the Carlsbad Irrigation District in 1937. This impounded water is channeled through the Pecos River to McMillan Reservoir as needed for irrigation, the distribution being controlled by Avalon Dam, which is at the head of the main canal. Some surface water is diverted directly from the Pecos and Black Rivers below Carlsbad.

The geology of the underground water supplies is described by Mower as follows (32, p. 117): The Yeso, Glorieta, San Andres, and Chalk Bluff formations of the Permian age, and the alluvial deposits (valley fill) of the Quaternary age constitute the major geologic formations in the hydrologic regime of the basin. The Glorieta sandstone overlies the Yeso and underlies the San Andres and ranges from 15 to 90 feet thick. The Yeso formation is as deep as 2,100 feet and yields only small quantities of water which are probably highly saline. The San Andres formation overlies the Glorieta sandstone and ranges in thickness from 1,000 to 1,200 feet. The depth to the top of the San Andres ranges from the surface in San Miguel County to more than 1,200 feet near Lakewood in Eddy County. The Chalk Bluff formation overlies the San Andres and forms a relatively impermeable barrier between the San Andres and the alluvium except in the vicinity of Roswell and northward. There the valley fill lies directly on the San Andres formation. The alluvial deposits range in thickness from 0 to more than 350 feet with the thickest deposits occurring parallel to and approximately 4 miles west of the Pecos River near Roswell. The alluvium forms the storage reservoir for the shallow ground water in the basin (figure 2).

There is virtually no ground water in the Upper Pecos River Basin. The output from wells is low, normally amounting to less than 100 gallons of water per minute. In the Colonias area about 80 acres were being irrigated with ground water. When interviewed, the farmer of this 80-acre tract indicated that pumpage was actually from the Pecos River and not from a ground-water aquifer. An additional 160 acres were irrigated with ground water in the upland portion of southwestern San Miguel County.

Ground-water pumpage in the Fort Sumner Basin accounts for a little more than one-third of total irrigation water diverted and is the northernmost extensive usage of ground water for irrigation along the Pecos River. In this area, ground water is pumped from alluvium and used to irrigate fields along the alluvial plain of the Pecos River. Maddox (27, p. 41) estimated the potential yield of these wells to range from 100 to 300 gpm. Water levels in the alluvium reflect the elevation of the surface water in the Pecos River and indicate a ground-water gradient roughly parallel to the gradient of the river (27, p. 41). Wells in this area are finished at depths of less than 200 feet.

Ground water pumped from wells supplies all municipal and industrial requirements and about 95 percent of the irrigation requirement in the Roswell Artesian Basin. The principal water-yielding formations are the San Andres limestone (artesian aquifer), which is the deeper formation, and the Quaternary alluvium (shallow aquifer or valley fill). However, aquifers in the lower part of the Chalk Bluff formation in the southern part of the basin yield sufficient quantities of water for irrigation.

The use of artesian water for irrigation was begun about 1900 and expanded rapidly until 1916. During this time artesian head pressure declined to the point where pumps had to be installed in order to continue irrigation. Overexpansion of the artesian water for irrigation in the Roswell area finally resulted in enactment of a state law to control and regulate the use of underground water (35).

About 60 percent of the ground water used for irrigation is diverted from the artesian aquifer in the Roswell Artesian Basin (22). The water is confined under pressures where the full section of the San Andres is saturated and dips beneath overlying confining beds of the Chalk Bluff formation. Water in the lower part of the artesian aquifer south of Artesia is saline because of poor circulation. A section of the artesian aquifer east and northeast of Roswell is saturated with saline water (28, p. 28).

Wells finished in the artesian aquifer range from 300 to 1,200 feet deep. The average depth in the Roswell-East Grand Plains Area is about 600 feet while wells in the Dexter-Hagerman area are about 1,000 feet deep. Wells in the Artesia area are deeper and have a lower supply of water and a higher seasonal drawdown than those in areas to the north. The depth of artesian wells in this area is about 1,050 feet (26, pp. 28-29). The pumping lifts range from 100 to 150 feet (30).

About 40 percent of the ground water used for irrigation in the basin is pumped from the alluvium or shallow aquifer. Hood, *et al.* (24, p. 22) described the recharge into the aquifer as coming from five sources: 1) interformational leakage from the San

Andres through the Chalk Bluff, 2) streamflow across the alluvium, 3) percolation losses from irrigated fields, 4) direct precipitation upon the alluvium, and 5) leakage from faulty artesian wells. The latter two are considered to be minor sources of recharge. In areas of concentrated pumping and low permeability of the aquifer, water level decline may be severe. A cone of depression forms in the water table around a discharging well. Grouping of wells causes these cones to intersect to form one large cone, and continuous water level decline exists (28, p. 84). In certain areas of the basin such a continuation of decline has resulted in the abandonment of fairly large acreages of farm land due to the approaching exhaustion of economically recoverable water for irrigation.

Wells drilled in the shallow aquifer range in depth from 100 to 300 feet and yield an average of about 1,000 gpm (27, p. 43). The yield may be as low as 100 gpm in areas of severe water-table decline.

Ground-water pumpage in the Carlsbad Basin accounts for less than 20 percent of the total diversion for irrigation. Ground water in this area is similar to ground water in the Roswell Artesian Basin, in that irrigation water is pumped from two aquifers, limestone and alluvium. The yield from the limestone varies from 2,000 gpm north of Carlsbad to 200 gpm near the state line. The primary recharge for the limestone aquifer is from water moving from the southwest through solution openings in the Capitan Limestone. The alluvium or shallow aquifer extends southward from the City of Carlsbad to about halfway to the state line. Water in this aquifer originates as precipitation on the alluvium and return flow from irrigation. Ground-water gradients in this aquifer reflect the elevation of surface water in the Pecos River (27).

Farming Operations

Farm units in the Upper Pecos River Basin are mainly small subsistance operations, with most of the crop production being used by the operator for livestock feed or home consumption. The major crops are alfalfa, grain, pasture, and horticultural crops.

In the Fort Sumner Basin two types of farming operations exist. The surface-irrigated portion of the basin contains small owner-operated units, most of them smaller than 40 acres and producing mainly alfalfa, small grains, cotton, pasture, and apples. The farming operations using ground water for irrigation range in size from 80 to over 700 acres, averaging about 400 acres. The major crops are small grains, sorghums and other forages.

In the Roswell Artesian Basin about half of the farms are sufficiently large to be classified as commercial farming units. The average-sized farm in the basin is approximately 130 acres of cultivated land. The major crops produced in the Roswell Artesian Basin are alfalfa and cotton with minor amounts of small grains and forage crops.

In the Carlsbad Basin the average farm size is slightly less than 100 acres of cultivated land. The primary crops produced are cotton, alfalfa, and irrigated pasture.

Chapter 3

UPPER PECOS RIVER BASIN

The Upper Pecos River Basin is located in northeastern New Mexico and includes parts of Santa Fe, Mora, San Miguel, and Guadalupe Counties. The entire irrigated cropland acreage in the area lies in San Miguel and Guadalupe Counties, with about two-thirds of it in San Miguel and one-third in Guadalupe County. This is one of the oldest irrigated areas in New Mexico, dating to at least 1540 when Coronado observed Pueblo Indians irrigating crops in the vicinity of Pecos, New Mexico, in the northern extremes of the area (35, p. 69). Spanish settlers moved into the region during the late 1700's, settling along the Pecos River as far south as Anton Chico, and gradually inhabited all of the area by the mid-1800's. Today the majority of the population are Spanish-Americans, descendants of early settlers who moved north from Mexico. The area below Anton Chico was not settled until the years of the American Civil War. The first irrigation ditches and diversion structures were maintained by the farmers using them. In 1902 Congress passed the Federal Reclamation Act to assist irrigation development in the western states. Most of the cropland irrigated by surface water was developed between 1890 and 1930, during which time the Storrie Project near Las Vegas was formed (29).

Two major population centers, Las Vegas and Santa Rosa, county seats of San Miguel and Guadalupe Counties respectively, serve as the major trade centers for the area. There are several small villages located intermittently along the Pecos and Gallinas Rivers. The principal transportation arteries are Interstate 25, U. S. 84, U. S. 85, and a number of state highways, for San Miguel County (figure 3). The other secondary roads are either unimproved, or maintained by the county or privately. In Guadalupe County, Interstate 40, U. S. 84, U. S. 66, and U. S. 54 are the principal arteries, with a number of state and county roads.

Agriculture is the dominant industry in the area, with the sale of livestock being the predominant source of income (23, p. 36).

The climate in the Upper Pecos River Basin is characterized by a relatively short growing season, varying from 132 days at Las Vegas to about 181 days at Santa Rosa. Annual precipitation varies from about 13.9 inches at Santa Rosa to 13.6 inches at Las Vegas with larger amounts not uncommon in the higher elevations. Temperatures range from an average of 65.8°F in the summer to 31.4°F in the winter at Las Vegas, and from 76.3°F in the summer to 39.8°F in the winter at Santa Rosa (39). Brief hailstorms occurring from June through August may damage crops in small localized areas.

The terrain is rough and broken, limiting the acreage of irrigable cropland to the floodplain of the rivers and creeks. The elevation along the Pecos River declines rapidly from 13,102 feet north of Cowles to 4,300 feet above sea level in southern Guadalupe County. Countless creeks, arroyos, and draws feed into the Pecos River primarily from the east. The main tributaries are the Gallinas River, Tecolote and Cow Creeks in San Miguel County, and Alamogordo Creek in southern Guadalupe County. The drainage area of the Upper Pecos River Basin is approximately 4,390 square miles.

Soil Productivity and Water Quality

All of the soils in the area are Group II and Group III and are made up primarily of alluvial deposits originating from limestone, gypsum, and sandstone. They are moderately deep to deep, medium-textured soils with rolling topography, interspersed with areas of shallow and deep sandy soils. About 75 percent of the irrigated cropland is Group II soil (table 4), mainly of the Manzano and San Jose series typical of those described in the Appendix. The major limitations to productivity on these soils are moderate yields, slow permeability, and subjectivity to wind and water erosion. The Group III soils, primarily of the Pajarito series, account for about 10 percent of the irrigated cropland (figure 3). These soils' major limitations are depth and the possibility of occasional flooding. The shallow soils of this group restrict the selection of crops and reduce yields. Approximately 50 percent of the out-of-production cropland is Class II soil.

Table 4. Acreage of irrigated cropland by soil productivity groups, Upper Pecos River Basin, San Miguel and Guadalupe Counties, New Mexico, 1966.

Soil Productivity Group	Acres	Percentage
Group I	0	0.0
Group II	15,030	75.3
Group III	2,020	10.0
Unreported and out of production	2,920	14.6
Total	19,970	100.0

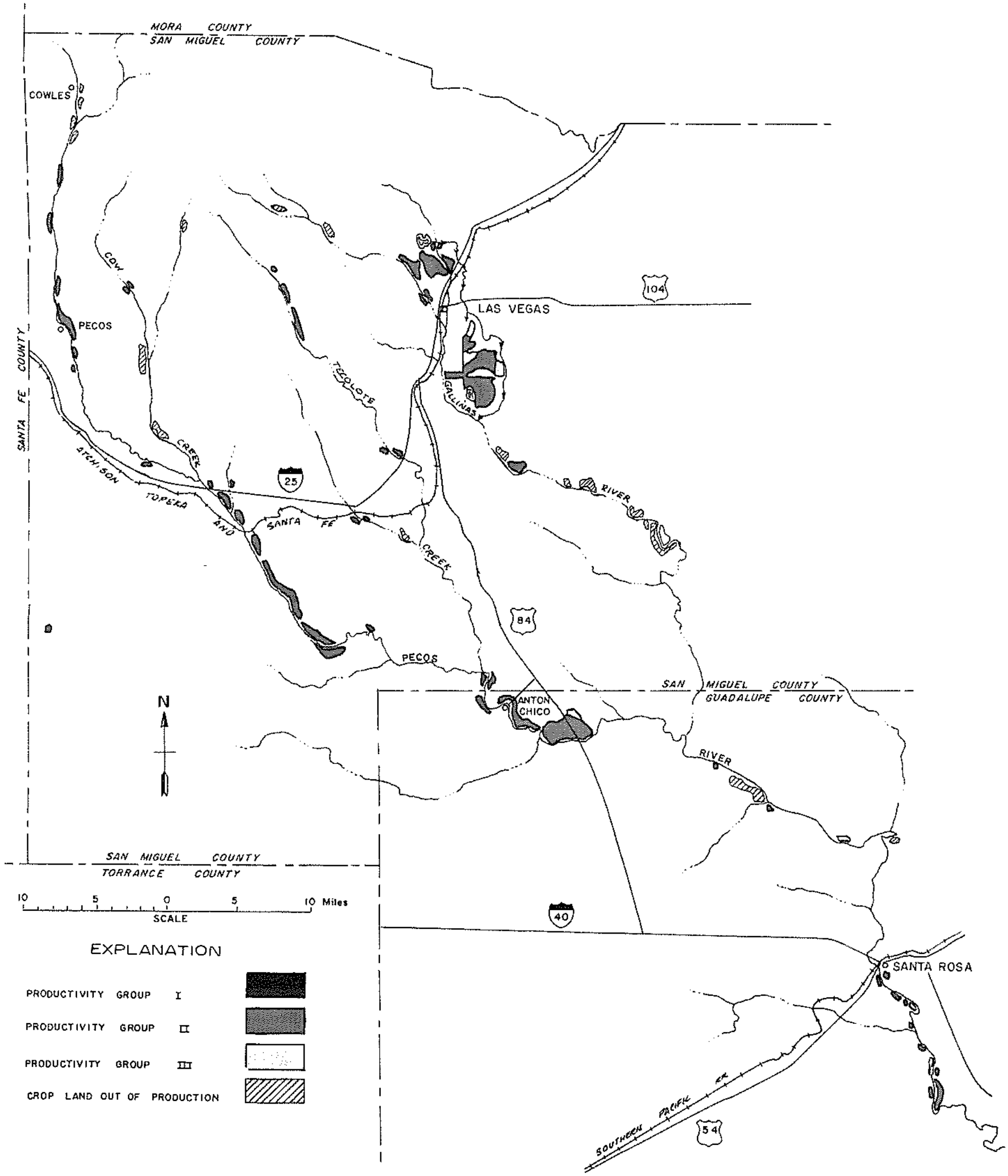


Figure 3. Soil productivity, Upper Pecos River Basin, New Mexico, 1966.

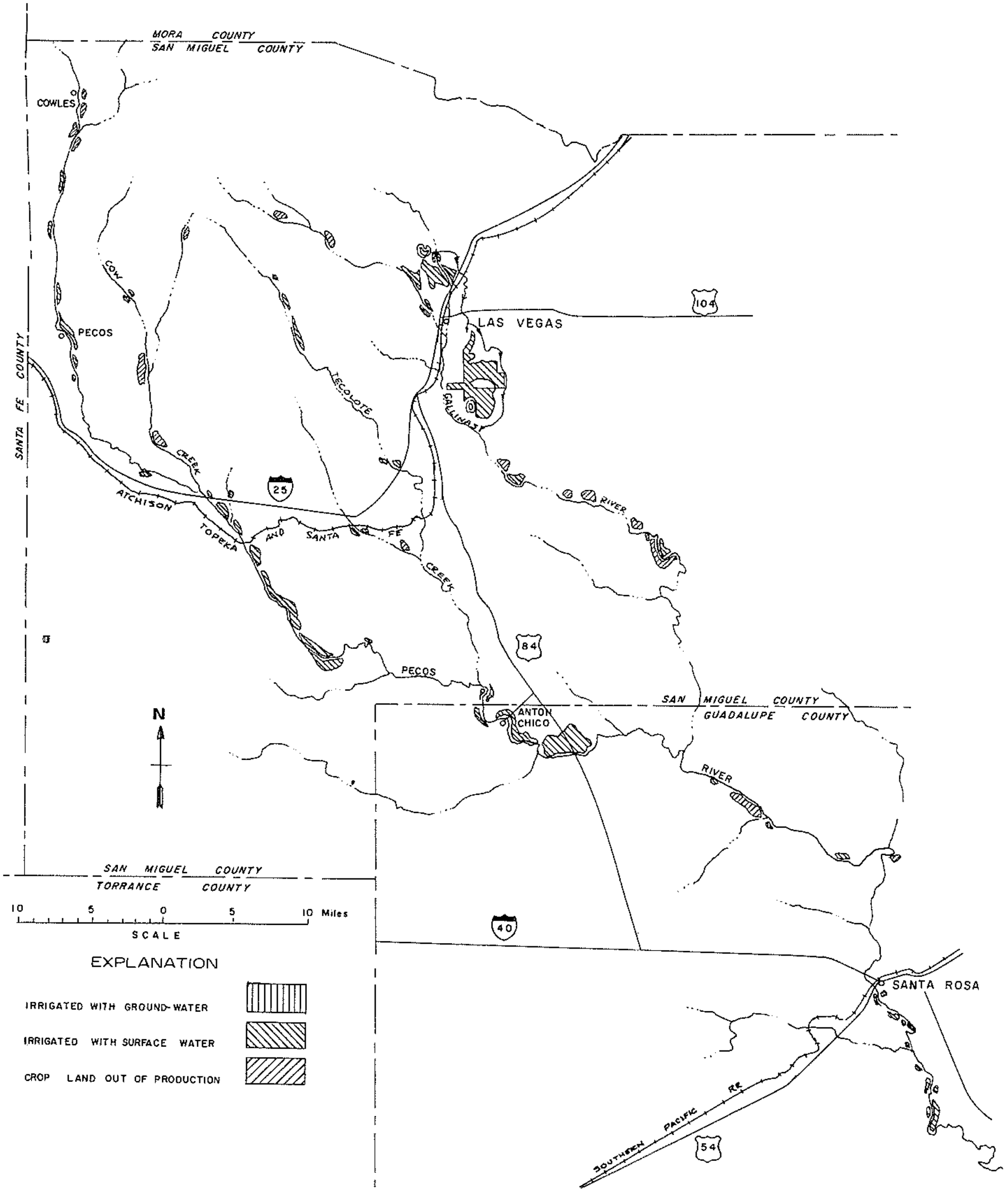


Figure 4. Source of irrigation water, Upper Pecos River Basin, New Mexico, 1966.

Source of Irrigation Water

Surface water is the primary source of irrigation water in the Upper Pecos River Basin (figure 4). This is fresh water that is discharged into the rivers and creeks primarily from precipitation in the area and from melting snow in the Sangre de Cristo mountains which percolates into the Magdalena aquifer. In the area north of Anton Chico nearly all of the base flow of the river and its tributaries comes from ground water that is discharged by the Magdalena Group. Owing to the availability of fresh surface water, plus the fact that wells in this area are low-yielding (less than 100 gallons per minute), ground water is not considered an important source of irrigation water although it is used on a minor amount of acreage (27, p. 36). The shallow depth and low salinity make it an attractive source for other needs. Below Anton Chico the water is similar to that in San Miguel County except that the aquifers are geologically younger rocks, and the older aquifers lie at increasing depths. The potential yield of wells in this area and the depth to ground water are similar to those in San Miguel County, even though, generally, different aquifers are involved.

The availability of surface water in the Upper Pecos River Basin was determined by interviews with Soil Conservation Service personnel, the State Engineer Office, and county extension agents. For the purposes of this study the presence of a reliable source of surface water was considered to be an indicator of the long-run economic potential of an area. The quantity of irrigation water in the Storrie Project was considered to be a severe limitation varying from less than 0.5 acre-foot to more than 3.0 acre-feet of irrigation water per acre per year. Interviews with farmers along the Pecos River in San Miguel County indicated that the Pecos River had been dry once in the last 80 years. However, in some years not enough irrigation water was available in the early summer months. This is also true of the tributaries of the Pecos River, as most of the irrigation water is direct runoff from precipitation and the melting snow in early summer, from mountain slopes at the higher elevations.

The Pecos River Adjudication of 1933 established water rights for the irrigation of a total of 25,346 acres on the Pecos River and its tributaries in San Miguel and Guadalupe Counties (29, p. 136), of which 12,000 acres were in the Storrie Project and were subject to proof of beneficial use and certification. The proven water-right acreage for the Storrie Project was 6,552.52 acres.

Excepting the Storrie Project, there are practically no storage facilities for irrigation water in the Upper Pecos River Basin, making the users dependent upon stream flow. The Storrie Project reservoir (capacity approximately 26,000 acre-feet) is situated a few miles north of Las Vegas on Sanguijuela Creek, a tributary of the Gallinas River. A canal diverting from the Gallinas River at the mouth of the canyon supplies part of the water impounded in Storrie Lake for irrigation of mesa land east of Las Vegas (29, p. 136).

Water is allocated on the basis of 1.5 acre-feet delivered to the farm per water-right acre. Prior to the time of this study, however, only estimates were available as to how much water was actually diverted. Farmers along the Pecos River receive water approximately every three weeks. Studies conducted in 1966 (12, 13, 17, 18, 19, 23) reported the estimated diversion to be about 4.0 acre-feet per cultivated acre. Irrigation water diversion for 1966 was estimated to be 4.0 acre-feet per water-right acre, 4.69 acre-feet per cultivated acre, and 5.28 acre-feet per cropped acre (table 5). State Engineer estimates prior to this time were approximately 2.0 acre-feet per irrigated acre in the southern portion of the basin (1).

Gauges were installed in two ditches in the Puerto de Luna area of the basin in 1967. Actual measurements in 1967 indicated the average to be 9.0 acre-feet per water-right acre on the Puerto de Luna East Ditch and 16.4 acre-feet per water-right acre on the Puerto de Luna West Ditch, indicating a much higher diversion than any previous estimates. Plans call for additional gauges to be installed on other ditches in the area. If future water use is administered according to actual rights, water quantity

Table 5. Irrigation water diversion by source, Upper Pecos River Basin, San Miguel and Guadalupe Counties, New Mexico, 1966.

Source	Water Diverted	Water-Right Acres		Cultivated Acres		Cropped Acres	
		Total	Per Acre	Total	Per Acre	Total	Per Acre
	(acre-feet)	(acres)	(acre-feet)	(acres)	(acre-feet)	(acres)	(acre-feet)
Surface	78,980	19,730	4.00	16,810	4.70	14,890	5.30
Ground	900	240	3.75	240	3.75	240	3.75
Total	79,880	19,730		17,050		15,130	
Weighted average			4.00		4.69		5.28

may become a severe limitation to crop production in this area. Henderson and Sorensen (21) estimated consumptive irrigation requirements to be about 1.0 acre-foot per cropped acre in San Miguel County and 1.53 acre-feet per cropped acre in northern Guadalupe County, and about 2.0 acre-feet per cropped acre in southern Guadalupe County.

Economic Indicators

Irrigated crop production has been practiced in the Upper Pecos Basin for many centuries but has not advanced a great deal relative to other areas of the United States. In fact the operations in most of the area are smaller in size than they were several generations ago, due to land divisions resulting from inheritance. The average farm size is about 11 acres, because there are a few fairly large farms of more than 100 acres, but a majority of the farms are less than 5 acres. About 90 percent of the farms in this area may be described as part-time or subsistence operations severely limited by lack of off-farm employment opportunities and restrictions to farm consolidation (23, p. 26). A few larger operations (average size less than 100 acres) are located in the southern part of the basin but these usually are part of large ranching operations and the crops are used for supplemental feeding of livestock.

The average farm size in the Storrie Project is larger than in other parts of San Miguel and northern Guadalupe Counties. During 1966 and 1967 about 35 percent of the total acreage in the Storrie Project was purchased by the Bureau of Sport Fisheries and Wildlife and the land was leased back to the original owner to be planted in a grain crop. One-fourth of the planted acreage must be left standing in the field for bird feed, and the remaining three-fourths could be harvested by the operator. The New Mexico Department of Game and Fish has been purchasing irrigation water rights in the Storrie Project for Lake McAllister, thus this area may be considered severely limited with respect to future irrigation development.

The generally small farm size throughout the Upper Pecos River Basin has resulted in the continued use of primitive farming methods to a large extent. The lack of adequate marketing facilities is also considered a severe limitation to expanded development of agriculture in the area, as is field size. The majority of the fields are divided into long narrow strips which restrict the use of modern machinery, and most of the fields have not been leveled and irrigation practices are limited by the natural slope of the land.

The major crop in the Upper Pecos River Basin is alfalfa, from the standpoint of total acreage as well as net return to land and management. A total of 6,364 acres of alfalfa was grown in the Upper Pecos River Basin in 1966, which is about 40 percent of the cultivated acreage of the area (table 6). The second most important crop in terms of acreage is irrigated pasture

Table 6. Acres of irrigated cropland by use and percentage of designated acreage in the Upper Pecos River Basin, San Miguel and Guadalupe Counties, New Mexico, 1966.

Land Use	Acres	Water-Right Acres (percent)	Cultivated Acres (percent)	Cropped Acres (percent)
Cotton	0	—	—	—
Alfalfa	6,364	31.9	37.3	42.1
Small grains	1,455	7.3	8.5	9.6
Grain sorghum	50	.3	.3	.3
Forage crops	1,545	7.7	9.1	10.2
Pasture	3,876	19.4	22.7	25.6
Pecans	0	—	—	—
Fruits and vegetables	1,840	9.2	10.8	12.2
Miscellaneous	0	—	—	—
Subtotal	15,130	75.8	88.7	100.00
Diverted and fallow	1,920	9.6	11.3	
Subtotal	17,050	85.4	100.0	
Out of production	2,920	14.6		
Unreported	0	—		
Total	19,970	100.0		

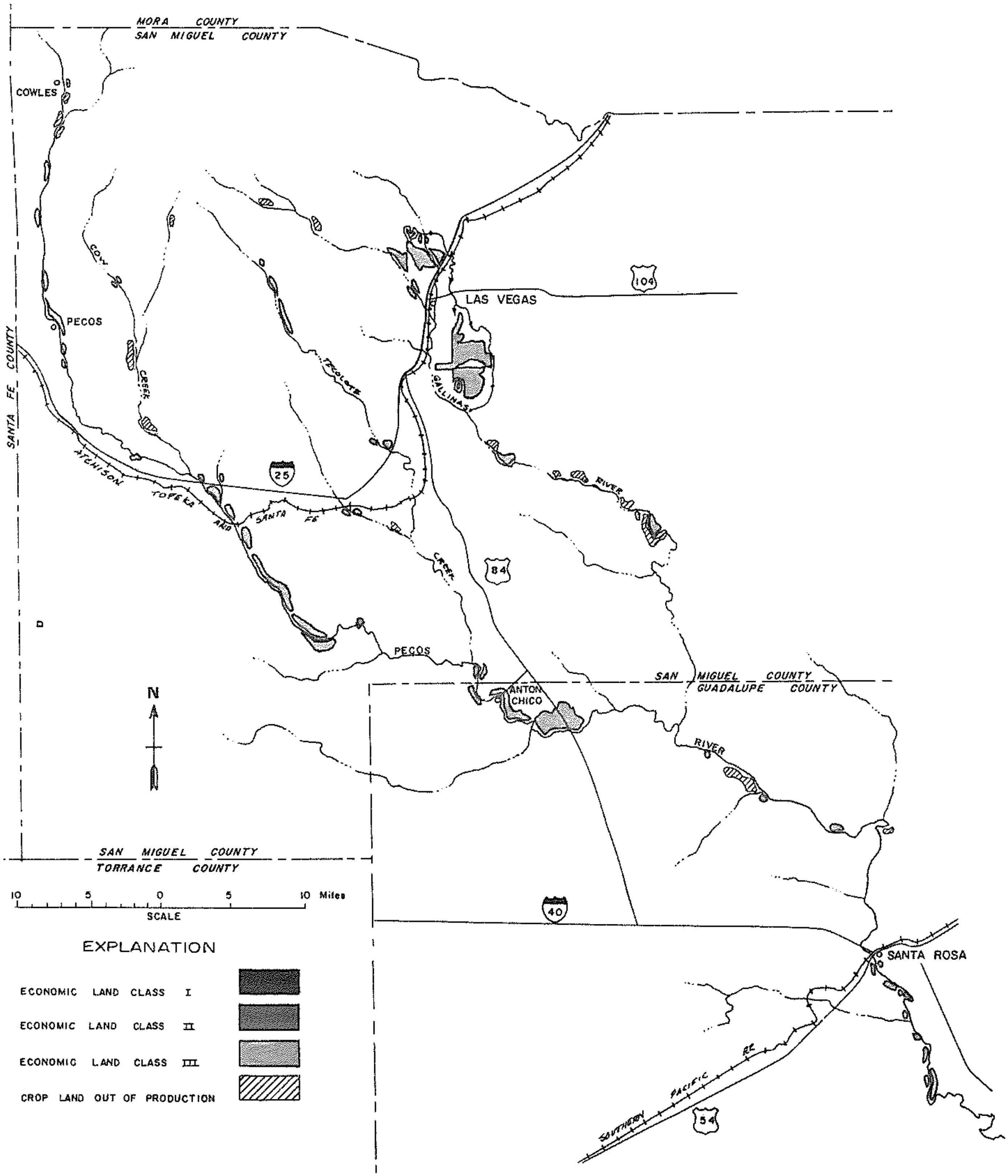


Figure 5. Economic land classification, Upper Pecos River Basin, New Mexico, 1966.

which accounted for about 20 percent of the cultivated acreage, although irrigated pasture is not usually considered a major crop since it is usually grazed. Fruits and vegetables were next in importance, consisting primarily of corn, chile, and cucumbers. These higher labor-using crops would appear to be more suited to a low capital, high labor-intensive area such as the Upper Pecos River Basin.

Equipment for cultivating crops ranges from primitive hand tools to horsedrawn implements on the smaller farms, and power machinery on some of the larger farms. Most of the power machinery consists of small one-to-two-row tractors, usually 15 to 20 years old. The average total investment per farm was estimated to be approximately $1,685. In many cases all of the cultivation operations are performed by hand, therefore many of the high labor-intensive crops can be produced.

With the exception of the Storrie Project, irrigation systems in the area consist of community ditches which were originally constructed through a cooperative arrangement between farmers who had access to them. The ditches are maintained by hand labor furnished primarily by the farmers and their families through a joint agreement with farmers in the area. Labor costs for maintaining ditches amount to about $4 per acre per year on the basis of prevailing wage rates of approximately $1.35 per hour.

The farmsteads in the Upper Pecos River Basin generally did not require large investments in capital. The houses were usually small two- and three-room structures inexpensively constructed from adobe, few of which were modern. Barns and equipment storage facilities were the exception rather than the rule.

Economic Land Classification

The economic land-classification map (figure 5) reflects the interaction of soil and water quantity, farm size, and economic indicators. Severe limitations to income expectancies caused all the cropland in this area to be classified as Economic Class III (table 7). In 1966 the average net return to land and management per cultivated acre for the Upper Pecos River Basin was estimated to be $30. The most severe limitation was considered to be that posed by extremely small farm size. Division and subdivision of farms through inheritance has reduced the average farm size to a point where development of commercial farm enterprises is virtually impossible. Shape as well as size was considered a severe limitation to the efficiency of the farms, as they have been divided into long narrow strips to insure that no land owner would be excluded from access to irrigation water. Soil quality was considered to be a moderate to severe limitation on all farms in the area. Climate limits the length of the growing season and therefore the selections of crops. While such crops as alfalfa may be grown in the area, resulting yields are usually less than one-half those obtained in other areas of the Pecos River Basin. The availability of irrigation water was considered to be a moderate limitation on all farms of the basin and a moderate to severe limitation to income expectancies in the Storrie Project.

Table 7. Acreage of irrigated cropland by economic land classification, Upper Pecos River Basin, San Miguel and Guadalupe Counties, New Mexico, 1966.

Economic Land Classification	Acres	Percentage
Class I	0	0.0
Class II	0	0.0
Class III	17,050	85.4
Unreported and out of production	2,920	14.6
Total	19,970	100.0

Chapter 4

FORT SUMNER BASIN

The Fort Sumner Basin comprises 124 square miles along the Pecos River in De Baca County. All of the irrigated cropland in the county is included in the basin and most of it is located in the valley, contiguous to the Pecos River. Additional acreages are located on the upland plain north and southwest of Fort Sumner (figure 6). Of the approximately 9,900 acres of irrigated cropland, about two-thirds is in the valley and one-third in the upland part of the area. The area was first settled as an army fort and Indian reservation in 1862. Irrigation ditches were constructed and considerable farming was carried on by the Indians until 1866 when they were removed from the area. Much of the present surface-irrigated cropland acreage has been farmed continuously since that time (29, p. 137).

Fort Sumner, the county seat of De Baca County, is the only population center of consequence in the area. It facilitates almost all the trade, school, and social activities. The main highways, U. S. 60 and 84 and State Highway 20, serve as trade routes through the area while a number of state and county roads serve the farming sections.

Topography and Climate

Topography varies from a flat, low-lying alluvial plain in the valley floor to rolling hills in the upland area. Several draws feed into the Pecos River in this area but cause only minor limitations in the upland portion. The cropland in the valley is subject to occasional flooding because of severe thunderstorms which occur during the growing season. The climate is characterized by low relative humidity, low annual rainfall, and mild, dry winters. Temperatures vary from as high as 110°F in the summer to a minus 27°F in the winter. These are extremes, however, and the average temperatures are 76.4°F in summer and 38.2°F in winter (39).

The growing season varies from about 160 to 210 days with an average of 184 days. Precipitation, resulting primarily from brief thundershowers, averages about 14 inches per year. Evaporation losses are usually high due to low relative humidity and high wind movement.

Soil Productivity and Water Quality

Soils in the area are predominantly sandy or light, loamy-surface soils with heavier subsoils and thus they are easily cultivated and take up moisture readily. The heavy clay subsoils have a high water-holding capacity and release moisture to crops as needed. About 50 percent of the soils are Group I of the Harkey and Reagan series (table 8). The remaining acreage is composed of the Anthony and Pima soils, Groups II and III (see Appendix), in approximately equal proportions. Soil quality is a moderate to severe limitation on more than 40 percent of the cropland acreage in the area, partly because the soils are subject to wind erosion in the spring, especially in the upland areas, and to occasional flooding in the valley. Figure 6 shows the location of the different soil groups in the area.

Surface water quality has gradually decreased. Total dissolved solids were 1,210 ppm in 1955 but had increased to 2,020 ppm by 1967 (20, p. 57). During the time of this study, water quality did not appear to affect crop yields to any appreciable extent. Ground-water quality was not considered a limitation in the upland portion of the Fort Sumner Basin.

Source of Irrigation Water

Approximately two-thirds of the cultivated acreage in the Fort Sumner Basin is irrigated with surface water (figure 7), which includes all of the irrigated cropland adjoining the Pecos River south of Fort Sumner. This district holds a senior right for not more than 100 cubic feet per second of water from the natural flows of the Pecos River. Water is released from Alamogordo Reservoir to the district in amounts equivalent to the inflow to the reservoir, but not exceeding 100 cubic feet per second, and is diverted by the Fort Sumner Diversion Dam, approximately three miles north of Fort Sumner. The canal system is made up of two canals, the Main Canal of more than 16 miles with a capacity of 100

Table 8. Acreage of irrigated cropland by soil productivity groups, Fort Sumner Basin, DeBaca County, New Mexico, 1966.

Soil Productivity Group	Acres	Percentage
Group I	4,688	47.4
Group II	2,053	20.7
Group III	1,238	12.5
Unreported and out of production	1,921	19.4
Total	9,900	100.0

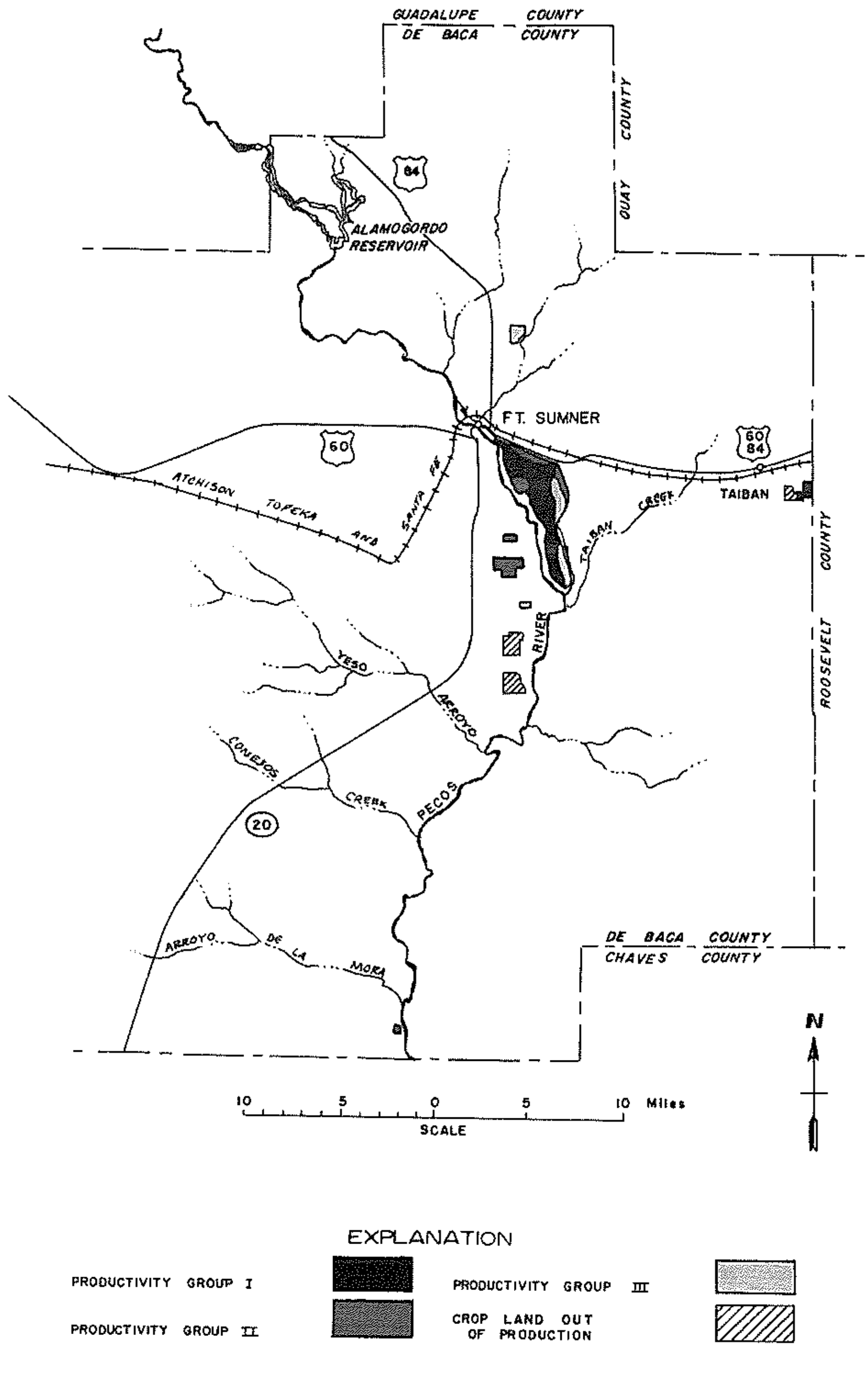


Figure 6. Soil productivity, Fort Sumner Basin, New Mexico, 1966.

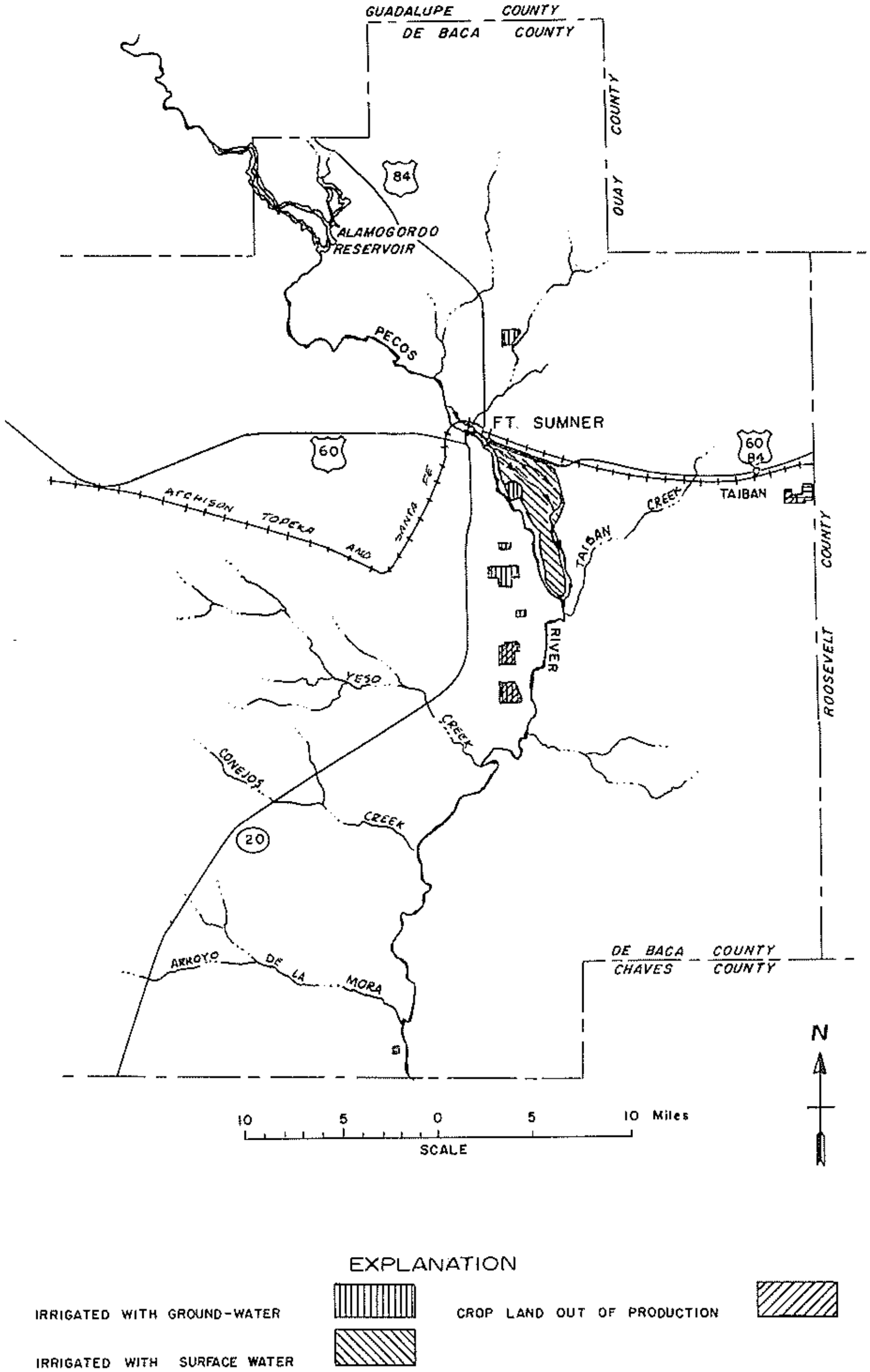


Figure 7. Source of irrigation water, Fort Sumner Basin, New Mexico, 1966.

cubic feet per second, and the High Line Canal of more than eight miles with a capacity of 20 cubic feet per second. Water is pumped from the Main Canal to the High Line Canal just northwest of Fort Sumner.

Surface water diversion was about 5.0 acre-feet per water-right acre for 1966 (table 9). Of the total 33,281 acre-feet diverted, the Bureau of Reclamation (2) estimated that only 23,260 acre-feet were delivered to the farms, approximately 70 percent of the total diverted. About 1.0 acre-foot per water-right acre was lost in conveyance.

In the upland area, irrigation water is diverted by pumpage from the alluvium or shallow aquifer. Wells in the pumped area are finished at depths less than 200 feet with estimated yields between 100 and 300 gpm (27, pp. 38-39). Data are unavailable on the volume of water pumped but, following interviews with farmers and SCS and extension personnel, it was estimated to be between 3.0 and 4.0 acre-feet per cultivated acre at the time of this study. Enterprise budgets by Garnett *et al.* (11, 14, 15, 16) suggest that pumpage was about 3.75 acre-feet per cultivated acre.

Data are not available on the decline of water levels in the ground-water areas but in interviews with farmers and SCS and extension personnel it was reported that the water level has declined less than five feet in the past four to five years.

Henderson and Sorensen (21) estimated consumptive irrigation requirements to be about 1.92 acre-feet per cropped acre in the surface area, and about 1.29 acre-feet per cropped acre in the pumped area.

Economic Indicators

Farming operations in the surface-irrigated valley of the Fort Sumner Basin are small owner operated units, most of them less than 40 acres. A large percentage of the small farm operators are employed off the farm or receive supplemental income from retirement benefits. In addition to small farm size, small field size restricts the development of commercial agriculture on most farms, especially in the northern part of the valley near Fort Sumner. Possibilities for incorporation of the small farms is limited by the large investment in farm buildings represented by each unit. Some farmers in the area own small farms (about 20 acres) and lease the cropland to other farmers. But even under such an arrangement as this, the total farm size remains relatively small, usually 160 acres or less. Consolidation appeared to be more feasible in the southern part of the valley where farms are usually larger (about 100 acres). Possibilities for consolidation are enhanced through a lower ratio of fixed assets per acre and increased field size which allows the use of larger, more modern equipment. Farm size was considered to be a moderate to severe limitation in this area.

Farming operations in the Fort Sumner Irrigation District (surface-irrigated area) are largely diversified and include enterprises such as alfalfa, oats, wheat, irrigated pasture, cotton, and apples. Table 10 reports the acreages of different crops produced in the area. Small livestock grazing operations are incorporated into many of the farms in order to utilize feed grain and roughage production.

Farming operations in the ground-water irrigation area of the basin are typically large, owner-operated units averaging about 300 acres. The fields are large in size and laid out in a way that facilitates the efficient management of these farms. However, two of the larger units were not being farmed in 1966 and it was questionable whether they were farmed in 1965.

Farming operations in the pumped area are largely specialized, producing grain and forage sorghums, small grains, alfalfa, and pasture. All types of sorghums account for over 50 percent of the cultivated acres.

About 20 percent of the farms may be considered commercial operations (over 100 acres). Farms in this category are located in the lower or southern part of the valley (surface-irrigated) and on the upland plain (pumped area). They average about 180 acres in size although a few are near or larger than 1,000 acres. The commercial farms appeared to support large investments in buildings and equipment. There is less livestock on these farms as they tended toward higher levels of cash crop production, mainly alfalfa, cotton, and grain sorghum. Cotton, one of the higher-income crops, is

Table 9. Irrigation water diversion by source, Fort Sumner Basin, DeBaca County, New Mexico, 1966.

Source	Water Diverted	Water-Right Acres		Cultivated Acres		Cropped Acres	
		Total	Per Acre	Total	Per Acre	Total	Per Acre
	(acre-feet)	(acres)	(acre-feet)	(acres)	(acre-feet)	(acres)	(acre-feet)
Surface	33,281	6,500	5.12	5,959	5.58	4,565	7.29
Ground	7,609	3,400	2.24	2,020	3.77	1,689	4.51
Total	40,890	9,900		7,979		6,254	
Weighted average			4.13		5.12		6.54

Table 10. Acres of irrigated cropland by use and percentage of designated acreage, Fort Sumner Basin, DeBaca County, New Mexico, 1966.

Land Use	Acres	Water-Right Acres (percent)	Cultivated Acres (percent)	Cropped Acres (percent)
Cotton	371	3.75	4.65	5.93
Alfalfa	2,792	28.20	34.99	44.64
Small grains	346	3.49	3.34	5.53
Grain sorghum	718	7.25	9.00	11.48
Forage crops	461	4.67	5.78	7.37
Pasture	1,293	13.06	16.20	20.67
Pecans	0	—	—	—
Fruits and vegetables	153	1.55	1.92	2.45
Miscellaneous	120	1.21	1.50	1.93
Subtotal	6,254	63.18	78.38	100.00
Diverted and fallow	1,725	17.42	21.62	
Subtotal	7,979	80.60	100.00	
Out of production	1,921	19.40		
Unreported	0	—		
Total	9,900	100.00		

restricted because of acreage allotments. Interviews with ASC personnel revealed that in 1966 the total cotton allotment for DeBaca County was 506 acres with a projected yield of 523 pounds. Diversion under existing programs was near the maximum, 35 percent in 1966. The small cotton acreage limits the feasibility of maintaining a ginning facility in the area and part of the cotton produced is transported to Roswell to be ginned. As a result, the transfer of allotments to other counties, especially Chaves, has increased during recent years, according to an interview with ASC personnel in Fort Sumner.

Alfalfa is the principal cash crop in terms of total dollars and accounts for about one-third of the total cultivated acreage. The second largest total acreage is devoted to irrigated pasture, most of which is Midland Bermuda grass. In DeBaca County the farmer is eligible to receive payment for about one-half the establishment costs for permanent irrigated pasture under the existing conservation payment program. The favorable characteristics of the government program and the fact that, once the pasture is established it is easily maintained by irrigation and fertilization, have made this crop especially appealing to the low capital-intensive operation typical of the small farms in the area. Low net return per acre has discouraged the production of irrigated pasture on the larger farms (14).

Both alfalfa and irrigated pasture require large seasonal applications of irrigation water. The high percentage of total cropland devoted to these crops may account for high average water diversion per acre in this area. The production of labor-intensive crops such as apples and other fruits was initiated on the small farms in the valley during the early 1940's. Although they continue to be produced on about 2 percent of the cultivated land in the valley, they have gradually declined in importance during recent years until only a limited number of orchards are being managed on a commercial basis. Lack of low-cost labor and sufficient volume of production to establish reliable market outlets has probably contributed to this trend. Most of the production is marketed locally through roadside stands or to small independent dealers from nearby areas. Small, specialized livestock operations prevail on many of the part-time farms in the valley that produce irrigated pasture.

Equipment size and repair varied with farm size in the Fort Sumner Basin. Only small or, most often, obsolete equipment was used on the part-time farms. Although larger equipment size predominated on the commercial farms, new and modern equipment was the exception rather than the rule since most of the commercial farms in this area are relatively small. Equipment appeared to be larger and in better repair in the ground-water areas of the basin.

Irrigation systems in the valley consist mostly of concrete-lined diversion ditches and field laterals although some earthen field laterals are used. Soil type

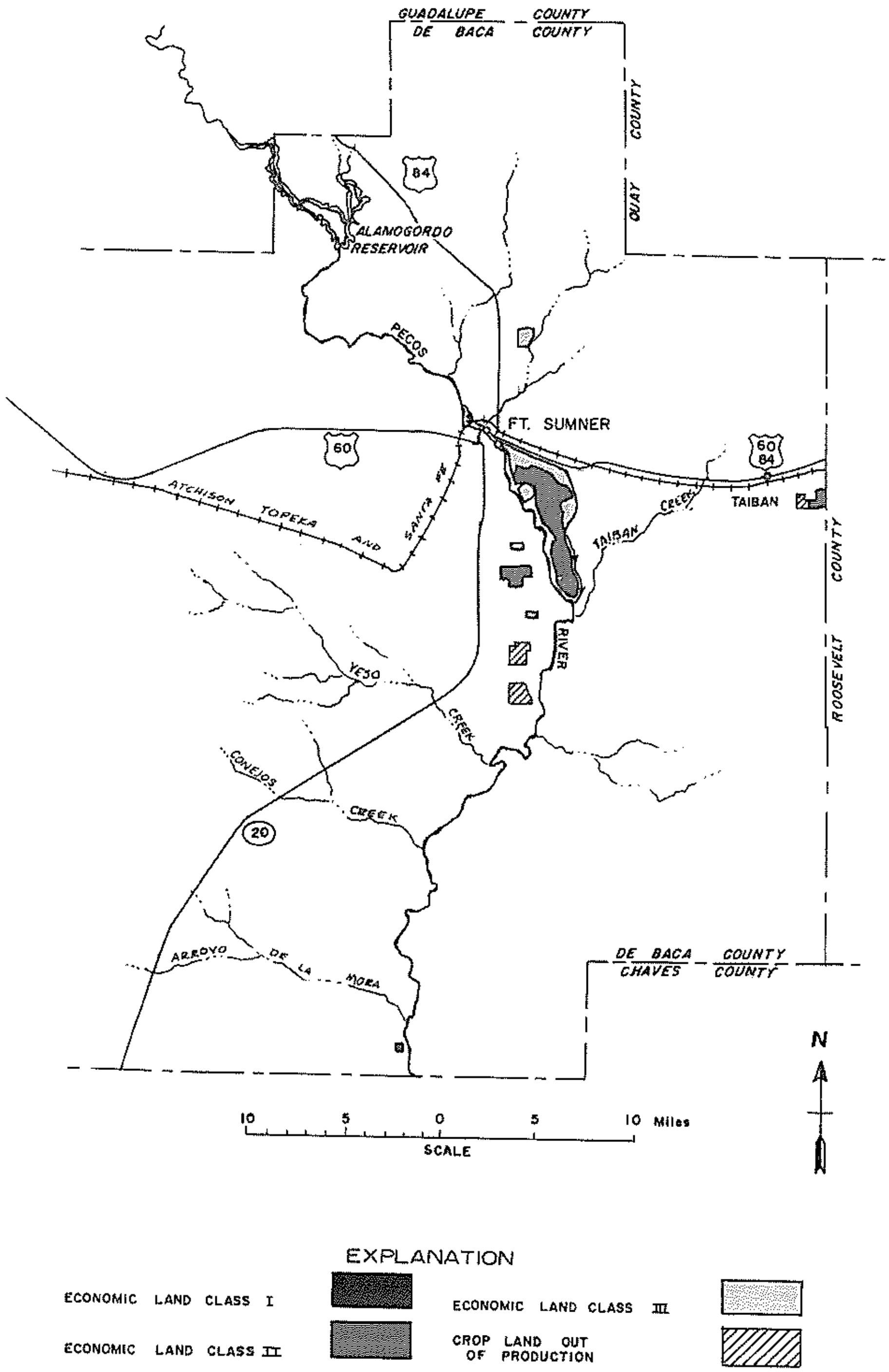


Figure 8. Economic land classification, Fort Sumner Basin, New Mexico, 1966.

in the upland area limits the use of ditches and field flooding, thus most farms in this section use either underground pipe or sprinkler systems for irrigation application. Per-acre investments in irrigation systems in the basin are comparatively high because of the large proportion of concrete-lined ditches and laterals on the surface-irrigated farms, and the cost of irrigation wells, underground pipeline, or sprinkler systems on ground-water irrigated farms.

Farmsteads in the basin usually represent low investments in houses, barns, and other buildings. Farm houses are small frame structures while the out-buildings consist of pole-type hay barns and small livestock sheds. Large investments in modern buildings and houses were observed on only a few of the commercial farms and rural residences in the area, which tends to indicate moderate farm incomes. A number of the larger farms in the area were equipped with adequate storage and shop facilities for maintenance of machinery and equipment.

Economic Land Classification

The economic classification map (figure 8) reflects the interaction of soil and water quality, farm size, and the economic indicators. There is no Economic Class I land in the Fort Sumner Basin (table 11). In the surface-irrigated area, farm size was the primary limitation in classifying about two-thirds of the cropland as Economic Land Class II. Soils in this area were considered to be highly productive with ample irrigation. However, the small field sizes and high per-acre investment in improvements were considered as limitations to consolidation into commercial units. Moderate limitations were imposed on about half of the ground-water areas, primarily because of moderately productive soils and low yields of irrigation wells.

Table 11. Acreage of irrigated cropland by economic land classification, Fort Sumner Basin, DeBaca County, New Mexico, 1966.

Economic Land Classification	Acres	Percentage
Class I	0	0.0
Class II	5,229	52.8
Class III	2,750	27.8
Unreported and out of production	1,921	19.4
Total	9,900	100.0

Severe limitations were imposed on approximately one-third of the cultivated acreage, primarily because of low-productive soils and small farm size. Most of the low-productive soils are sandy and subject to wind erosion, requiring a higher level of management to maintain crop production and establish stands in the spring months.

In 1966, the average net return to land and management per cultivated acre for the Fort Sumner Basin was estimated to be $55 for the Economic Class II land, and $30 for the Economic Class III land.

Chapter 5

ROSWELL ARTESIAN BASIN[1]

The Roswell Artesian Basin is located in Chaves and Eddy counties in southeastern New Mexico (figure 1), extending from 24 miles north of Roswell to 24 miles south of Artesia for about 90 miles and ranging from 6 to 20 miles in width. Nearly two-thirds of the basin is in Chaves County and about one-third is in Eddy County. The principal irrigated cropland is west of the Pecos River and it contains two major population centers, Roswell and Artesia.

The principal highways are U. S. 285, 70, 380, and 82 which serve as trade routes through the area while various state and county roads provide access to the farms.

Topography varies from fairly level areas in the central part of the basin to gently rolling plains and hills in the northern and southern extremes. The basin drains into the Pecos River which flows south along the eastern edge. Numerous tributaries flow into the Pecos River from the west but it receives little run-off from the east. Altitudes vary from approximately 3,600 feet in the northern extremities of the basin to 3,300 feet near Lake McMillan (5, p. 77).

The climate is semiarid with low average annual precipitation, low relative humidity, high temperatures, and persistent wind movement. Irrigation is required for economic crop production. Winters are usually mild and dry but heavy snows and extremely cold temperatures have been experienced. Temperatures above 100°F are not uncommon in the summer. The growing season usually begins in early April and lasts about 200 days until late October. Precipitation amounts and distribution vary widely from year to year, but usually average about 10 inches (39). About two-thirds of the rainfall results from thundershowers in the spring and summer months. Occasionally these thundershowers are accompanied by high winds and hail and may cause flooding and severe damage to crops and property. Due to high temperatures and low relative humidity, rainfall is quickly evaporated or transpired.

Soil Productivity and Water Quality

About 75 percent of the cultivated cropland in the basin has Group I soils that are fairly uniform throughout the basin (table 12). These soils are deep, clay loams and are considered highly productive. Group I soils are primarily of the Reagan series with small amounts of Pima and Harkey series. The high water-holding capacity and deep root zone of these soils is favorable for the production of most crops grown in the basin. While slope presents slight problems on some of the soils they are deep enough to allow leveling.

Slightly more than 5 percent of the soils had moderate limitations restricting maximum production and were classified as Group II. Common problems associated with these soils include moderate slope, shallow depth, and gypsum within 36 inches of the surface. In general they do not respond as favorably to improved management practices as soils in Group I. Lower crop yields and incomes may be expected on farms with a relatively high percentage of these soils. Group II soils are comprised primarily of the Reeves and Atoka series with small quantities of the Upton and Karro series.

Almost 10 percent of the soils have severe limitations that restrict maximum production and were classified as Group III. Common problems associated with these soils include a high degree of salinity, low permeability, and gypsum close to the surface. In general they do not respond as favorably to improved management practices as soils in Groups I and II. Lower crop yields and incomes may be expected on farms with a greater percentage of these soils. Group III soils occur primarily close to the Pecos River but they are fairly uniform throughout the basin (figure 9). Group III soils consist primarily of the Arno, Russler, and Anthony series.

Table 12. Acreage of irrigated cropland by soil productivity groups in the Roswell Artesian Basin, Chaves and Eddy Counties, New Mexico, 1967.

Soil Productivity Group	Acres	Percentage
Group I	102,938	76.9
Group II	7,287	5.5
Group III	11,559	8.6
Unreported and out of production	12,056	9.0
Total	133,840	100.0

[1]Adapted from a Master's Degree thesis, "Economic Classification of the Irrigated Cropland in the Roswell Artesian Basin, New Mexico," by Edwin T. Garnett, New Mexico State University, 1968.

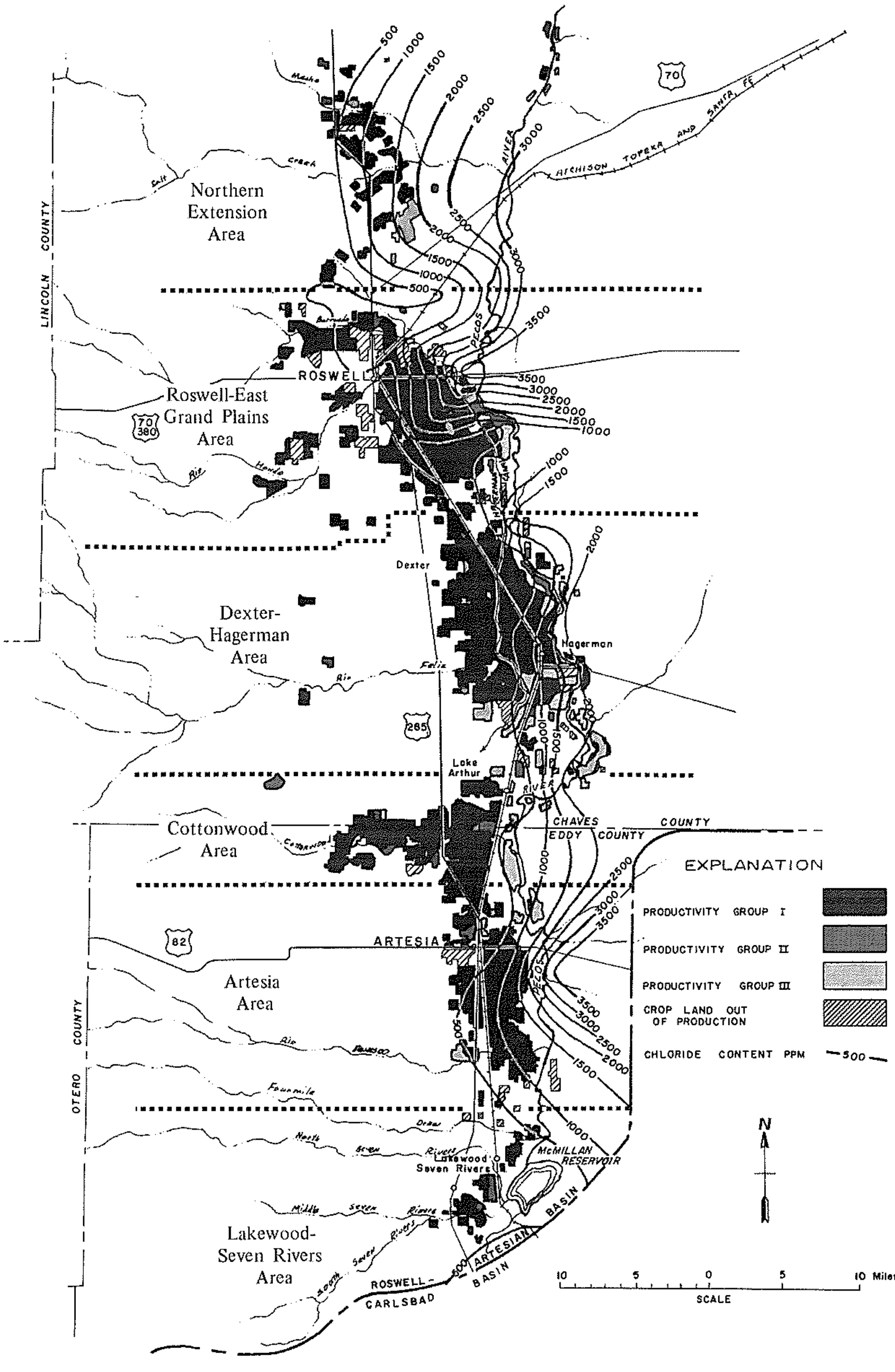


Figure 9. Soil productivity and irrigation water quality, Roswell Artesian Basin, New Mexico, 1967.

Irrigation water quality was considered to be sufficiently important to lower the classification on about one-fourth of the cropland in the basin. The largest acreage so affected was in the Roswell area, in almost all portions located near the Pecos River (figure 9).

Source of Irrigation Water

Sources of irrigation water varied within areas of the basin but almost all irrigation water was diverted from the artesian and shallow aquifers along with a relatively small amount from surface diversion (figures 10 and 11). The primary source of irrigation water is ground water. Table 13 reports the estimated acreage irrigated from different sources and combinations of sources in different areas of the basin. Farms diverting water from more than one source are usually considered to have a slight advantage over those using only one source, especially in areas where water quality is more a problem with one source than another.

With the exception of Dexter-Hagerman area, all areas in the basin diverted almost twice as much water from the artesian aquifer as from all other sources combined. However, about 95 percent of all water diverted was ground water from either the shallow or artesian aquifers. Less than 5 percent of all water was diverted for purposes other than irrigation (table 14).

Water diversion per water-right acre varied widely from one area to another. The lowest average diversion per acre was 1.98 acre-feet in the area north of Roswell (Northern Extension) while the highest diversion was 3.42 acre-feet per acre in the Lakewood-Seven Rivers area (table 15). These same two areas continue to represent the low and high extremes (2.67 and 3.98 acre-feet per acre, respectively) when water diversion is computed on the basis of cultivated acreage, but the margin is narrower.

Table 13. Rights to water for irrigation, Roswell Artesian Basin, Chaves and Eddy Counties, New Mexico, 1967.

Water Source	Acres	Percent
Artesian only	66,369	49.6
Shallow only	35,419	26.5
Artesian and shallow combined	13,609	10.2
Surface[1]	6,172	4.6
Artesian or shallow and surface	12,271	9.1
Total, all sources	133,840	100.0

[1]Includes both public and private rights.

Table 14. Water diversion by areas, Roswell Artesian Basin, Chaves and Eddy Counties, New Mexico, 1967.

Area Description	Diversion by Source[1]				Water-Right Acres	Average Diversion All Farms
	Surface	Shallow	Artesian	All Sources		
	(acre-feet)	(acre-feet)	(acre-feet)	(acre-feet)		(acre-feet per acre)
Northern Extension	221.8	984.6	19,839.1	21,045.5	10,610	1.98
Roswell-East Grand Plains	719.8	27,083.9	70,364.9	98,168.6	36,930	2.66
Dexter-Hagerman	18,212.4	51,342.2	47,758.1	117,312.7	41,560	2.82
Cottonwood	2,461.8	23,860.9	46,860.2	73,182.9	22,220	3.29
Artesia	.8	21,708.1	36,361.9	58,070.8	18,510	3.14
Lakewood-Seven Rivers	—	7,324.9	6,402.0	13,726.9	4,010	3.42
Total for basin[2]	21,616.6	132,304.6	227,586.2	381,507.4	133,840	2.85
Additional diversion:						
Municipal		15.5	14,512.8	14,528.3		
Commercial and industrial		193.3	1,389.3	1,582.6		
Total				397,618.3		

[1]Sources classified by adjudication.
[2]Does not include Upper Felix area.

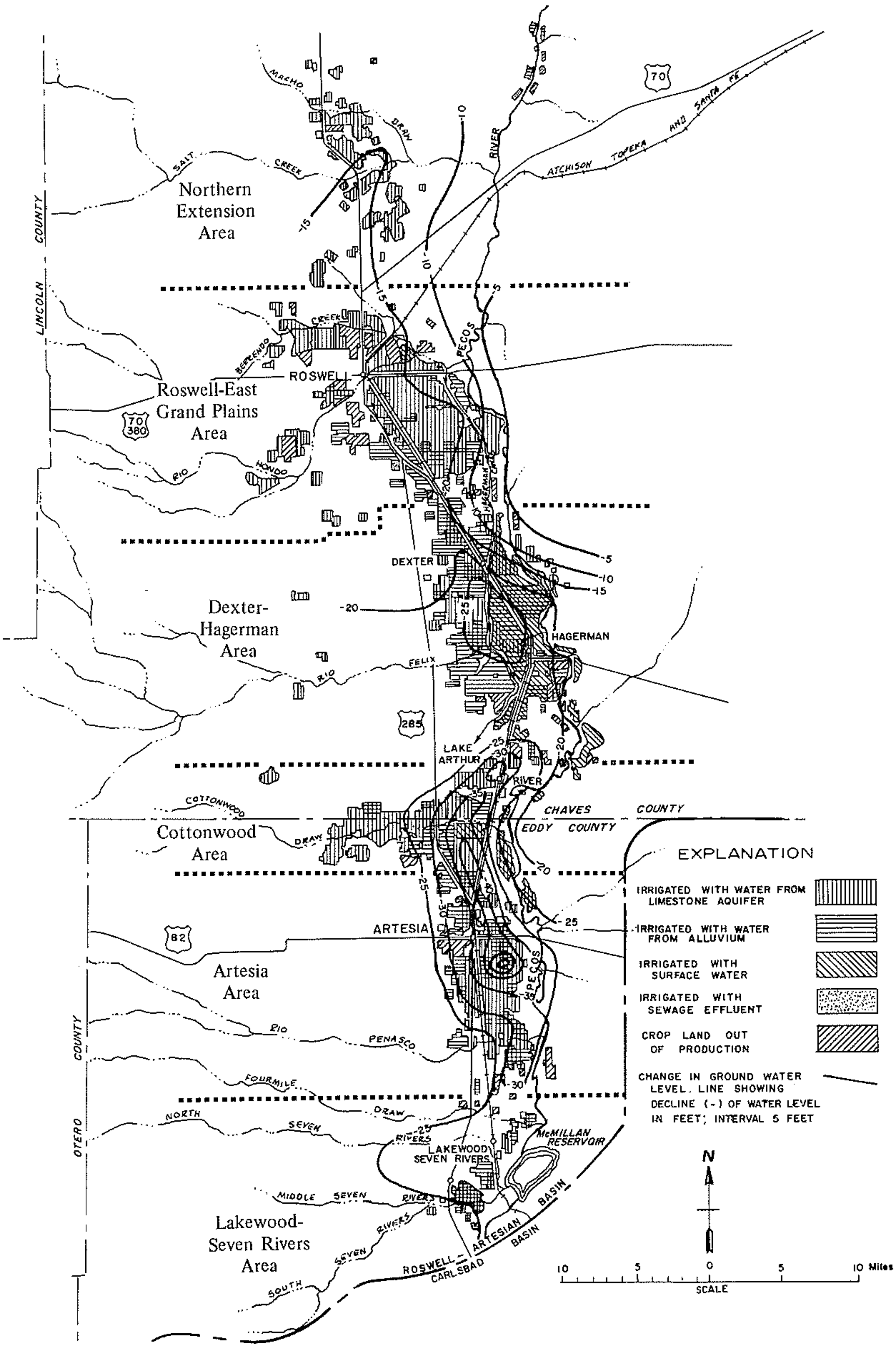


Figure 10. Source of irrigation water and change in ground-water levels in artesian aquifer (1961-1966), Roswell Artesian Basin, New Mexico, 1967.

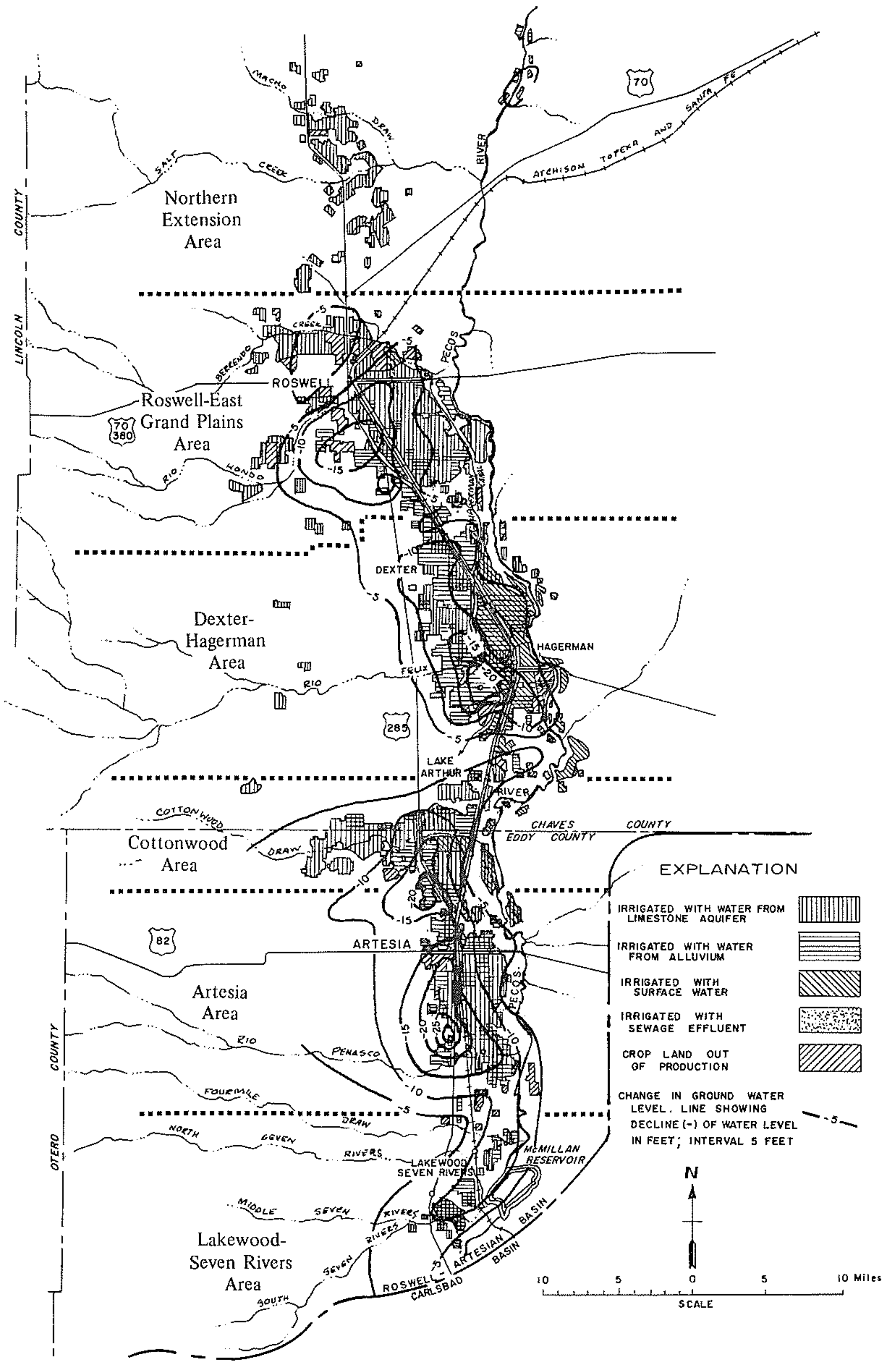


Figure 11. Source of irrigation water and change in ground-water levels in alluvium (1961-1966), Roswell Artesian Basin, New Mexico, 1967.

Due to the large percentage of crops grown during the summer growing season, perhaps the figures computed on the basis of cropped acreage present a more meaningful reference to water diversion than either the water-right acres or the cultivated acreage. On the basis of cropped acres the Northern Extension area was one of the highest water diversion areas in the basin (3.79 acre-feet). The Lakewood-Seven Rivers area remained the highest water diversion area (4.49 acre-feet) but the difference between it and the Northern Extension area was less than half that calculated on the basis of water-right acres.

Larger rainfall amounts in the Roswell-East Grand Plains and the Dexter-Hagerman areas during the 1967 growing season may account for part of the difference in water diversion per cropped acre in these two areas as compared to other areas of the basin. Table 15 reports the difference in water diversion per acre calculated on the basis of water-right acres, cultivated acres, and cropped acres for the six areas as well as the entire basin.

Henderson and Sorensen (21) estimated the consumptive irrigation requirement for Roswell and Artesia at 1.68 and 1.81 acre-feet per cropped acre respectively. The Roswell Artesian Basin consumptive irrigation requirement was estimated at 1.74 acre-feet per cropped acre.

Decline in the water table was considered to be a moderate to severe limitation in the Dexter-Hagerman area in both the artesian and shallow aquifers, near the Chaves-Eddy County line in the artesian aquifer, the Artesia area in both aquifers, and a moderate limitation in the artesian aquifer in the Lakewood-Seven Rivers area (figures 10 and 11).

Economic Indicators

About 58 percent of the farms in the basin may be classified as part-time farms (less than 100 acres). The average size is about 40 acres, but mainly they are small suburban residences of 10 acres or less near the cities of Roswell and Artesia. While they account for 18 percent of the total cropland and use 17 percent of the irrigation water, their contribution to the overall economy of the basin is small in proportion to the commercial farms (larger than 100 acres).

Commercial, medium-size farms (100 to 299 acres) include about 32 percent of the total farms, 46 percent of the cropland, and use 47 percent of the irrigation water. These are primarily owner-operator family farms with an average size of 185 acres, distributed throughout the central part of the basin.

The remaining 35 percent of the irrigated cropland is included in 100 farms in the basin. These are large commercial operations and, while they average less than 500 acres, many of them contain more than 1,000 acres.

There was no difference in water diversions per acre between the two categories of commercial farms in 1967 (table 16).

Farm size was considered to be a limitation on small farms in and near Roswell and Artesia. These were mostly suburban residences with fewer than 10 acres of cropland, mostly devoted to home gardens and pastures for domestic animals. Some larger acreages were operated by the owner on a part-time basis or leased to commercial farmers in the area. In the Dexter-Hagerman area there appeared to be a large number of part-time farms varying in size from 40 to 80 acres.

Table 15. Irrigation water diversion by sub-area, Roswell Artesian Basin, Chaves and Eddy Counties, New Mexico, 1967.

Area Description	Water Diverted	Water-Right Acres		Cultivated Acres		Cropped Acres	
		Total	Per Acre	Total	Per Acre	Total	Per Acre
	(acre-feet)	(acres)	(acre-feet)	(acres)	(acre-feet)	(acres)	(acre-feet)
Northern Extension	21,045.5	10,610	1.98	7,865	2.67	5,548	3.79
Roswell-East Grand Plains	98,168.6	39,930	2.66	33,416	2.94	28,980	3.39
Dexter-Hagerman	117,312.7	41,560	2.83	38,325	3.06	34,570	3.39
Cottonwood	73,182.9	22,220	3.29	21,290	3.44	19,169	3.82
Artesia	58,070.8	18,510	3.14	17,438	3.33	15,636	3.71
Lakewood-Seven Rivers	13,726.9	4,010	3.42	3,450	3.98	3,054	4.49
Total	381,507.4	133,840		121,784		106,597	
Weighted average			2.85		3.13		3.58

The typical cropping pattern on 100 acres of cultivated land in 1967 consisted of about 25 acres of cotton, 44 acres of alfalfa, 7 acres of small grain, 4 acres of grain sorghum, and 5 acres of forage crops. Part of the remaining acreage was used for pasture, fruits, and nuts, along with a small acreage of miscellaneous crops such as soybeans and castor beans. Due to the favorable characteristics of the 1967 cotton program a larger acreage of cropland was diverted from production than might have been otherwise. More than 12 percent of the cultivated acreage was not cropped in 1967 (table 17).

Cotton and alfalfa dominated the cropping pattern in all parts of the basin and, while adverse weather conditions in 1967 did not favor the production of high

Table 16. Irrigation water diversion by farm size, Roswell Artesian Basin, Chaves and Eddy Counties, New Mexico, 1967.

Farm Size[1]	Number of Farms	Percentage of Basin Farms	Total Water-Right Acres	Average Size Farm	Irrigation Water Used: Total	Irrigation Water Used: Per Acre
(acres)				(acres)	(acre-feet)	(acre-feet)
0–99	597	57.8	24,309	41	64,224.6	2.56
100–299	336	32.5	62,118.3	185	180,011.8	2.90
300 and over	100	9.7	47,412.7	474	137,271.0	2.90
Total	1,033	100.0	133,840.0	130	381,507.4	2.85

[1]Farm size is by ownership.

Table 17. Acres of irrigated cropland by use and percentage of designated acreage, Roswell Artesian Basin, Chaves and Eddy Counties, New Mexico, 1967.

Land Use	Acres	Land Use Expressed As Percentage of Total Designated Acreage: Water-Right Acres	Cultivated	Cropped
		(percent)	(percent)	(percent)
Cotton	30,922	23.1	25.4	29.0
Alfalfa	52,942	39.6	43.4	49.5
Small grain	8,520	6.4	7.0	8.0
Grain sorghum	4,645	3.5	3.8	4.3
Forage crops	6,519	4.9	5.4	6.1
Pasture	1,414	1.0	1.2	1.3
Pecans	1,549	1.2	1.3	1.4
Fruits and vegetables	249	.2	.2	.2
Miscellaneous[1]	197	.1	.2	.2
Subtotal	106,597	80.0	87.9	100.0
Diverted and fallow	14,827	11.1	12.1	
Subtotal	121,784	91.1	100.0	
Out of production	10,513	7.8		
Unreported	1,543	1.1		
Total	133,840	100.0		

[1]Includes castor beans and soybeans.

yields from either of these crops, improved prices for both were considered to offset most of the loss experienced by farmers in the basin.

The size, age, and repair of equipment appeared to be closely related to the size and productivity of the farm unit. In general, large farms appeared to support substantial investments in modern, six-row machinery, while the equipment used on the medium-sized farms was usually four-row. Small, obsolete equipment was not uncommon on farms less than 100 acres in size.

Irrigation systems usually consisted of wells pumping directly into large unlined earthen reservoirs, and water was diverted to fields through systems of open lined ditches, open earthen ditches, or underground pipelines. Most of the field laterals are earthen. In the Northern Extension most of the ditches are open and unlined. Concrete-lined ditches and underground pipeline systems were used only to a limited extent and were confined mostly to areas where slope and light soils presented problems with water management. In the Roswell-East Grand Plains area most of the main diversion ditches and a large percentage of the field laterals were concrete-lined or underground pipe. In the Dexter-Hagerman area irrigation systems consisting mainly of concrete ditches and underground pipe were in evidence on almost all farms where bench leveling had been necessary. Concrete-lined ditch was used as the primary diversion implement throughout the area. Unlined ditches were commonly used as field laterals on the more productive farms whereas the entire irrigation system often consisted of unlined ditches on the smaller, less efficient farms. Although earthen reservoirs existed on many farms, their continued use appeared questionable since many were either not in use or were being destroyed at the time of the field survey.

In the area south of Lake Arthur most of the irrigation systems consist primarily of concrete-lined ditches or underground pipe. Reservoirs appeared to be less used in the County Line (Cottonwood) area than in other areas of the basin.

Farms were, for the most part, laid out in an efficient manner. In most areas of the basin field size was adequate for efficient operation of equipment. Farms divided by or adjacent to waterways were limited by shape of fields where contouring or bench leveling was necessary. This was considered to be a moderate limitation. Severe slope (greater than 2 percent) and small, irregular field shape were regarded as severe limitations to efficient irrigation water management, equipment operation, and yields.

Farmsteads in the basin typically reflected the size and profitability of farms in the basin. Farmsteads on the small farms near towns and cities varied from expensive homes to single house trailers. Houses on the commercial farms (over 100 acres) were generally of modest design and well kept, and some houses on the large farms were fairly new, of brick construction, and well maintained. Barns and storage facilities appeared to be adequate for most farms throughout the basin.

Economic Land Classification

The geographic location of cropland in each of the three economic land classes is shown in figure 12. Approximately 50 percent of the total acreage in the basin was considered to have only minor income expectancy limitations and was classified as Economic Class I (table 18). Most of the land in this class is being used for full-time commercial farming. Inputs per crop acre are high. Buildings are being kept up to date and in good repair, machinery and irrigation systems are modern, fields are large, and well situated for the most efficient use. Economic Class I land is fairly evenly distributed throughout the basin with the area north of Roswell Northern Extension having the lowest percentage and the Lakewood-Seven Rivers area having the highest percentage (figure 12). All four of the major producing areas of the basin also having large amounts of Class I land are: Roswell-East Grand Plains area southeast of Roswell, Dexter-Hagerman area, Cottonwood area on the county line, and the Artesia area.

Economic Class II includes about 44 percent of the land where irrigation water quality and water level decline are common problems. Fields are often divided by natural waterways which either cross or lie adjacent to them, resulting in excessive slope which must be corrected. Occasional flooding during the growing season presents additional problems on lands in this class in certain parts of the basin.

Economic Class II land is fairly uniformly distributed throughout the basin with the exception of the Lakewood-Seven Rivers area where only about 13 percent of the cropland is Class II. Restrictions placed on the Northern Extension were primarily water quality, soil, and appearance of economic indicators. In the Roswell-East Grand Plains moderate restrictions were imposed primarily because of water quality, water level decline, and in some cases, farm size. Water quantity was the major item reducing about one-third of the cropland in the Dexter-Hagerman area to Class II

Table 18. Acreage of irrigated cropland by economic land classification, Roswell Artesian Basin, Chaves and Eddy Counties, New Mexico, 1967.

Economic Land Classification	Acres	Percentage
Class I	61,501	46.0
Class II	35,585	40.0
Class III	6,698	5.0
Unreported and out of production	12,056	9.0
Total	133,840	100.0

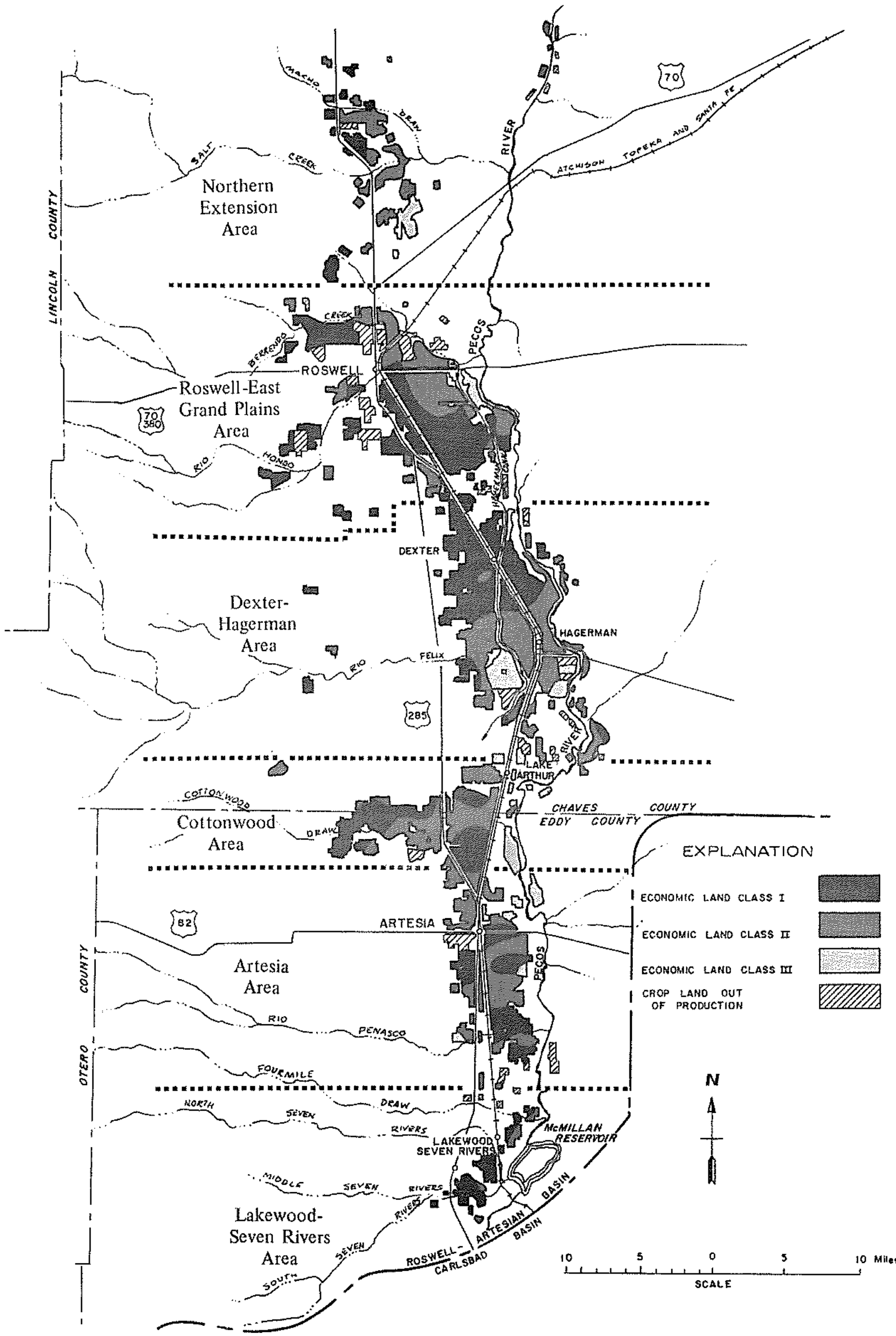


Figure 12. Economic land classification, Roswell Artesian Basin, New Mexico, 1967.

land. Land with moderate limitations in the Cottonwood area was usually restricted by combinations of small farm size, water level decline, or shallow soils most often occurring on broken terrain near Walnut and Cottonwood Creeks. In the Artesia area Class II lands made up nearly 50 percent of the area. Combinations of soil, water table decline, farm size, and slope are associated with these lands. Soil quality reduced about 13 percent of the land in Lakewood-Seven Rivers to Class II.

Buildings were being maintained at levels suitable for commercial farming but seldom as well as those in Class I. The type of irrigation systems used, age and repair of machinery, and other economic indicators often pointed to lower expenditures of time and money than in Class I but higher than Class III.

Slightly more than 5 percent of the land had severe limitations with respect to soil and water quality, topography, and farm size, lowering it to Class III. In this class many of the farms are small and many are operated on a part-time basis. Buildings are often in poor repair and structurally obsolete. Equipment is generally old. Irrigation systems consist largely of earthen reservoirs and ditches and a large proportion of the land is not farmed annually.

Economic Class III land is diversely distributed throughout the basin, varying from none in the Lakewood-Seven Rivers area to 10 percent in the Artesia area. The severe limitations placed on lands in the Roswell area were because of soil and water quality, while in the Dexter-Hagerman area water quantity generally dropped this land into Class III along with soil and water quality near the Pecos River. Soil and water quality were the variables for placing lands in Eddy County in Class III. Diversions of water directly from the Pecos River further lowered parts of the cropland into Class III due to the lack of reliability when this was the only source of irrigation water.

In 1967 the average net returns to land and management per cultivated acre in the Roswell Artesian Basin was estimated to be $100 for Economic Class I cropland and $75 for Economic Class II and $35 for Economic Class III cropland, respectively.

Chapter 6

CARLSBAD BASIN

The Carlsbad Basin includes most of Eddy County and parts of Lea and Otero Counties in southeastern New Mexico, with all of its irrigated cropland located in Eddy County. This basin encompasses 36,398 acres of irrigated cropland within the boundaries of the Pecos Basin from just south of Lake McMillan to the New Mexico-Texas state line (figure 13). Most of the irrigated cropland is located along U. S. 285 between Carlsbad and Malaga.

Carlsbad, the county seat of Eddy County, is the major population center for the area. The villages of Otis, Loving, and Malaga are located along U. S. 285 and serve as sources of basic family needs and farm supplies as well as limited marketing facilities for some farm products. The area is served by U. S. Highways 285, 180, and 62 which function as trade routes to its farms. The primary industries on which the economy of the area is based are agriculture, mining, and oil.

The elevation is the lowest in the basin, about 3,125 feet at Carlsbad. The irrigated cropland of the area is typically low-lying valley land. Many small draws and arroyos feed into the Pecos River from the west, the main ones being Dark Canyon, Black River, and the Delaware River. These tributaries result in only moderate limitations to some of the irrigated croplands of the area.

The climate of the area is similar to that of the Roswell Artesian Basin to the north. The winters are usually mild with little precipitation. The growing season, longest of any in the basin with an average of 221 days, is characterized by long, hot, dry summers, adequate for growing most crops common to the area. The average temperatures are 79.6°F in summer and 42.9°F in winter. On the average the Carlsbad area receives slightly more precipitation than the Roswell Basin.

Soil Productivity and Water Quality

The soils vary widely in texture, slope, and overall quality in the Carlsbad Basin, About 56 percent of the soils are Group I, located in the vicinity of Carlsbad and southeast along U.S. 285 (figure 13). These soils are primarily of the Reagan and Harkey series, further described in the Appendix. Soil quality was considered a moderate to severe limitation to about 35 percent of the area. For the most part these limitations were associated with high levels of gypsum at 30 inches, high water tables, or poor drainage. In the area west of U. S. 285 and north of Loving, these conditions were especially evident (figure 13). About 19 percent of the soils were classified as Group II, with slightly over 13 percent in Group III (table 19). Salinity of the soils in Group III has caused a large percentage of them to be removed from production during recent years, a trend that is likely to continue due to high production costs and low yields and farm incomes realized from them. Flooding of the irrigated cropland, adjacent to the river, is also a limitation.

Quality of the surface water below McMillan Reservoir is somewhat better than that described above, which can be attributed primarily to inflow to the river from springs that have their recharge area west of the river, and to some deposition of calcium carbonate in the river channel. Dissolved solids between Carlsbad and the state line increase significantly with downstream flow. The flow of the Black River is borderline fresh to slightly saline water (20, p. 63). In general, ground water near the Pecos River reflects the quality of the water in the river, except near the Malaga Bend of the Pecos River, about 5 miles east of Malaga, where a body of highly saline ground water exists. Fresh water occurs in the limestone aquifer in the Guadalupe Mountains and saline water occurs near the Pecos River in the same aquifer and in the alluvial aquifer. Water quality was considered to be a moderate to severe limitation on most of the cropland in the basin (figure 13).

Source of Irrigation Water

Surface-water irrigation in the area has been practiced since 1888 (29, p. 142). Most of the surface water is diverted from the Pecos River by the Avalon Dam about

Table 19. Acreage of irrigated cropland by soil productivity groups, Carlsbad Basin, Eddy County, New Mexico, 1967.

Soil Productivity Group	Acres	Percentage
Group I	20,296	55.8
Group II	7,009	19.2
Group III	4,903	13.5
Unreported and out of production	4,190	11.5
Total	36,398	100.0

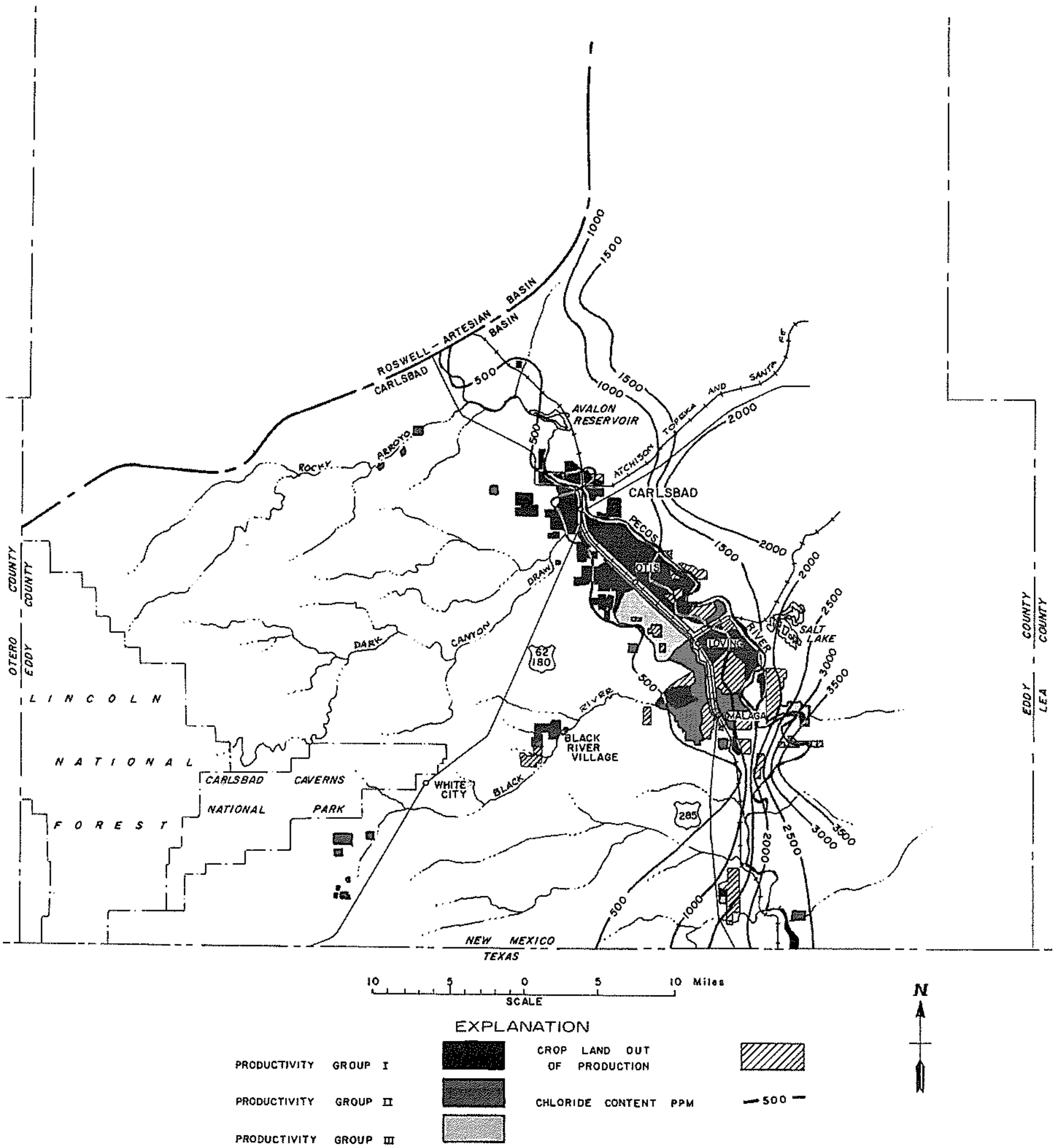


Figure 13. Soil productivity and irrigation water quality, Carlsbad Basin, New Mexico, 1967.

6 miles north of Carlsbad. The storage of the surface water is achieved in three reservoirs, Avalon, McMillan, and Alamogordo. With the main and lateral canals it is possible to irrigate about 26,000 acres of land extending from north of Carlsbad to the vicinity of Malaga. Diversion from the Black River was 6,100 acre-feet in 1967 and irrigated about 1,100 acres. Since the supply of these waters depends on precipitation in the Pecos River Basin, the reliability of this source varies from year to year. Diversion per acre may range from 1.5 to 3.5 acre-feet per year (26, 1).

Surface-water diversion in 1967 was about 75,600 acre-feet with 50,230 acre-feet being delivered to the farms (2). Approximately one-third of the total diversion was lost in conveyance.

Uncertainty of supply was probably one of the main factors contributing to the development of ground water. For many years, surface-water supplies in the Carlsbad Basin were in short supply. Beginning in about 1945 individuals began to develop ground water to supplement surface-water rights. The Carlsbad Underground Water Basin was originally declared in 1947, extended in 1958 and 1964, and now includes about 1,500 square miles (4, p. 59). Ground water in the Carlsbad Basin occurs in limestone of Permian period—Capitan limestone and Tansill formation—and in alluvium of Quaternary period. Water in limestone in the Capitan and Tansill formations constitutes one continuous aquifer, and will be referred to simply as the limestone aquifer. The alluvium includes valley fill along the Pecos and Black Rivers and contains water where sufficiently thick. Both aquifers yield large quantities of water for irrigation north of Malaga (4, p. 59).

Water occurs under artesian pressure in interconnected solution channels in the limestone and moves with relative ease. The aquifer is widespread and permeable, so that rises or declines are relatively uniform over large areas. The decline in the ground-water level was greatest in the vicinity of Otis (figure 14), more than 30 feet, while declines of up to 20 feet occurred further to the south and west. This was mainly attributed to the increased pumpage from the limestone aquifer. Declines in the alluvium in the upper Black River probably resulted from pumpage exceeding recharge, thus reducing the amount of ground water in storage.

By 1967 about 6,860 acres of cropland in the basin were entirely dependent upon ground water for irrigation. About 5,900 acres were irrigated from the alluvium or shallow aquifer and the remaining 950 acres from the limestone or artesian aquifer. About 20,000 acre-feet were pumped from these two sources (table 20).

In 1967 there were 111,467 acre-feet of irrigation water diverted from all sources in the Carlsbad Basin to irrigate the 36,398 water-right acres. This was about 3.1 acre-feet per acre on the water-right acres, 3.5 acre-feet on the cultivated acres, and 4.3 acre-feet on the cropped acres (table 20). Henderson and Sorensen (21) estimated the consumptive irrigation requirements for the Carlsbad Basin at 2.06 acre-feet per cropped acre.

Economic Indicators

Farm size and organization ranges from very small, rural residence and part-time farms near Carlsbad to medium-size commercial operations (larger than 100 but less than 300 acres) throughout the area. A few large commercial farms (over 300 acres) are located mostly in the southern half. A majority of the operations are owner operated. Jackson (26, p. 23) noted in 1961 that 59 percent of the farms were fully owner operated, 23 percent were renter operated, and 18 percent were part-owner operations. The part-time operators are residents of the vicinity who work in the City of Carlsbad or in the mines located nearby. These farms usually engage in production of livestock and crops such as irrigated pasture, alfalfa, and cotton. Interviews with farmers in this area indicated that the part-time farmers usually rent their cotton and alfalfa acreage to the

Table 20. Irrigation water diversion by source, Carlsbad Basin, Eddy County, New Mexico, 1967.

Source of Irrigation Water	Water Diverted	Water-Right Acres		Cultivated Acres		Cropped Acres	
		Total	Per Acre	Total	Per Acre	Total	Per Acre
	(acre-feet)	(acres)	(acre-feet)	(acres)	(acre-feet)	(acres)	(acre-feet)
Surface	37,983	11,196	3.39	9,971	3.81	8,410	4.52
Shallow	17,102	5,910	2.89	5,278	3.24	4,715	3.63
Artesian	2,844	948	3.00	844	3.37	751	3.79
Surface and ground	53,538	18,344	2.92	16,175	3.31	12,396	4.32
Total	111,467	36,398		32,208		26,212	
Weighted average			3.06		3.46		4.25

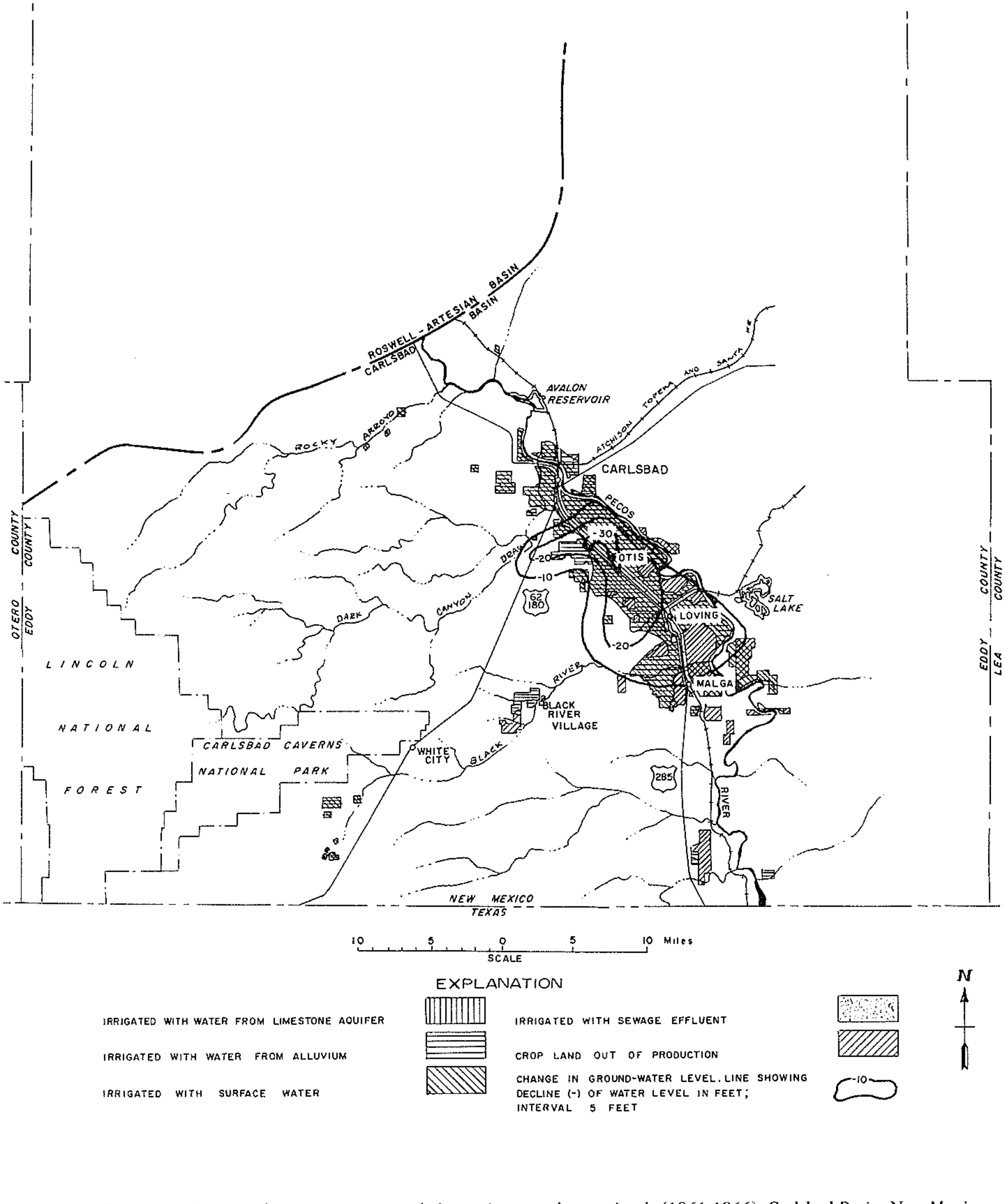


Figure 14. Source of irrigation water and change in ground-water levels (1961-1966), Carlsbad Basin, New Mexico.

commercial farmers and maintain only the livestock (usually grazing) operations which require less intensive care. The larger farms usually concentrate on higher-income cash crops such as alfalfa and cotton.

Field size in the Carlsbad Basin tended to be small, with short irrigation runs, making for more efficient use of the water but adversely affecting machinery efficiency. Field size is possibly dictated by the unreliability of supply and possible shortages of water for irrigation.

In 1967, more than 40 percent of the cropped acres were used to produce cotton, about 46 percent was devoted to alfalfa (table 21), and the remainder was primarily used for small grains, grain sorghum, forage and pasture crops, with minor acreages of nuts, fruits, and vegetables. A fairly large percentage (about 27 percent) of the water-right acres was either diverted or out of production. Of the 25,055 water-right acres in the Carlsbad Irrigation District, only about 17,500 were cropped during 1967 (2).

Equipment size, age, and state of repair tended to vary with farm size in the Carlsbad Basin. Mostly small, obsolete equipment was used on the part-time farms. Although larger equipment size was predominant on the commercial farm, new and modern machinery was not as evident as in the Roswell Artesian Basin. The large commercial farms in the southern and southwestern portion of the basin used four- to six-row, modern equipment. In almost all cases the equipment appeared adequate for the farm size.

The canal system from Lake Avalon to the farms consisted primarily of open unlined canals and laterals. Irrigation systems on the farms were primarily of concrete-lined ditches with earthen field laterals when used. Some underground pipe was used, especially where ground water was included as a source of irrigation water. Areas of poor soil quality appeared to have a lower percentage of lined ditches or underground pipeline systems. Irrigation water appeared to be efficiently used in the basin.

Large variations were noted in the size, type, and repair of farmsteads in the Carlsbad Basin. Those on the small part-time farms varied from expensive homes with modern landscape designs, to a house trailer, to tarpaper frame two-room houses. Farmsteads on the commercial farms were generally of modest design, frame or stucco construction with inexpensively built barns and sheds. Farmsteads on the largest farms tended to have larger and more modern houses, barns, and machinery storage facilities.

Economic Land Classification

The economic land-classification map (figure 15) reflects the interaction of soil and water quantity and

Table 21. Acres of irrigated cropland by use and percentage of designated acreage, Carlsbad Basin, Eddy County, New Mexico, 1967.

Land Use	Acres	Water-Right Acres (percent)	Cultivated Acres (percent)	Cropped Acres (percent)
Cotton	11,111	30.53	34.50	42.39
Alfalfa	12,058	33.13	37.44	46.00
Small grains	739	2.03	2.29	2.82
Grain sorghum	865	2.38	2.69	3.30
Forage crops	968	2.65	3.00	3.69
Pasture	432	1.19	1.34	1.65
Pecans	11	.03	.03	.04
Fruits and vegetables	28	.08	.09	.11
Miscellaneous	0	—	—	—
Subtotal	26,212	72.02	81.38	100.00
Diverted and fallow	5,996	16.47	18.62	
Subtotal	32,208	88.49	100.00	
Out of production	4,037	11.09		
Unreported	153	.42		
Total	36,398	100.0		

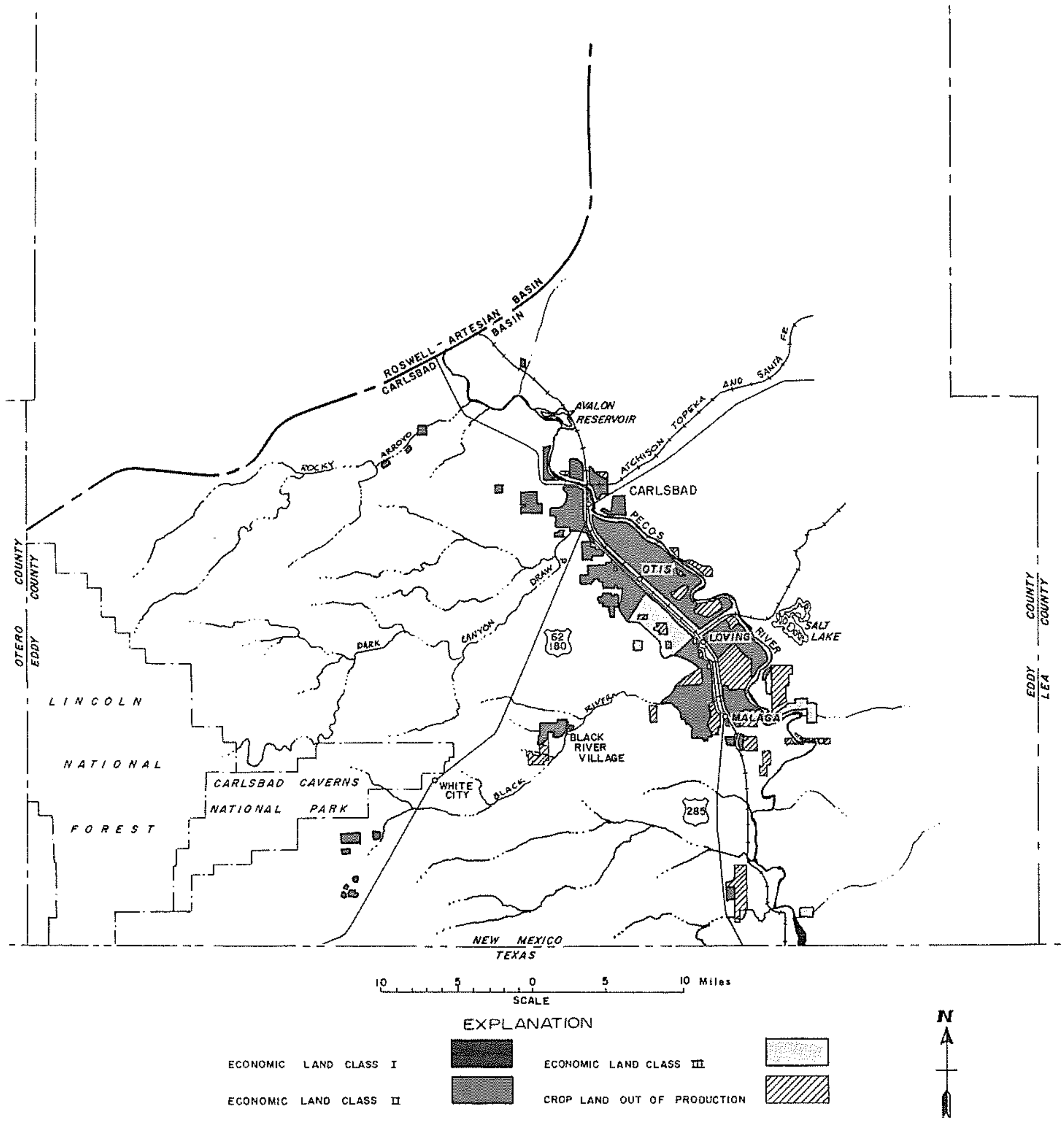


Figure 15. Economic land classification, Carlsbad Basin, New Mexico, 1967.

quality, farm size, and economic indicators. There is no Economic Class I land in the Carlsbad Basin. The major limitations that lowered 75 percent of the irrigated cropland to Economic Class II were those resulting from poor water quality and quantity (table 22). The additional limitations of soil quality lowered approximately 14 percent of the irrigated cropland to Economic Class III. Approximately 11 percent of the irrigated cropland is out of production. This land is located in areas of marginal soil productivity, high levels of salt concentration in irrigation water, and unreliable source of irrigation water.

In 1967 the average net return to land and management per cultivated acre was estimated to be $75 for Economic Class II and $30 for Economic Class III.

Table 22. Acreage of irrigated cropland by economic land classification, Carlsbad Basin, Eddy County, New Mexico, 1967.

Economic Land Class	Acres	Percentage
Class I	0	0.0
Class II	27,064	74.4
Class III	5,144	14.1
Unreported and out of production	4,190	11.5
Total	36,398	100.0

Chapter 7

SUMMARY

The climate in the Pecos River Basin in eastern New Mexico is semiarid. As rainfall averages only about 12 inches annually, irrigation is required for the commercial production of cultivated crops. Increased withdrawals of water, mostly for agricultural use, since the early 1900's have caused a lowering of underground reserves as well as deterioration of water quality in the southern portion of the basin. Water use in New Mexico is regulated by state laws administered by the State Engineer Office. Water policies governed by these laws require continual study and frequent revisions in order to meet the goals of the people and the society to which the laws pertain--specifically, the production of the highest income, for the good of individual farms and the basin as a whole, consistent with the best use of the water resource.

In an effort to provide a basis for more meaningful policy decisions regarding water use in the Pecos River Basin of New Mexico, the New Mexico Water Resources Research Institute was authorized by the Office of Water Resources Research, United States Department of Interior, to carry out a complete study of the Pecos River Basin. As a part of that study an economic classification was made of the irrigated cropland in the Pecos River Basin.

The Pecos River Basin was selected for this study primarily because of its importance to the agricultural sector of the state's economy, and because it includes a cross section of almost every type of problem associated with irrigated agriculture in the state. Because it was a large, established basin, there was an adequate amount of secondary information and it contained a large number of farms.

This study was based on the Cornell system of economic land classification. Through the use of certain primary variables (soil and water quality and/or quantity) and economic indicators, a map was constructed to show areas of different income expectancies within the Pecos River Basin.

The Cornell system of economic land classification provides an effective basis for an attempt to forecast farm income expectancies in the basin. Prior to this study, however, to the knowledge of the authors there had been no attempt to apply the Cornell system to an irrigated cropland area. Due to the nature of the primary independent variables chosen to indicate future income expectancies, it was necessary to incorporate data such as irrigation water source, water quality, and water quantity into the system. This called for the cooperation of many agencies and organizations to supplement the economist's knowledge in areas such as agronomy, geology, hydrology, and water-use law.

A preliminary classification map was constructed showing the geographic location of areas in the basin with varying degrees and combinations of soil, irrigation water quality, and water table decline. The basin was divided into four different sub-areas, each considered to have common similarities regarding location, source of irrigation water, and soil and water quality.

A field survey was conducted to appraise the general economic conditions and the size of farm businesses in each area. The survey included two aerial and one ground examinations of the Roswell Artesian and Carlsbad Basins. A ground survey alone was conducted in the Upper Pecos River and Fort Sumner Basins. Approximately 40,000 miles of travel, 6 hours of flying time, and 300 man days, were required to complete the field survey. Field survey data were used to modify the preliminary classification map to reflect a more meaningful classification of the areas. A computer program was used to group farming areas according to the degree of limitation posed by any different combination of the independent variables and the economic indicators. The final economic classification map was constructed on the basis of results of this procedure.

The Soil Conservation Service provided capability classification data used as a basis for determining the different levels of soil quality and the degree of limitations which might be expected in each of the areas of the basin. It was necessary to consult with New Mexico Extension Service and Experiment Station personnel to verify decisions made with respect to crop yields resulting from different soils, and combinations of soil and water. Additional crop yield data were obtained from Agricultural Stabilization and Conservation (ASC) records in the basin. These soils data were combined to classify irrigated soils into a three-way soil productivity grouping.

ASC aerial photographs were used to locate farm boundaries and to note use being made of irrigated cropland acreage in the basin. Land use was then determined by planimetering acreages according to the designated use observed during the field survey. In this way it was possible to estimate acreages of the different crops in the entire basin.

Many maps and reports furnished by the State Engineer Office and U. S. Geological Survey were most useful in determining the amount of water diverted for irrigation, the source and points of diversion, and water quality in each of the areas in the basin. These two agencies also furnished information concerning the geology and hydrology of the basin, providing a broader base for understanding past as well as expected future changes in water conditions.

A knowledge of water-use law relating to the basin was necessary to allow fuller rationalization of income expectancies in areas having failing wells or poor water quality. Under New Mexico law it is possible to transfer water rights from one farm to another within certain limits, which was often done in areas being removed from production, and it was necessary to take that fact into account in analyzing a particular area.

Factors in Income Expectancy

Little prior knowledge of the effect of soil and water on income expectancies was available at the outset of this study. For the first time in New Mexico, it became necessary to attempt an estimate of these effects in terms of dollars and cents, to use as a basis for income expectancies in the basin. The Department of Agronomy at New Mexico State University provided physical data used to determine the economic effect of different levels of irrigation water applications, irrigation water quality, and soil qualities in the Roswell and Carlsbad Basins.

Although the cooperation of various agencies is of utmost importance to the success of a study such as this, the data must be interwoven with a thorough knowledge of the agricultural business in both the area being studied and the entire economy. Since judgment plays a major role in making the final decision the researcher must be able to take into consideration many characteristics of the farm business in order to predict the outcome of agricultural changes as they affect future expected income.

Management and Farm Size

Appraisal of the farm business includes not only soil and water but the way the farm is handled and appears to respond to a given level of management. The organization of the farm unit with respect to size and type of enterprises should be considered an important indicator of future success since returns from farming stem from both capital and labor. A higher capital-labor ratio is usually associated with large crop-enterprise operations that require added ability in financial management.

Farms in the Roswell Artesian Basin are generally centered around crop production; limited farm size and managerial ability may pose limitations on the opportunities for future financial success. Inability to expand the size of farm units or adapt them to combinations of labor-intense enterprise such as dairy cattle, feeder pig, or vegetable production may limit the future income expectancies of an area.

Management is one of the most important determinants of financial success and must be carefully allowed for in any income expectancy appraisal. Results of this study indicated that the better managers farmed the better land while the less capable managers were usually located on the less productive land. This is consistent with findings of other farm management studies. The researcher's ability to recognize this tendency is very important in mapping income expectancy.

Areas with few limitations as to productivity but limited by farm size may be expected to move up in the classification with consolidation of additional acreage into larger farm units. Farms moderately limited by physical factors may be expected to decline without changes in the operation.

Soil Productivity

About 64 percent of the cropland in the basin is Group I soil and occurs primarily in the Roswell Artesian and Carlsbad Basins (table 23). The Roswell Artesian Basin alone accounts for about 75 percent of the Group I soils. These soils are deep clay loams, considered to be highly productive. While slope presents slight problems on some soils, they are deep enough to allow corrective measures and they respond well to application of improved management practices such as fertilization, crop rotation, and conservation methods.

Table 23. Acreage of irrigated cropland by soil productivity groups, Pecos River Basin, New Mexico.[1]

Area	Soil Productivity Group						Unreported and Out of Production		Total
	Group I		Group II		Group III				
	(acres)	(percent)	(acres)	(percent)	(acres)	(percent)	(acres)	(percent)	(acres)
Upper Pecos River Basin	0	0.0	15,030	75.3	2,020	10.1	2,920	14.6	19,970
Fort Sumner Basin	4,688	47.4	2,053	20.7	1,238	12.5	1,921	19.4	9,900
Roswell Artesian Basin	102,938	76.9	7,287	5.5	11,559	8.6	12,056	9.0	133,840
Carlsbad Basin	20,296	55.8	7,009	19.2	4,903	13.5	4,190	11.5	36,398
Total	127,922	63.9	31,379	15.7	19,720	9.9	21,087	10.5	200,108

[1]Data for Upper Pecos River and Fort Sumner Basins for 1966 crop year, and Roswell Artesian and Carlsbad Basins for 1967 crop year.

More than 15 percent of the soils have moderate limitations restricting maximum production and were classified as Group II. These soils occur in relatively equal proportions throughout the Pecos River Basin. Common problems associated with these soils include moderate slope, shallow depth, and gypsum within 36 inches of the surface. In general they do not respond as favorably to the use of improved management practices as soils in Group I, thus lower crop yields and incomes can be expected on farms with a greater percentage of Group II soils.

Group III soils occur to the greatest extent in the Fort Sumner and Carlsbad Basins and along the Pecos River in the Roswell Artesian Basin. Sandiness and lack of depth are the primary difficulties with these soils in the northern portion of the Pecos River Basin, and high salinity and low permeability may severely restrict the productive capacity of these soils in the southern half of the basin. Almost 10 percent of the cultivated acreage in the basin plus a large percentage of the cropland that is shown to be out of production would be classified as Class III soils.

Water Quality and Quantity

When water of inferior quality is used for irrigation, crop selection is restricted either to salt-tolerant crops such as cotton and barley or to moderately salt-sensitive crops such as alfalfa and most vegetables, with frequent heavy irrigations. In either case certain inefficiencies may exist that directly affect income expectancies.

On the basis of parts per million chloride, irrigation water was categorized into one of these classes: Class I, less than 1,000 ppm chloride; Class II, 1,000-2,000 ppm chloride; Class III, more than 2,000 ppm chloride. Class I water was considered suitable for all crops, Class II water was satisfactory with improved management, and Class III was considered satisfactory as a supplementary source if the primary source was of Class I or II quality.

Irrigation water quality was considered sufficiently important to lower the classification on about one-third of the cropland in the Pecos River Basin. The largest acreages affected were in the Roswell Artesian and Carlsbad Basins. Surface-water quality in the Fort Sumner Basin has begun to decline but at the time of this study it was not considered a limitation.

Quantity of water was used primarily to refer to changes in the ground-water level in the basin and availability of an adequate supply of surface water for crop production. For purposes of this study, irrigation water quantity was categorized into three classes: Class I, greater than 3.0 acre-feet per acre of surface-water diversions and/or water-level declines of less than 20 feet in ground water; Class II, 2.0 to 3.0 acre-feet per acre of surface-water diversions and/or water-level declines of 20 to 30 feet in ground water; Class III, less than 2.0 acre-feet per acre of surface-water diversions and/or water-level declines of more than 30 feet in ground water.

Class I water is generally a suitable amount for maximum economic yields, Class II irrigation water indicates the probability of lowering maximum economic yields, and Class III indicates the probability of uneconomical yields.

Irrigation Water Source

Source of irrigation water varied from one area to another but all parts of the basin received irrigation

Table 24. Irrigation water-right acres and irrigation water diverted by water source and area, Pecos River Basin, New Mexico.[1]

Water Source	Upper Pecos River Basin		Fort Sumner Basin		Roswell Artesian Basin		Carlsbad Basin		Total	
	Water-Right Acres	Diversion	Water-Right Acres	Diversion	Water-Right Acres	Diversion	Water-Right Acres	Diversion	Water-Right Acres	Diversion
	(acres)	(acre-feet)	(acres)	(acre-feet)	(acres)	(acre-feet)	(acres)	(acre-feet)	(acres)	(acre-feet)
Surface	19,730	78,980.0	6,500	33,281.0	6,172	21,616.6	11,196	91,520.7	43,598	225,398.3
Ground	240	900.0	3,400	7,609.0	115,397	359,890.8	6,858	19,946.0	125,895	388,345.8
Surface and ground combined[2]	0		0		12,271		18,344		30,615	
Total	19,970	79,880.0	9,900	40,890.0	133,840	381,507.4	36,398	111,466.7	200,108	613,744.1
Average diversion per water-right acre		4.00		4.13		2.85		3.06		3.07

[1]Data for Upper Pecos River and Fort Sumner Basins based on 1966 crop year; data for Roswell Artesian and Carlsbad Basins based on 1967 crop year.

[2]Diversion is included in ground and surface diversions.

water from both surface and ground sources. Ground-water rights accounted for about 63 percent of the total water-right acres and surface rights about 22 percent, with the remaining 15 percent being a combination of surface and ground (table 24). Ground water accounted for about 72 percent of the total agricultural diversions.

The water rights in the Upper Pecos River Basin are almost exclusively surface rights and accounted for about 99 percent of the irrigation water diversions. In the Fort Sumner Basin about two-thirds of the cropland has surface rights, but approximately 81 percent of the irrigation water originated from surface sources (table 24).

The Roswell Artesian Basin has approximately 133,840 water-right acres, of which about 86 percent has ground-water rights and about 5 percent has surface rights. The remaining 9 percent, or 12,271 acres, has a combination of ground and surface rights (table 24). Ground water was the most important source and accounted for over 94 percent of the water diverted for irrigation.

In the Carlsbad Basin over 30 percent of the cropland has surface rights, about 19 percent has ground-water rights, and the remaining 50 percent has a combination of surface- and ground-water rights (table 24). Approximately 82 percent of the total irrigation water diversion was from surface-water sources and the remaining 18 percent was from ground-water sources.

In general, farms using water from more than one source are considered to have a slight advantage over those using only one source. Farms in the Upper Pecos River and Fort Sumner Basins typically have only one source of irrigation water and cannot supplement existing rights. In the Roswell Artesian Basin there are three sources of irrigation water, with surface sources being of minor importance. However, farms with only surface rights were judged to be severely restricted because of unreliability of the source.

Areas with both alluvium and artesian rights were judged to have a definite advantage over the other cropland, for having a reliable source of irrigation water and, in some areas, irrigation water of higher quality. In the Carlsbad Basin areas having supplementary ground-water rights to surface rights were considered to have a definite advantage over areas having only surface- or ground-water rights. Cropland with surface rights exclusively was considered to have severe limitations because of the fluctuating nature of the supply. Ground-water rights were severely restricted in the basin because of the low quality of this source of irrigation water.

Irrigation Water Diversion

Water diversion per water-right acre varied widely from one sub-basin to another, with the Roswell Artesian Basin having the lowest and the Fort Sumner Basin the highest per-acre diversion at 2.85 and 4.13 acre-feet, respectively (table 24). The Carlsbad Basin was about average and the Upper Pecos River Basin was close to the Fort Sumner Basin with 4.0 acre-feet per acre.

Since "water-right acres" include land that is fallow, diverted, and out of production, the term is not a meaningful reference to water diversions for crop production because irrigation water is not generally applied to such lands. On the basis of cropped acres, water diversion per acre was approximately 30 percent higher than water-right acres. On the basis of cropped acres, the Roswell Artesian Basin diversions were about 26 percent higher than on water-right acres and the Fort Sumner Basin was approximately 58 percent higher. The Carlsbad and Upper Pecos River Basins percentage increase was slightly over the average of the entire basin with 39 and 32 percent respectively (table 25).

Table 25. Irrigation water diversion by areas, Pecos River Basin, New Mexico.[1]

Area Description	Water Diverted	Water-Right Acres		Cultivated Acres		Cropped Acres	
		Total	Per Acre	Total	Per Acre	Total	Per Acre
	(acre-feet)	(acres)	(acre-feet)	(acres)	(acre-feet)	(acres)	(acre-feet)
Upper Pecos River Basin	79,880.0	19,970	4.00	17,050	4.69	15,130	5.28
Fort Sumner Basin	40,890.0	9,900	4.13	7,979	5.12	6,254	6.54
Roswell Artesian Basin	381,507.4	133,840	2.85	121,784	3.13	106,597	3.58
Carlsbad Basin	111,466.7	36,398	3.06	32,208	3.46	26,212	4.25
Total Basin	613,744.1	200,108		179,021		154,193	
Weighted average			3.08		3.43		3.98

[1]Data for Upper Pecos River and Fort Sumner Basins based on 1966 crop year; data for Roswell Artesian and Carlsbad Basins based on 1967 crop year.

In terms of acres produced, alfalfa is the most important crop in the basin, accounting for 37 percent of the water-right acres and 48 percent of the cropped acres (table 26). Alfalfa acreage constituted the largest percentage of all crops in each of the four sub-basins.

Cotton is the second most important crop in terms of acreage, accounting for 21 percent of the water-right acres and 27 percent of the cropped acres. It is produced in three of the four sub-basins but is most important in income generation in the Roswell Artesian and Carlsbad Basins. Cotton accounts for less than 6 percent of the cropped acres in the Fort Sumner Basin.

Cotton and alfalfa together account for 75 percent of the cropped acres in the Pecos River Basin. The remaining 25 percent of the cropped acres was composed primarily of low income-generating crops such as small grains, grain sorghum, forage crops, and irrigated pasture.

Economic Classification and Income Expectancy

About 31 percent of the total acreage in the Pecos River Basin was considered to have only minor income expectancy limitations and was classified as Economic Class I (table 27). All of this land is located in the Roswell Artesian Basin and most of it is being used for full-time commercial farming. Inputs per acre are high, buildings are well kept and in good repair, machinery and irrigation systems are modern, fields are large and well situated for the most efficient use.

Economic Class II includes about 43 percent of the irrigated cropland in the Pecos River Basin. Irrigation water quality, water-level declines, dependability of surface water, soil productivity, and farm size are limiting factors associated with these lands. There is no Class II land in the Upper Pecos River Basin. In the Fort Sumner Basin about 54 percent of the cropland was classified as Class II, primarily because of small farm size and low soil productivity.

In the Roswell Artesian Basin, Economic Class II includes about 40 percent of the land. Irrigation water quality and water-level decline are common problems. Fields are often divided by natural waterways that either cross or lie adjacent to them, resulting in excessive slope which must be corrected by small, odd-shaped fields.

In the Carlsbad Basin about 75 percent of the farmland was classified as Economic Class II. The major limitations are poor water quality and uncertainty of an adequate amount of irrigation water. All cropland in the Carlsbad Basin has moderate limitations because of water quality. Some of the land was lowered for having access to only one source of irrigation water.

In general, farm buildings on Class II farms in the Pecos River Basin are being maintained at levels suitable for commercial farming but seldom at levels comparable to Class I farms. The type of irrigation systems used, age and repair of machinery, and other economic indicators often point to lower expenditures of time and money than in Class I, but higher than in Class III.

Slightly more than 15 percent of the land in the Pecos River Basin had severe limitations and was classified as Economic Class III. In this class many of the farms are small and are operated on a part-time basis. Buildings are often in a state of poor repair and are structurally obsolete, and equipment likewise tends to be old and often out of date. Deficiencies in soil and water quality, lack of a dependable irrigation water source, unfavorable topography, and small farm size were the primary limitations imposed on these lands.

In the Upper Pecos River Basin all of the cropland is Class III. The most severe limitations were farm size and crop yields. Division and subdivision of farms through inheritance has reduced the average farm size to a point where commercial agriculture is virtually impossible. Because of the topography of this basin, shape of fields as well as size was considered a severe limitation. A large number of the farms have been divided into long, narrow strips of land, lowering irrigation efficiency and making it almost impossible to use modern, efficient machinery. Climate limits the length of growing season, which affects yield and choice of crops. Dependability of irrigation water supply was considered to be a moderate to severe limitation on about half of the land and soils a moderate to severe limitation on all of the cropland.

In the Fort Sumner Basin approximately 28 percent of the cropland was classified Economic Class III, primarily because of sandy soils and limited farm size. A large percentage of the ground-water area either had moderate or severe limitations placed on soils.

About 5 percent of the cropland in the Roswell Artesian Basin was classified Economic Class III. Severe limitations imposed by soil, water quality, underground water-table decline, and farm size reduced most of this land to Class III.

Approximately 14 percent of the cropland in the Carlsbad Basin is Economic Class III. The primary restrictions were poor water quality, inadequate source of irrigation water, and low soil productivity.

Many of the farms in the Pecos River Basin in Class III are small part-time farms. As a rule, the state of repair of irrigation systems, machinery, and buildings was not as good as those in Class I and II. Income expectancies measured in terms of net returns to land and management for the basin were estimated to be greater than $100 per cultivated acre for Economic Class I land, between $100 and $35 per cultivated acre for Economic Class II land, and less than $35 per cultivated acre for Economic Class III land.

If ground-water pumpage in the Pecos River Basin exceeds the natural rate of recharge, the natural hydrologic balance has been upset, resulting in decreases in the artesian heads and surface-water flows, increased pumping lifts, and encroachment of saline water into fresh ground-water aquifers (4, p. 36). Continued declines in water levels, surface flows, and encroachment of saline water in the Roswell Artesian and Carlsbad Basins eventually will lower the economic profitability and economic land classification of these areas.

Table 26. Acres of irrigated cropland by use and percentage of designated acreage, Pecos River Basin, New Mexico.[1]

Land Use	Upper Pecos River Basin	Fort Sumner Basin	Roswell Artesian Basin	Carlsbad Basin	Total	Land Use Expressed as a Percentage of Total Acreage: Water-Right Acres	Cultivated	Cropped
	(acres)	(acres)	(acres)	(acres)	(acres)	(percent)	(percent)	(percent)
Cotton	0	371	30,922	11,111	42,404	21.2	23.7	27.4
Alfalfa	6,364	2,792	52,942	12,058	74,156	37.1	41.4	48.0
Small grain	1,455	346	8,520	739	11,060	5.5	6.2	7.2
Grain sorghum	50	718	4,645	865	6,278	3.1	3.5	4.1
Forage crops	1,545	461	6,519	968	9,493	4.7	5.3	6.1
Pasture	3,876	1,293	1,414	432	7,015	3.5	3.9	4.5
Pecans	0	0	1,549	11	1,560	0.8	0.9	1.0
Fruits and vegetables	1,840	153	249	28	2,270	1.1	1.2	1.5
Miscellaneous[2]	0	120	197	0	317	0.2	0.2	0.2
Subtotal	15,130	6,254	106,597	26,212	154,553	77.2	86.3	100.0
Diverted and fallow	1,920	1,725	14,827	5,996	24,468	12.3	13.7	
Subtotal	17,050	7,979	121,784	32,208	179,021	89.5	100.0	
Out of production	2,920	1,921	10,513	4,037	19,391	9.7		
Unreported	0	0	1,543	153	1,696	0.8		
Total	19,970	9,900	133,840	36,398	200,108	100.0		

[1]Data for Upper Pecos River and Fort Sumner Basins for 1966 crop year; data for Roswell Artesian and Carlsbad Basins for 1967 crop year.
[2]Includes castor beans and soybeans.

Table 27. Economic classification of irrigated cropland by areas, Pecos River Basin, New Mexico.[1]

Area	Class I		Class II		Class III		Unreported and Out of Production		Total
	(acres)	(percent)	(acres)	(percent)	(acres)	(percent)	(acres)	(percent)	(acres)
Upper Pecos River Basin	0	0.0	0	0.0	17,050	85.4	2,920	14.6	19,970
Fort Sumner Basin	0	0.0	5,229	53.8	2,750	27.8	1,921	19.4	9,900
Roswell Artesian Basin	61,501	46.0	53,585	40.0	6,698	5.0	12,056	9.0	133,840
Carlsbad Basin	0	0.0	27,064	74.4	5,144	14.1	4,190	11.5	36,398
Total	61,501	30.7	85,878	42.9	31,642	15.8	21,087	10.6	200,108

[1]Data for Upper Pecos River and Fort Sumner Basins based on 1966 crop year; data for Roswell Artesian and Carlsbad Basins based on 1967 crop year.

A systematic program of retiring Economic Class III lands would have the least significant effect on the economy of the basin. The retirement of the 31,642 acres of Economic Class III cropland would release approximately 132,750 acre-feet of irrigation water. This water could be reallocated or used for recharge of ground-water reservoirs or to help stabilize diversions of surface sources. If this alternative were taken, all of the irrigated cropland in the Upper Pecos River Basin, 27.8 percent of the irrigated cropland in the Fort Sumner Basin, 5.0 percent of the irrigated cropland in the Roswell Artesian Basin, and 14.1 percent of the irrigated cropland in the Carlsbad Basin would be retired from crop production.

By transferring irrigation water from Class III to Class II cropland, especially where water quality is a problem in the Roswell Artesian and Carlsbad Basins, a majority of this cropland probably would migrate toward Class I cropland. Potential Economic Class I land in the Roswell Artesian Basin could be developed, thereby increasing the economic return per acre-foot of irrigation water in the Pecos River Basin.

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APPENDIX

SOIL PRODUCTIVITY GROUPS IN THE PECOS RIVER BASIN, NEW MEXICO

Group I

Soils in Productivity Group I have few limitations that restrict their use for irrigated crop production and they are suited to a wide range of crops, especially those common to the Roswell Artesian Basin. The soils are generally deep, well drained, and easily worked. The productive capacity is high since they either have a high fertility level or they tend to respond well to fertilizer inputs.

Some soils in Group I have certain slight limitations that reduce the choice of plants or require more careful management practices than others, but they have few limitations as a group, and in most cases corrective management practices are easy to apply. The following limitations may occur either singly or in combination 1) gentle slopes; 2) moderate susceptibility to wind and water erosion, or moderately adverse effects of past erosion; 3) less than ideal soil depth; and 4) somewhat unfavorable soil structure and workability. These soils may require special soil-conserving cropping systems, soil conservation practices, or tillage methods, depending on the occurrence and severity of the above limitations. In some parts of the basin, such practices as terracing, bordering, strip cropping, fertilization, green manure crops, and more specialized land planning may be required. The exact combination of practices varies from area to area depending on the soil characteristics and farming systems. A majority of the irrigated acreage in the basin occurs as Group I.

Table 28. Soils in Productivity Group I, Pecos River Basin, New Mexico, 1967.

SCS Map Symbol	Soil Name	Soil Description
3321/A	Reagan loam 0 to 1 percent	Deep, well-drained, medium-textured alluvial soils that are almost level and high in fertility. Occur regularly throughout the Roswell Artesian Basin.
43F1/B 3321/B 33F1/B 33F1/A 43F1/A	Reagan loam 1 to 3 percent	Similar to soils described above except for slope. However, due to their depth they can be leveled. Productivity does not differ greatly from the above.
331u/A 4331u/A 4331/A 4331u/A	Harkey very fine sandy loam 0 to 1 percent Harkey sandy loam	Deep, medium-textured soils. Well-drained, highly fertile, but occurring in low-lying positions and thus are sometimes flooded. Structure of some soils in this group limits choice of crops which may be grown on them.
3221/A 3221/A	Pima loam 0 to 1 percent	
3321k/A	Karro loam 0 to 1 percent	

Group II

Soils in Group II have certain moderate restrictions that narrow the choice of crops, require special management practices, or both. Conservation and management practices are usually more difficult to apply and maintain on these soils than on soils in Group I. Limitations of soils in Group II restrict the amount of clean tillage, and the timing of planting, tillage and harvesting, or some combination of these practices. The limitations may result from the effects of one or more of the following: 1) moderately steep slopes; 2) high susceptibility to water or wind erosion or severe adverse effects of past erosion; 3) occasional overflow accompanied by some crop damage; 4) slow permeability of the subsoil; 5) shallow depths to bedrock, hardpan, or claypan that limit the rooting zone and water storage; 6) low moisture-holding capacity; 7) low fertility not easily corrected; and 8) moderate salinity or sodium content.

Soils in Group II commonly require severe grade leveling and bench terraces in the basin. Land cuts made during the leveling process may expose underlying deposits of caliche, necessitating more careful management practices. In some irrigated areas of the basin, part of the soils in Group II have limited use because of high water table, slow permeability, and the hazard of salt accumulation. Each distinctive kind of soil in Group II has one or more special managerial requirements for successful use, but the number of practical alternatives for farmers with average managerial ability is less than that for soils in Group I.

Table 29. Soils in Productivity Group II, Pecos River Basin, New Mexico, 1967.

SCS Map Symbol	Soil Name	Soil Description
33F2/A 33G1/A	Atoka loam 0 to 1 percent	Similar to soils in Group I except that they are only moderately deep–20 to 36 inches. They are underlaid by indurated caliche.
33G1/As 33G1/Asw	Reagan loam saline	Similar to soils in Group I except that they are underlaid by gypsum which may cause salinity problems. Water-holding capacity is not usually as high as for soils in Group I.
33G1/N	Karro loam saline	
33F2/B 43F2/B	Atoka loam 1 to 3 percent	
43F2/A	Atoka loam 0 to 1 percent	
2221/A	Pima clay loam	
2221/As	Pima clay loam gray variate	Generally medium-textured. Subsoils are sandy loam. Wind erosion is a primary problem.
4441/A	Anthony sandy loam 0 to 1 percent	
3231/A	Manzano loam	Thick, brown, heavy loam to light clay loam A and B horizons with faint lime segregation in the lower part of the B horizon and in the C horizon.
2231/2B 120/B	Loma clay loam	Moderately dark-colored loam to light clay loam A horizons; heavy clay loam to light clay blocky B horizons and moderate accumulation of $CaCO_3$ in the C horizon.
3331/B 3331/2B 3331/B-1	San Jose loam	Reddish-brown, calcareous loamy A horizon; light reddish-brown calcareous moderately coarse-textured C horizon.
2221/2B 3221/B	Lacita silty clay loam	Light reddish-brown, calcareous silt loam to light silty clay loam A horizon; reddish-yellow, calcareous silt loam to light silty clay loam AC horizon; light reddish-brown, calcareous, heavy silt loam C horizon.

Group III

Soils in Group III have severe limitations that restrict the choice of crops, require careful management, or both. Crop selections are more limited for these soils than for soils in Group II. Conservation practices are more difficult to apply and maintain. Soils in Group III may be well suited for only one or two of the common crops, or the harvest may be low in relation to inputs over a long period of time. Use for cultivated crops is limited as a result of one or more permanent features such as 1) steep slopes, 2) severe susceptibility to water or wind erosion, 3) severe effects of past erosion, 4) shallow soils, 5) low moisture-holding capacity, 6) frequent overflows accompanied by severe crop damage, 7) excessive wetness with continued hazard of waterlogging after drainage, and 8) severe salinity or sodium content.

Soils in Group III account for only a small percentage of the total acreage of irrigated cropland in the basin, and many cases occur only as small isolated areas within a total farming operation. However, where they do occur their influence is exerted on the surrounding farm land since they are subject to wind and water erosion and require more special management than either of the other groups.

The above-described soil productivity groups were defined for purposes of this research and are not necessarily consistent with Soil Conservation Service classifications.

Table 30. Soils in Productivity Group III, Pecos River Basin, New Mexico, 1967.

SCS Map Symbol	Soil Name	Soil Description
32G2/A	Russler loam	Deep and moderately deep soils with a silty surface and underlaid by gypsum at depths ranging from 20 to 36 inches. Slowly permeable and usually saline.
32G2/A 32G1/A 32G2/A		
32G2/Bs 32G1/A		
2111/A 2111/Asw 2111/At2w,s3 2111u/A	Arno	Deep, fine-textured, slowly to very slowly permeable; well-drained but may become poorly drained and saline.
4441/B	Anthony sandy loam 1 to 3 percent	
03F	Upton	Medium-textured, moderately permeable, shallow, level soils.
33F3/A 33G3/A 33G3/Asw	Reeves loam shallow	
3231/B	Manzano loam	Thick, brown, heavy loam to light clay loam A and B horizons; faint lime segregation in the lower part of the B horizon and in the C horizon.
2231/C 120/C	Loma clay loam	Moderately dark-colored loam to light clay loam, A horizons; heavy clay loam to light clay blocky, B horizons; moderate accumulation of $CaCO_3$ in the C horizon.
11C1/2B 1111/C	Onava clay	Moderately dark-colored, heavy clay loam to light clay A horizons over clayey B and C horizons. Shale and/or limestone may occur below 40 inches.
4441/B 4441/2B	Pajarito sandy loam	Yellowish-red, calcareous, loamy fine sand to sandy loam A horizons; yellowish-red, calcareous, sandy loam B horizons.

Table 31. Maximum expected yields for selected crops on different economic land classes in the Pecos River Basin, New Mexico.

Economic Land Class	Crop Yield per Acre					
	Cotton	Alfalfa	Grain Sorghum	Forage Crops (Silage)	Small Grain	Pasture
	(pounds lint)	(tons)	(pounds)	(tons)	(bu.)	(aum)
I	1,200	11.0	8,600	28.7	85	20
II	1,050	9.5	7,260	24.8	65	14
III	900	6.7	6,050	22.5	45	10