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Effects of water prices and supplies on crop acreage in Westlands Water District

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EFFECTS OF WATER PRICES AND SUPPLIES ON CROP ACREAGE IN WESTLANDS WATER DISTRICT

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ABSTRACT

EFFECTS OF WATER PRICES AND SUPPLIES ON
CROP ACREAGE IN WESTLANDS WATER
DISTRICT

by Arleen Kiyomoto

The Federal Central Valley Project (CVP) is California's largest water supplier. Critics have argued that CVP supplies have not been put to economically efficient uses due to tax subsidies. The largest CVP contractor is the Westlands Water District (WWD), whose main customers are agricultural users.

This study examined whether water was used efficiently by agricultural users in the WWD service area. The use of water was considered economically efficient if it was used to grow crops that were high in value or low in water needs.

Multiple regression analyses were conducted in three investigations to determine the effects the following had on cropping patterns: (1) water supplies, water prices, and crop values; (2) the 1987-1992 drought; and (3) the State Drought Water Bank.

The results provided limited support to the claim that water would be used more efficiently by the agricultural sector as supplies grew scarcer or prices approached their true costs.

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LIST OF ABBREVIATIONS

AB9	California State Assembly Bill No. 9
AB10	California State Assembly Bill No. 10
AB12	California State Assembly Bill No. 12
AF	acre-feet (of water)
ASCS	Agricultural Stabilization and Conservation Service of the U.S. Department of Agriculture
Bay	San Francisco Bay
Bay/Delta Estuary	San Francisco Bay/Sacramento-San Joaquin Delta Estuary
BDOC	Bay Delta Oversight Council
Board	California State Water Resources Control Board
Bureau	U.S. Bureau of Reclamation
CCC	Commodity Credit Corporation
CEQA	California Environmental Quality Act
crop-water year	crop production-water supply year
CVP	Federal Central Valley Project
CVPIA	Federal Central Valley Project Improvement Act of 1992
DFG	California Department of Fish and Game
DWR	California Department of Water Resources
D1630	Water Right Decision 1630

EPA	U.S. Environmental Protection Agency
ESA	Federal Endangered Species Act
ET	evapotranspiration
Interior Department	U.S. Department of the Interior
MAF	million acre-feet
MET	maximal seasonal evapotranspiration
N/A	not applicable or not available
n.d.	no date of publication or writing provided in resource material (for Reference List and parenthetical references)
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
n.p.	no publisher or place of publication provided in resource material (for Reference List)
n.v.	no volume provided in resource material (for Reference List)
PEIS	Programmatic Environmental Impact Statement
RRA	Federal Reclamation Reform Act of 1982
SWB	California State Drought Water Bank
SWP	California State Water Project
UCAIC	University of California, Agricultural Issues Center
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
WWD	Westlands Water District

CHAPTER 1

INTRODUCTION

California's total developed water supply comes from surface streamflow, groundwater, and imports from out of the state. The Federal Central Valley Project (CVP) is the state's largest water supplier and accounts for 21.7%, or a little over 7 million acre-feet (MAF) per year, of the total water supply. The California State Water Project (SWP) provides 7.4%, or almost 2.5 MAF/year (Howitt, Moore, and Smith 1992, 3). Groundwater provides approximately 48%, or about 16 MAF/year, of the total supply. Another 4.4 MAF/year have been diverted from the Colorado River (University of California 1992).

Approximately 27 MAF of water per year are used for crop production in the state, while approximately 6 MAF/year are used by the urban sector for residential, commercial, and industrial needs (State of California, California Environmental Protection Agency, State Water Resources Control Board 1992, 9, 18).

A major criticism of the Federal Central Valley Project and the California State Water Project has been that subsidized water supplies from these projects have not been put to economically efficient uses. The claim has been that these supplies have been wasted on low-value or water-intensive uses because the users do not pay the full cost of making them available. Agricultural users have been a main target of this criticism. Furthermore, water marketing has been proposed as a major resource management strategy for allocating or reallocating California's limited supplies of developed water.

Objectives of this Study

The general objective of this study was to investigate whether or not agricultural water users in the Westlands Water District (WWD) service area of the San Joaquin Valley have used their water supplies in an economically efficient manner. If water supplies have not been used efficiently, what conditions would prompt efficient use to occur? The use of water is considered to be economically efficient if it is used to grow crops that are either high in value or low in water needs.

One specific objective of this study, addressed in Chapter 5, was to examine the effects that pricing and availability of supplies from each water supply source could have had on the cropping patterns of the WWD service area, and to then compare the results for all of the sources. Water supply sources consisted of CVP water, groundwater within the service area, water transfers from other water districts, transfers from the State Drought

Water Bank (SWB), and transfers from the CVP Water Bank. Part of the objective was to ascertain the extent to which higher water prices caused acreage to decrease for crops that are high in water needs. Also, part of the objective was to determine the extent to which decreased water supplies caused acreage to decline for crops that are high in water needs.

A second objective, addressed in Chapter 6, was to examine the impacts that the California drought of 1987-1992 could have had on crop acreage in the service area. As inexpensive sources of water supplies grew scarcer, did acreage expand for higher-value crops or crops with lower water requirements?

A third objective, addressed in Chapter 7, was to investigate the impacts that the SWB could have had on the cropping patterns in the service area. Because large quantities of water were made available for transfer through the SWB, and the prices of these supplies were closer to the true costs of making water available than the prices of subsidized supplies, SWB transactions were expected to cause changes in crop acreage for the importing region.

Investigations Conducted to Meet Objectives

Separate investigations were conducted to meet each objective. All three investigations relied on statistical methodologies that involved multiple regression analyses. However, the first objective was addressed by conducting time series regressions, while the other objectives were addressed by conducting cross section regressions.

In Chapter 5, Model 1A is specified for one set of time series regressions, which utilized 23 years of historical data from 1970 through 1992. Model 2A is specified for a second set of time series regressions, which utilized 15 years of historical data from 1978 through 1992. The explanatory variables included the availability and costs of WWD's water supplies, and the prices of crops received by farmers in the WWD service area. The dependent variable consisted of crop acreage. Periods of drought and normal rainfall were both included in the regression sets, but these time periods were not specifically compared to each other. Each set consisted of 15 regressions. One regression was run for every crop that was included in this investigation.

In Chapter 6, Models 1B-4B are specified for four cross section regressions. The models focused on a comparison between two specific time periods, six years of drought, which occurred from 1987-1992, and six years prior to this drought. The independent variables consisted of crop characteristics such as crop values during the pre-drought period, changes in crop values between the pre-drought and drought periods, water requirements, eligibility of crops to participate in government support programs, and the loan risks of crops. The dependent variable consisted of changes in crop acreages between both time periods. Each regression utilized data for the variables across all crops that were included in this investigation. (This is in contrast to the time series regressions in Chapter 5. Each time series regression utilized data for the variables across all years that were included in that investigation.)

In Chapter 7, Models 1C and 2C are specified for two cross section regressions. The models focused on a comparison between a two-year period for 1991-1992 when the SWB was in operation and a two-year period just prior to the establishment of the SWB. (Except for the differences in time periods and the exclusion of the variables for the government support programs, the variables in this investigation were very similar to the variables in the Chapter 6 investigation.)

Overview of Background Chapters

Chapter 4 lays the foundation for all three investigations by providing background information on some of the variables that were included in the models. This chapter discusses the farmer's decision to produce a commodity; the factors that affect the output of the commodity; the role that water plays in crop production and its effects on yield; how the agricultural loan process can hinder or encourage production; and how government support programs can affect crop acreage.

Chapter 3 gives an overview of the subject and site of this study, namely, the Westlands Water District and its service area. It explains WWD's entitlements to CVP water, WWD's system of allocation, and water rates. This chapter also describes the different sources of water, crop production, and water use in the service area.

Finally, Chapter 2 points to the importance of this study by discussing California's water supply problems. It gives a description of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, which has been the major focus of the problems because it serves as the state's largest source of developed water supplies. This chapter states that California's total water supply has been and will continue to be inadequate to meet demand; the drought of 1987-1992 exacerbated the problems that were already in existence; and as environmental, agricultural, and urban interests competed for limited water supplies, government officials were also in conflict over how to allocate and regulate the supplies. This chapter also describes how the passage of the Federal Central Valley Project Improvement Act of 1992 impacts the availability of CVP water supplies, the users who depend on them, and the environment.

CHAPTER 2

THE DEBATE OVER CALIFORNIA'S WATER SUPPLY PROBLEMS

Water Supply Inadequate to Meet Demand

California's total water supply has not been able to keep up with the demand even during years of normal precipitation. During the past twenty years, competition for water has been increasing among urban, environmental, and agricultural interests. Meanwhile, the total usable water supply has been reduced. In addition to the drought of recent years, some of the rights to the Colorado River and Mono Basin have been lost. The amount of groundwater that has been extracted is greater than the amount that has been recharged. Saltwater intrusion from overpumping and pollution from chemicals have affected the usability of some aquifers.

Water shortages in California are expected to continue into the next century. State water officials announced that a shortfall, ranging from 2 to 4 MAF/year, is anticipated for years of normal precipitation by the year 2020 (San Jose Mercury News, 2 December 1993, 3B). This prediction was based on the expected growth in population from the current 31 million to 49 million, on the assumption that water demand will range from 67.4 to 69.4 MAF/year, and on the expectation that the average annual water supply will increase to 65.2 MAF.

San Francisco Bay/Sacramento-San Joaquin Delta Estuary

The San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay/Delta Estuary) has been the center of controversy in California's water wars for the past twenty years. The Bay/Delta Estuary serves as California's single largest source of developed water supplies. It provides drinking water for approximately 20 million people and irrigation water for thousands of farmers. The Bay/Delta Estuary also serves as a habitat to more than 120 species of fish and wildlife (San Jose Mercury News, 16 December 1994, 1A, 30A). These uses have often been in conflict with one another. The battle has been fought among environmentalists, urban interests, and agricultural interests, and not between the northern and southern halves of the state as in decades past. Each of the three groups is politically powerful enough to block the goals of the other two, making it extremely difficult for them to resolve their conflicts.

The Bay/Delta Estuary is a hydrologically complex system (State of California, California Environmental Protection Agency, State Water Resources Control Board 1992, 27-28, 43). Under natural conditions, the Sacramento

River flows south into the Estuary, the San Joaquin River flows north into the Estuary, and they both proceed west toward Suisun Bay. The Old and Middle Rivers, which are tributaries of the San Joaquin River, flow northward. A small portion of the Sacramento River flows through the Georgiana Slough and into the central Delta. Saltwater from the Pacific Ocean moves inland through San Francisco Bay (Bay). The normal mixing zone where salt and fresh waters meet is in Suisun Bay, which provides a breeding ground for the Bay/Delta Estuary's aquatic food chain.

The Bay/Delta Estuary has been highly altered from its natural state due to the operation of major water supply conveyance facilities, which consist of manmade channels in the Delta, dams, reservoirs, canals, and pumps (State of California, California Environmental Protection Agency, State Water Resources Control Board 1992, 27-28). Some water diversions occur upstream from the Delta. The SWP, which is operated by the California Department of Water Resources (DWR), and the CVP, which is operated by the U.S. Bureau of Reclamation (Bureau), are the major exporters of water from the Delta. Their pumps, located in the southern Delta, transport water from the Sacramento River watershed in the northern part of the state to areas south and west of the Delta. When these pumps are in operation, the lower portions of the Old and Middle Rivers draw water from the central Delta by reversing their courses in a southerly direction toward these pumps. Under the combined conditions of high pumping rates and decreased inflow, the San Joaquin River also reverses its direction of flow and draws water upstream from the lower Sacramento River or Suisun Bay. High volumes of uncontrolled flows that once entered the Estuary during the winter and spring currently enter it as regulated flows during other parts of the year. The total annual fresh water outflow from the Delta to the Bay has declined due to upstream diversions and export pumping since the major water supply facilities were built. The reduced outflow has caused increased salinity levels in Suisun Bay and Suisun Marsh as well as lowered levels of dissolved oxygen.

Studies conducted by biologists from government agencies and the academic community have indicated that upstream diversions and the export of water from the Delta are the primary causes of declining populations of fish and wildlife in the Bay/Delta Estuary (State of California, California Environmental Protection Agency, State Water Resources Control Board 1992, 27-43). Young fish, eggs, and larvae are diverted or entrapped by the CVP and SWP pumps, and by unscreened agricultural diversions in the Delta. Low flows or reverse flows have hindered downstream migration of young winter-run Chinook salmon, fall-run Chinook salmon, and striped bass. They have also been detrimental to successful spawning and survival of eggs and larvae in the river by interfering with upstream migration of the adults, causing water temperatures to increase, and causing eggs or larvae to settle to the bottom. Increased salinity levels are blamed for the decreased production of microscopic plants, which serve as the base of the Bay/Delta Estuary's food chain; the degradation of habitat for rare, threatened, or endangered species of plants and animals; and the declining populations of the Delta smelt and the Sacramento split-tail fish. Suisun Marsh is considered to be an important habitat for the waterfowl of the Pacific Flyway, and there is concern that the increased salinity levels in the Marsh are interfering with the production of their food. Under the authority of the Federal Endangered Species Act (ESA), the U.S. Fish and Wildlife Service (USFWS) listed the Delta smelt as a threatened species on the Endangered Species List in March 1993 and reclassified the winter-run Chinook salmon from threatened to endangered in December 1993. The Sacramento split-tail was expected to be added to the list as a threatened species, but Federal wildlife officials postponed the decision in December 1994. They have also been considering a dozen other species as candidates to be listed. Designations of species as endangered or threatened allow officials to implement special protective measures to reverse the population declines of listed species. The National Marine Fisheries Service (NMFS) and the USFWS have exercised their authority under the ESA to institute regulations on reverse flows; river pulse flows; and the timing, rate, and amount of pumping from the Delta. As a result, the reductions in water supplies that were imposed during the drought continued for urban and agricultural users even after the drought was declared over. Because of regulatory restrictions, water deliveries amounting to full entitlements are no longer expected in the future during years of normal precipitation.

The California Drought of 1987-1992

The six-year drought, which occurred in California from 1987 through 1992, was considered to be severe. While State officials classified the San Joaquin River Basin as being critically dry for all six years, they classified the Sacramento River Basin as being critically dry for four years and dry for two years (State of California, California Environmental Protection Agency, State Water Resources Control Board 1992, 29). From 1987 through 1990, rainfall ranged from 61% to 86% of normal (or historical average), and runoff ranged from 45% to 70% of normal (State of California, Department of Water Resources, State Drought Center 1991, vii). By February 1991, water supply conditions were worse than they had been during any of the four prior years or during the drought of 1977. Statewide, snowpack and runoff were extremely low, precipitation was

25% of average, and reservoir storage was down to 50% of average with major reservoirs at record low levels (Howitt, Moore, and Smith 1992, 3; State of California, Drought Action Team 1991, i, 3, 7-10).

Both the SWP and the CVP provided full water deliveries to urban areas from 1987 through 1990, but they met all agricultural demands only during the first three years of the drought. In 1990, reductions in deliveries to the agricultural sector ranged from 25% to 50% of entitlements (State of California, Drought Action Team 1991, 8). Prior to this, the first and only delivery cutbacks for both water projects were during the drought of 1977 (State of California, Department of Water Resources, State Drought Center 1991, 1). In February 1991, DWR announced that SWP deliveries to urban areas would be limited to 10% of their entitlements and that no water would be delivered to the agricultural sector (State of California, Department of Water Resources 1992, 1). In 1992, SWP deliveries were reduced by 55% (McClurg 1992a, 9). In both 1991 and 1992, reductions in CVP deliveries ranged from 25% to 75% of entitlements (McClurg 1992a, 9; State of California, Department of Water Resources 1992, 1).

In addition to the diversions and pumping of large quantities of water, the drought has been another major contributor to the ecological decline of the Bay/Delta

Estuary. It contributed to the movement of the normal mixing zone of salt and fresh waters in Suisun Bay by as much as 10 miles inland toward Sacramento, to the increased salinity levels of the lower San Joaquin River, to the lower quality of drinking and irrigation water supplies, to the decline of fish populations, to the reduction of Delta inflows and outflows, and to higher demands for water supplies (San Jose Mercury News, 2 November 1993, 1A, 14A; State of California, California Environmental Protection Agency, State Water Resources Control Board 1992, 30; State of California, Drought Action Team 1991, 18, 25).

Although water rationing programs were enacted, other responses to the drought created further problems and concerns. During the early years of the drought period, water that was stored in some of the CVP and SWP reservoirs was drawn down to low levels with the hopes that the drought would not continue (State of California, California Environmental Protection Agency 1992, 65; State of California, Department of Water Resources, State Drought Center 1991, viii; State of California, Drought Action Team 1991, vii, 18-19, 25). This low carryover storage meant that less water was available for each of the subsequent years to control salinity in the Delta and to meet water demands, that water supply reliability was reduced, and that survival of downstream fish was potentially threatened by a rise in water temperatures. Urban water suppliers and farmers responded to the drought by relying more heavily on groundwater extraction. Groundwater tables dropped, creating problems with groundwater quality, causing a need to deepen some existing wells, and raising the potential for land subsidence.

Following an above-average rainfall during the winter of 1992-93, Governor Wilson declared an official end to the six-year drought in February 1993. However, the shortfall in water deliveries continued because of the need to replenish reservoirs, maintain adequate carryover storage, recharge groundwater basins, and provide environmental protection (San Jose Mercury News, 16 February 1993, 1A, 12A; San Jose Mercury News, 25 February 1993, 3B). Furthermore, another year of drought occurred after the winter of 1993-94 had produced below-average levels of rainfall and runoff from snowmelt. Out of the twenty years prior to the winter of 1994-95, the total number of drought years reached eight.

Conflicting Positions Held by Interest Groups

During the drought years, an unusual coalition formed among environmentalists, fishermen, businesses, and some cities in the state. These interest groups have been angry with the agricultural industry, which had been using over 80% of California's water supply while generating only 4% of the state's economy (San Jose Mercury News, 31 October

1992, 20A). Business and urban government leaders have feared that water shortages would not only limit economic growth, but would also cause companies and jobs to leave the state. In support of a position held by environmental groups, they have been in favor of making more water available to cities by transferring it from agricultural areas (Schmidt and Cannon 1991). A representative of Silicon Valley high-tech companies justified this position by claiming that these companies produce $34 billion in goods annually, an amount that is nearly double the state's agricultural production (San Francisco Chronicle, 14 February 1992, A20). Threatened by bankruptcy due to declining populations of salmon, commercial fishermen and recreational anglers also joined forces to fight agricultural water use and to support efforts at increasing water flows in the state's rivers for the purpose of promoting fish survival.

Critics of the environmental position have argued that instead of taking water away from users to make more of it available for fish and wildlife, other measures that are adequate to promote fish and wildlife survival should be followed (San Jose Mercury News, 22 June 1992, 6A). Such measures include installing new screens to prevent fish from being drawn into the pumps, providing more gravel at spawning grounds, and making physical improvements to allow water to flow through the Delta more easily. The critics have also advocated increasing the water supply by constructing more canals and reservoirs.

Other criticisms regarding the reduction of water supplies to users as a way of providing environmental protection have centered around the methods that were used to determine the extent and cause of declining fish populations (San Jose Mercury News, 26 March 1993, 3B; San Jose Mercury News, 13 June 1994, 3B; Sheely 1993; State of California, California Environmental Protection Agency, State Water Resources Control Board 1992, 38-39; Turnquist 1993). Users have complained that the official numbers were derived from sampling methods and mathematical models that were based on faulty underlying assumptions. They have also been critical about the emphasis placed on water diversions as the cause of the dwindling numbers of fish. They have advocated that other factors should be explored such as water pollution from all sources, logging practices that destroy spawning grounds, poaching, changes in the food chain, disease, and predation by other fish such as the nonnative striped bass. Furthermore, a study that was conducted later by the USFWS failed to confirm previous claims of a connection between fish populations and the diversion of water (San Jose Mercury News, 26 September 1994, 3B).

Agricultural interests have been especially critical about the cutbacks their industry has received in water supplies (Bohigian n.d.c., 4-5; San Francisco Chronicle, 11 February 1992, A13, A14; San Jose Mercury News, 15 February 1992, 1B, 2B; San Jose Mercury News, 22 June 1992, 1A, 6A; San Jose Mercury News, 9 October 1992, 1A, 28A; San Jose Mercury News, 13 March 1993, 3B; San Jose Mercury News, 18 September 1993, 3B; San Jose Mercury News, 15 February 1994, 1B, 4B). Farmers have had to face larger cutbacks than urban areas, and they claimed that the State never built the canals and reservoirs that it had promised. Six years of drought were followed by one year of above-average precipitation with the state's rainfall being 150% of normal during the winter of 1992-93 (San Jose Mercury News, 25 April 1993, 3B). Yet, reductions in agricultural water allocations continued because of measures to protect the environment. Furthermore, the combination of western water reform and environmental regulations caused uncertainty in future allocations for farmers, and it appeared unlikely that they would ever again receive their full entitlements. Some agricultural water representatives acknowledged the need to protect the environment, but expressed their desire to see that social and economic needs of other water users be balanced with those of the environment. Other farm interests argued that with continued cutbacks in their water supply, they would not be able to recover from the economic losses they already sustained from the drought. They claimed that conditions would worsen as crop production decreased and more land is fallowed. They argued that land values would decline even more than they already had, that the costs of pumping groundwater would continue to increase as groundwater supplies became scarcer, and that bank loans would become more difficult to secure. It was also suggested that more land would be used to grow low-value crops that have low water requirements. Meanwhile, farmers would continue to face fixed costs for mortage, equipment, taxes, insurance, and salaries. They argued that as a result, more farmers would face foreclosures or bankruptcy. Furthermore, the economic impacts would include farm workers, truckers, pilots, suppliers of agricultural inputs, grocers, schools, and bankers.

Critics of agricultural water use have pointed out that despite the cutbacks in water supplies, California's total farm income continued to rise during the early years of the drought, reaching a record of $18.9 billion in 1990 (San Jose Mercury News, 22 June 1992, 1A, 6A). The break in the trend occurred when total cash receipts dropped by $1 billion to $17.9 billion in 1991, according to the State Department of Food and Agriculture (San Francisco Chronicle, 6 February 1992, C1, C14). However, the decline was not only a result of a fifth year of drought. It was also due to the freeze in December 1990 and the whitefly infestation in November 1991. The department's senior economist stated that the 1991 decline was much less than what had been predicted the previous year. He credited this outcome to the diversity of crops grown. In addition, he said that farmers adopted water conservation measures and switched to crops with lower water requirements. He also acknowledged that farmers depended more heavily on groundwater supplies.

Those who have opposed the use of federally subsidized water by farmers have called for a more rational water distribution system in which water would be used for the greatest economic benefit (San Francisco Chronicle, 18 February 1992, A4; San Jose Mercury News, 22 March 1992, 6C; San Jose Mercury News, 18 September 1993, 3B). These critics have claimed that providing water at below-market prices allows farmers to waste it on low-value, water-intensive crops. To encourage conservation and the use of water for higher-value uses, some of these critics have advocated that farmers be forced to pay the full costs of their water, while others have pushed for a more widespread water market system. Because water subsidies enable consumers to purchase food at lowered prices, farmers have found their opponents' attitudes to be "ironic," especially of those who represent the urban interests.

Regulatory Agencies and Government Officials

State and Federal officials who are responsible for protecting water resources, fish and wildlife resources, or the distribution of California's water supplies have all agreed at one time or another that the export of water from the Delta has had detrimental effects on various fish species. However, some officials have been in conflict with each other over the specifics of how to deal with this issue and over water supply delivery amounts or cutbacks to the three major competing interest groups. These groups have contributed to the conflicts through political pressures, lawsuits, and threats of lawsuits.

After almost two years of hearings, the California State Water Resources Control Board (Board) proposed new standards for the Bay/Delta Estuary in 1988 during Governor George Deukmejian's administration. The protection plan was withdrawn after heavy criticisms were voiced by agricultural and urban interests.

Based on recommendations by his own water task force, Governor Pete Wilson announced a plan in April 1992 for ending the twenty-year-old conflict over the Bay/Delta Estuary water supplies and for ensuring that the state's water supply will be able to meet growing demands into the next century (San Francisco Chronicle 6 April 1992, A1, A12; San Francisco Chronicle, 7 April 1992, A1, A12; San

Jose Mercury News, 22 June 1992, 1A, 6A). His strategy called for:

1. Stronger environmental protections and a long-term study of the Bay/Delta Estuary

2. The establishment of interim standards to reverse the environmental damage and a three-year planning process for permanent standards

3. The expansion of existing water supplies through the use of conservation measures by cities and farms, the creation of a regulated water market, and the use of reclaimed wastewater

4. The establishment of groundwater management

5. The purchase of the Federal CVP by the State

6. New water supplies to be provided by the construction of the Los Banos Grandes Reservoir

7. Widening existing channels in the Delta

The last two proposals were projects that were being planned under Deukmejian's administration, but they had never materialized due to opposition from environmentalists or lack of commitments by water delivery contractors. Governor Wilson's plan also called for the creation of the Bay Delta Oversight Council (BDOC) to develop long-term solutions. During the fall of 1992, Governor Wilson appointed environmentalists, business leaders, urban water suppliers, and farm representatives to be members of the BDOC as a means of promoting negotiation and compromise among the major constituent groups.

Governor Wilson ordered the Board to come up with a new set of interim standards by the end of 1992. The Board had been considering the adoption of rules to reduce the amount of water that was being diverted and pumped out of the Delta for urban and agricultural uses. During public hearings conducted by the Board that year, representatives of urban interests and irrigation districts challenged the agency's authority to reduce allocations while threatening to take legal action (San Jose Mercury News, 23 June 1992, 3B). Also at the hearings, environmental groups charged the Bureau and DWR with violating the existing water quality standards for the Bay/Delta Estuary over 200 times during the previous two years (Hull 1992, A1, A17). They claimed that the violations occurred because continued deliveries of large supplies of water during part of the drought period led to a lack of fresh water flowing through the Delta. In the meantime, the Federal Environmental Protection Agency (EPA) had been pressuring the Board to reduce pumping and allow more fresh water to flow into San Francisco Bay. These actions were meant to serve as ways to restrict the amount of saltwater in the lower stretches of the Sacramento and San Joaquin Rivers, and to increase the number of migrating salmon that make it safely to the ocean. The EPA acknowledged that it would take a reduction in water supply deliveries of up to 25% over normal deliveries to accomplish these goals (San Jose Mercury News, 25 August 1992, 3B).

As ordered, the Board proposed a set of interim standards, known officially as Water Right Decision 1630 (D1630), for the Bay/Delta Estuary in December 1992 (State of California, California Environmental Protection Agency, State Water Resources Control Board 1992). It called for a reduction in diversions and pumping by 800,000 AF of water from the Delta annually during normal years of precipitation and 1.9 MAF during drought years. Also among the requirements of the proposal was the establishment of a mitigation fund, which would collect close to $60 million annually from water users who exported water from or used water within the Delta watershed.

In March 1993, Board members announced a proposal to change parts of D1630 in an effort to appease farmers and urban interests (San Jose Mercury News, 9 March 1993, 3B; San Jose Mercury News, 10 March 1993, 3B). The changes called for reducing pulse flow requirements and allowing the diversion of 130,000 AF more than what was proposed in the original plan. In addition, the charging of $60 million in fees would be delayed until fall. The proposed changes were met with criticisms by the USFWS and EPA. Environmentalists threatened to file a lawsuit, claiming that to begin with, the original protection plans would have merely arrested the decline of many fish species instead of reversing it. Threats of lawsuits were also made by farmers who insisted that the new rules would still hurt their business.

At the beginning of April 1993, Governor Wilson requested the Board to withdraw D1630 (San Francisco Chronicle, 6 April 1993, A15). He argued that State interim standards were no longer necessary because the Federal government was already in the process of reducing exports from the Delta under the authority of the Federal ESA and the Federal Clean Water Act. However, he acknowledged that development of a long-term protection plan was still needed. The announcement was followed by heavy criticisms from representatives of environmental groups and urban water agencies who viewed the State's protection plan as being the first step in resolving California's water wars. Some of the well-known environmental organizations, such as the Sierra Club and the Environmental Defense Fund, responded further by dropping out of the Governor's BDOC.

The Board officially abandoned D1630 by the end of April, but it also stated that it would continue its work on developing a long-term plan (San Jose Mercury News, 28 April 1993, 3B). It sided with the Governor when it stated that the temporary protection plan was no longer necessary because of the above-average rainfall that California had been receiving during the 1992-93 winter season, and because of protective measures already in effect under the

ESA and CVPIA. The EPA insisted that new interim standards were needed and reiterated its plans to issue its own rules that would further curtail pumping from the Delta. The Board, which has the power to issue fines for violations, received additional opposition after a June announcement that it would not take actions against the Bureau and DWR for violating the existing Bay/Delta salinity standards over 200 times in previous years (San Jose Mercury News, 16 July 1993, 3B). Nineteen State legislators urged the Board to reverse its decision. The Board justified its position by claiming that the violations were minor in consideration of the severe drought conditions.

The EPA, USFWS, Bureau, and NMFS, four Federal agencies that had often been in conflict among themselves, teamed up to devise their own plan for restoring the ecological health of the Bay/Delta Estuary (San Francisco Chronicle, 15 December 1993, A1, A19; San Jose Mercury News, 2 November 1993, 1A, 14A; San Jose Mercury News, 16 December 1993, 3B; San Jose Mercury News, 17 December 1993, 3B). Their proposal was made public in November 1993 and focused on the goal of restoring fish populations to levels that existed during the late 1960s and early 1970s, a time period that preceded massive water diversions. The plan included restrictions on salt concentrations near the confluence of the Sacramento and San Joaquin Rivers that would result in a 9% reduction in exports during years of normal precipitation, and as much as a 21% reduction (or a cutback of approximately 1.1 MAF) during drought years. Federal officials wanted all water delivery systems to share in the reductions, including those that were diverting water from rivers and tributaries upstream from the Delta. However, the SWP and CVP are the only systems that are subject to direct Federal control under the ESA, and the Board is the only government agency that has the authority to order all systems to decrease diversions. The Governor and other State officials objected to the Federal plan by insisting once more that the State holds exclusive domain over allocating California's waters and claiming that the plan would cost Californians their jobs. Federal officials argued that they have a legal obligation to protect the Bay and the Delta. They also stated that the impacts to water users could be minimized through conservation practices, the use of reclaimed water, and water transfers or sales. Nevertheless, Governor Wilson ordered the Board to make attempts to work with the Federal agencies.

Central Valley Project Improvement Act of 1992

The Central Valley Project Improvement Act (CVPIA), Title XXXIV of Public Law 102-575, was signed into law by President Bush on October 30, 1992. Section 3402 listed the purposes of this title to be as follows:

(a) to protect, restore, and enhance fish, wildlife, and associated habitats in the Central Valley and Trinity River basins of California;

(b) to address impacts of the Central Valley Project on fish, wildlife, and associated habitats;

(c) to improve the operational flexibility of the Central Valley Project;

(d) to increase water-related benefits provided by the Central Valley Project to the State of California through expanded use of voluntary water transfers and improved water conservation;

(e) to contribute to the State of California's interim and long-term efforts to protect the San Francisco Bay/Sacramento-San Joaquin Delta Estuary;

(f) to achieve a reasonable balance among competing demands for use of Central Valley Project water, including the requirements of fish and wildlife, agricultural, municipal and industrial and power contractors. (Westlaw Congressional Record Database 1992)

Under section 3409, the U.S. Secretary of Interior is required to prepare a Programmatic Environmental Impact Statement (PEIS), pursuant to the National Environmental Policy Act (NEPA). The direct and indirect effects of implementing Title XXXIV and renewing all existing CVP water contracts must be analyzed. The analyses must include impacts and benefits within the Sacramento, San Joaquin, and Trinity River basins, and the San Francisco Bay/Sacramento-San Joaquin River Delta Estuary. In cooperation with the USFWS, the Bureau has been working on the development of interim rules and regulations, and of the PEIS through a public involvement process.

The CVPIA mandates significant changes in the management and priorities of the CVP, especially for fish and wildlife purposes, which includes the reallocation of water resources. Section 3406, subsection (b), calls for:

1. Implementation of fish and wildlife restoration activities, including the dedication of 800,000 AF of CVP water annually to fish, wildlife, and habitat restoration

2. Protection of the waters of the Bay/Delta Estuary

3. Installation of a temperature control device at Shasta Dam

4. Implementation of an ongoing program to replenish spawning gravel that is lost as a result of CVP operations

5. Protection of fishery resources of the Hoopa Valley Tribe by releasing a minimum of 340,000 AF of CVP water per year to the Trinity River for permanent instream flow

6. Implementation of a program to terminate anadromous fish losses as a result of flow fluctuations that are caused by the operation of CVP facilities

7. Minimization of fish passage problems of anadromous fish at Red Bluff Diversion Dam

8. Implementation of a program that will sustain natural production of anadromous fish in Central Valley rivers by the year 2002, at a minimum of twice the levels that occurred during the 1967-1991 period

Anadromous fish, as defined by Title XXXIV, refers to stocks of salmon, striped bass, sturgeon, and American shad. Other provisions that are included in subsection (b) call for the protection of fish from diversions by the SWP and CVP pumping plants through changes in operations and practices associated with the plants; the construction of new fish screens, fish recovery facilities, and control structures; and the improvement of existing screens, recovery facilities, and control structures. Subsection (d) requires that firm water supplies shall be provided to State and Federal wetland habitat areas in the Central Valley. The supplies would amount to over 380,000 AF annually.

In addition to facing the potential for reduced water supplies due to the dedication of CVP water to fish and wildlife purposes, beneficiaries of the CVP will be affected by other changes imposed by Title XXXIV. The establishment of the Restoration Fund is required by section 3407 for the purpose of carrying out fish, wildlife, and habitat restoration and improvement activities. It is to be financed by water and power users who will pay up to $50 million per fiscal year. While section 3404 forbids new CVP water supply contracts until fish, wildlife, and habitat restoration goals are achieved, it also reduces the period of long-term water supply contracts from forty to twenty-five years. A system of tiered water pricing, based on an inverted block rate structure, is imposed by section 3405 on all water contracts. That section also has water transfer provisions, which allow the sale of water to California water users or agencies who are not within the CVP service areas.

Another major area of change in the management of the CVP is required by section 3408. It calls for the development of a plan to increase the CVP yield by the year 2002. The increase should be the same as the amount that is dedicated to fish and wildlife purposes under the title. Among the options to be considered in the plan are changes or additions to CVP facilities and operations, conservation measures, water transfers, conjunctive use of supplies, the purchase of water or water rights, and the purchase of agricultural lands for the purpose of retiring them from irrigation.

The passage of the CVPIA has brought forth a number of issues (U.S. Department of the Interior, Bureau of Reclamation and Fish and Wildlife Service, Water Policy and Allocation Office, 1993, 11-13). There are concerns about how the dedication of 800,000 AF of water per year for fish and wildlife purposes would impact the water supplies for CVP contractors and what would happen during drought years. There are objections by agricultural interests to the new water pricing system and the Restoration Fund because they will be facing higher costs simultaneously with less availability of water supplies; they are worried that the pricing system could penalize those that have already implemented water conservation measures; and they are concerned about the effects that increased water prices could have on agricultural production. Furthermore, agricultural interests are worried that the CVPIA could cause land values in the Central Valley to decrease and large agricultural areas to go out of business. Both urban and agricultural interests want reliable water supplies, a consistent approach to the allocation of water, and an equal consideration of the potentially adverse socio-economic impacts that Title XXXIV could have on them as its potential benefits could have on fish and wildlife. The CVPIA has also been criticized for being impractical in its fishery goals to protect many species simultaneously and for its failure to address population growth or groundwater regulation as part of the efforts to resolve water problems.

Latest Attempts to Resolve the Water Wars

On 15 December 1994, a public announcement was made that State and Federal officials, environmentalists, urban interests, and agricultural interests finally reached an agreement on a plan for protecting the Bay and Delta (San Jose Mercury News, 15 December 1994, 1A, 16A; San Jose Mercury News, 16 December 1994, 1A, 30A). The goal of the plan is to protect fish by allowing more fresh water to flow through the Bay and Delta. The plan included a reduction in water diversions from the Delta by an average of 10% during normal years of precipitation, and by up to 21% or 1.1 MAF during very dry years. Water users will receive credit for approximately half of the 800,000 AF that must be dedicated to fish and wildlife restoration under the 1992 CVPIA. As a result, the total reductions could reach 1.5 MAF during very dry years. Furthermore, the plan will require water delivery systems that divert water from tributaries upstream of the Delta to absorb their share in cutbacks. Also, the plan will provide additional environmental protections such as the installation of new fish screens on diversion pipes along the Sacramento and San Joaquin Rivers. Moreover, it calls for joint decisions to be made by Federal and State officials concerning the Bay/Delta Estuary's environment, and it calls for a closer coordination between the CVP and SWP systems.

The plan is similar to other protection plans that were proposed in previous years but were subsequently abandoned. However, the success of the latest proposal has been attributed to three main reasons (San Jose Mercury News, 16 December 1994, 1A, 30A). First, Federal fish and wildlife officials were willing to accept a more flexible pumping regime. Second, Federal officials were willing to allow more water to be diverted during years of normal or above-normal precipitation in exchange for greater restrictions on pumping during drought years. Third, they promised not to impose greater pumping restrictions over the next three years, even if more fish are added to the Endangered Species List. The USFWS was expected to designate the Sacramento split-tail fish as a threatened species, but officials announced that they had postponed the decision. If more water becomes needed for new listings, the Federal government will attempt to secure supplies by purchasing them from willing sellers.

The competing interest groups were highly motivated to reach a compromise. After experiencing uncertainty in water deliveries during the three years prior to this accord, urban and agricultural interests were seeking reliability in their water allocations even at the expense of having them reduced. With the 1994 November elections resulting in a new Congress dominated by Republicans, the environmentalists were afraid that changes in the ESA could be made in the future. For about two decades, environmentalists objected to and were successful in preventing the construction of new dams and canals, but they became willing to consider this possibility.

The accord is considered to be the foundation for building a long-term solution to California's water problems, while development of the solution is expected to occur over the following three years. Decisions are expected to be made on how to balance environmental needs with the growing demands for water. In the meantime, short-term decisions will have to be made by the Board regarding the allocation of water supply reductions. Because farmers use over 80% of the state's water, it is expected that they will experience the deepest cuts. This means that some agricultural land, especially on the west side of the San Joaquin Valley, will probably be fallowed.

CHAPTER 3

BACKGROUND ON THE WESTLANDS WATER DISTRICT AND ITS SERVICE AREA

This chapter provides background on the subject and site of this study, namely, the Westlands Water District and its service area. It discusses crop production trends in the area and some of the factors that can influence those trends. For example, WWD's entitlements to CVP water, system of water allocation, and water rates can affect farmers' crop production. Farmers' access to various sources of water, such as CVP, groundwater, and transferred supplies, can also affect crop acreage. The development of the time series regression models in Chapter 5 were based on some of these factors.

Westlands Water District serves the largest agricultural irrigated acreage in the United States. Its service area consists of about 604,000 acres of some of the most fertile and productive farmlands in the world. The service area is located between the California Coast Range mountains and the western portions of Fresno and Kings Counties in the San Joaquin Valley. The service area averages 15 miles in width and extends 70 miles from

Mendota in the north to Kettleman City in the south (Westlands Water District 1992a, xiii, 1).

The region has a semiarid climate with an average growing season of 280 days. It has an average annual precipitation of about 7 inches, with most of the rainfall occurring during the months of December through March. Maximum temperatures often exceed 100 degrees Fahrenheit during the summer. Temperatures occasionally fall below freezing during the winter (Westlands Water District 1992a, 1).

Prior to WWD's formation, almost all of the land in its current service area had been irrigated with groundwater. Severe overdraft conditions led farmers and landowners to seek a surface water supply, and WWD was organized under California Water District Law in 1952 as a result of their petition. At the time of its formation, WWD's service area covered approximately 376,000 acres. A merger between WWD and its western neighbor, Westplains Water Storage District, added about 210,000 acres in 1965. From 1965 through 1978, 18,000 acres were annexed after the merger (Vuicich 1994; Westlands Water District 1992a, 1). The original area that was serviced by WWD, the area that was originally serviced by Westplains Water Storage District, and the annexed acreage are referred to as Priority Areas I, II, and III, respectively.

The primary function of WWD is to administer the delivery of water, which consists mostly of supplies from the CVP, to farmers and landowners in its service area. It also provides, operates, and maintains facilities for the delivery. Other major activities of WWD include a water conservation and management program for farmers, searching for solutions to drainage problems, groundwater monitoring, and securing additional water supplies from other sources.

CVP Water Supply

WWD's entitlement and allocations. Soon after the formation of the original WWD, it began negotiating a contract with the Bureau to receive a dependable supply of surface water through the CVP. In 1963, they entered into a forty-year contract, which provided a firm agricultural water supply of 1,008,000 AF annually. In 1979, the supply was changed to 900,000 AF and Priority Area I has a priority right to this water supply. The Bureau committed an additional 250,000 AF for Priority Area II after the merger occurred. Priority Area III does not receive an allocation unless the needs in the other two Priority Areas are satisfied (Westlands Water District 1989, 4; Westlands Water District 1990).

The WWD service area has been receiving water from the San Luis Unit of the CVP since 1968. The major components of the Unit include the Delta-Mendota Canal, the San Luis

Dam and Reservoir, the San Luis Canal, and the Coalinga Canal.

The current contract with the Bureau entitles WWD to a total of 1.15 MAF of water from the CVP annually during nondrought years, making WWD the largest CVP contractor in terms of the amount of its entitlement. The entire irrigable acreage in WWD's service area requires a total water supply of 1.5 MAF/year. Even with the amount of annual safe yield from the groundwater supply, which is estimated at a maximum of 135,000 AF/year, there is still a shortage of 215,000 to 220,000 AF/year. Therefore, WWD must allocate or ration CVP water to over 600 farms each year (Westlands Water District 1992a, xix, 17, 33; Westlands Water District, Public Information Department 1990, 3). Farmers must apply for their allocations from WWD during December for the upcoming water year, which begins in March. The amounts of CVP water that will be available to contractors for the upcoming water year are estimated by the Bureau during February. If WWD is unable to secure additional water from the CVP or other sources, tens of thousands of productive acres are fallowed, while others are underirrigated with a subsequent reduction in crop yields and values (Westlands Water District 1992a, xix, 33).

WWD is allowed to purchase surplus water from the Bureau when it is available. This surplus, which is termed "interim water," is allocated first to Priority Area II. As much as 200,000 AF/year of interim supplies were made available to WWD in the past. Between 1975 and 1988, WWD was able to purchase an average total of 1.23 MAF of CVP water annually. Since 1989, interim water supplies were not available due to the drought and the purchase of CVP water by new contractors (Vuicich n.d., 4; Westlands Water District 1990).

In February 1989, the Bureau announced that CVP agricultural water contractors would receive 50% of their entitlements for the upcoming water year because of the drought. After the water year had already begun, allocations were restored to 100% of the entitlements because of heavy precipitation during March. As the drought continued, WWD received allocations of 50% of its entitlement in 1990, 25% in 1991, and 25% in 1992. The prolonged drought was declared over in 1993 because of the heavy precipitation during the winter of 1992-93. Due to regulatory restrictions to protect the environment, WWD received an allocation of 50% in the 1993 water year. (Hudson 1994a; Leake 1993). Whenever WWD receives reductions in CVP supplies, the deficiencies are applied in equal percentages to the three Priority Areas.

Water rates. The Bureau charges a wide range of prices for each acre-foot of CVP water it sells to WWD. The prices vary according to the status of the landowner, farmer, or irrigated land, as defined by the Federal Reclamation Reform Act of 1982 (RRA). The original Reclamation Law, enacted by Congress in 1902, allowed the use of public funds to construct water supply and management facilities to deliver water for agricultural use. It also provided for the repayment of the construction costs by farmers at an interest-free rate. The amount of land that could be irrigated with the subsidized water was limited to 160 acres for an individual landowner or 320 acres for a married couple. The RRA allowed the ownership limitation to be increased to 960 acres per farm family under different water pricing requirements. It also resulted in divisions of large landholdings. The number of farms increased from 243 in 1980 to 613 in 1990 as the average farm size decreased from 2016 acres to 865 acres during the same ten-year period (Westlands Water District 1990, 3; Westlands Water District 1992a, 17-18).

The 1963 contract with the Bureau fixed WWD's rate at $8/AF of CVP water, which still applies to water supplied to lands that are held by individuals under prior law with the 160-acre limitation. The rates for water supplied to lands that are subject to the 960-acre limitation under the RRA, cover the Bureau's estimated annual operation and maintenance costs, in addition to capital costs. The rates charged to WWD by the Bureau for this water have ranged from $9.38/AF for the 1987 water year to $12.90/AF for 1989-90. The rates for water provided to lands that are farmed in excess of 960 acres cover the full costs of making the water available. They consist of operation and maintenance costs, capital costs, and interest on unpaid capital. The prices charged to WWD for this water ranged from $42.81/AF in 1987-88 to $45.79/AF in 1991-92 (Westlands Water District 1992a, 18-19).

The water rates charged to agricultural customers by WWD cover the costs of obtaining the CVP water from the Bureau, WWD's operation and maintenance costs, and the costs of special projects. The rates are structured according to the water pricing categories that are used by the Bureau, but customers in Priority Area II are charged slightly less per acre-foot of water than customers in Priority Area I for each of the categories. Prices charged to Priority Area I farmers for the three categories ranged from $15.90/AF to $50.10/AF in the 1987-88 water year. By the 1991-92 water year, the prices ranged from $22.48/AF to $60.27/AF (Westlands Water District 1992a, 20). Table 19 in Appendix A lists the average prices charged to all agricultural customers by WWD for CVP water from 1970-71 to 1992-93.

Groundwater Supply

Prior to 1968, which is the year when surface water deliveries from the CVP began, agriculture in the WWD service area depended heavily on supplies from its groundwater basin for irrigation. CVP supplies have come to provide most of the region's water since then, but groundwater supplies still play an important role in irrigation. The groundwater basin consists of two water-bearing zones that are separated by an almost impervious Corcoran Clay layer. Groundwater is pumped from the lower, confined aquifer. Under some areas of the region, clay layers that exist close to the soil surface have contributed to an accumulation of unused, percolated irrigation water (Westlands Water District 1992a, 4, 8, 33-34; Westlands Water District 1993b, 1-2). Some crops, such as safflower, are able to use this shallow groundwater if they can tolerate the levels of salinity that are found in this water supply and if the root zone is not saturated (Bohigian n.d.c., 8; Westlands Water District 1992a, 8).

Although WWD monitors the groundwater table and its quality, it does not provide this water to the farmers or regulate pumping. Farmers who use groundwater must pump it from their own wells. There are over 600 of these private wells in WWD's service area (Westlands Water District 1993b, 6).

Surface water supplies from the CVP are preferred over groundwater supplies for irrigation usage. The quality of the region's groundwater is generally poor in comparison to the quality of surface supplies. In addition, the costs for the installation of new wells or restoration of old wells, and for the maintenance and pumping of existing wells are high. Because the depth-to-piezometric-groundwater surface for the confined aquifer varies throughout the service area, these costs can vary widely (Pacific Gas and Electric Company, Marketing Department 1993; Valley Well and Pump Company 1993; Westlands Water District 1989, 4; Westlands Water District 1993b, 2-10).

The annual safe yield of the confined aquifer has been estimated to be between 100,000 and 135,000 AF in a study conducted by the Bureau, WWD, and the U.S. Geological Survey (Westlands Water District 1992a, 34). Overdraft conditions caused land subsidence, ranging from 1 to 24 feet, across the region between 1926 and 1972. Further subsidence of approximately 4 inches occurred as a consequence of the 1977 drought in California. During that year, WWD received only 25% of its entitlement from the CVP. Farmers responded by reactivating old wells, installing new ones, and pumping a total of 472,000 AF of groundwater (Westlands Water District 1992a, 33-34; Westlands Water District 1993b, 1-2).

From 1978 to 1989, annual groundwater use in the service area ranged from a low of 31,000 AF to a high of 228,000 AF. Faced with cutbacks from the CVP, farmers increased groundwater pumping to an estimated volume of 300,000 AF in 1990, and 600,000 AF/year in both 1991 and 1992. To make this possible, some farmers had new wells installed or had old, previously unused wells restored, while other farmers increased their level of pumping from wells that were already in use (Westlands Water District 1992a, 34; Westlands Water District 1993b, 2, 11).

Transferred Water Supplies

General information about water transfers can be found in Appendix D. It explores water marketing as a mechanism for meeting water needs. Furthermore, it presents the laws, regulations, and policies that govern water transfers in California. In addition, Appendix D describes the Federal Central Valley Project Water Bank and the California State Water Bank, both of which were created to lessen the effects of drought conditions.

Transfers from water districts. WWD has received transferred water supplies from other water districts since 1985. These transfers consisted of water that was purchased from supplies that were held in storage by the other water districts, supplies that were obtained through water banking arrangements which required repayments of water in the future, and water supplies that were acquired through the purchase of water rights. In addition to the transfers that WWD has been purchasing, WWD's regulations have allowed individual water users to secure transferred water supplies directly from outside sources since 1987.

The costs to WWD for obtaining transferred water can vary widely according to the source of the water and the costs that are incurred by the transferor, water supply conditions or market availability, the amount of carriage water loss, the costs for processing and obtaining approvals for the transfer, and the costs for having the water delivered to WWD. The costs that are incurred by WWD are then passed on to its water users. WWD sold transferred water supplies to its agricultural water users at average prices that ranged from a low of $10.04/AF in 1985 to a high of $69.82/AF of water in 1992 (Westlands Water District 1993a, 60-61; Westlands Water District 1993d).

<u>Transfers from the CVP Water Bank in 1977</u>. WWD purchased over 22,300 AF of water from the CVP Water Bank in 1977. This amounted to more than half of the bank's total sales. The second largest purchase by a single water agency was only about 5,400 AF (Roos-Collins 1987, 867). WWD sold its CVP Water Bank supply to its farmers at an average price of $63.37/AF (Vuicich 1994).

Transfers from the State Drought Water Bank. WWD purchased over 13,100 AF of water from the SWB during the first year of its operation in 1991 (Westlands Water District 1993a, 59, 62). This water was sold to its farmers at an average price of $222.64/AF (Westlands Water District 1993d). In 1992, WWD purchased 48,450 AF of water from the SWB (Bohigian n.d.c., 7; Westlands Water District 1993a, 59) and sold this water at an average price of $126.11/AF (Westlands Water District 1993d). According to WWD, the large amount of water that was purchased during the second year was a result of a high demand from farmers because of the relatively lower price and higher availability of that year's SWB supply (Westlands Water District 1993a, 62).

The costs of SWB water did not affect the costs of CVP supplies. Therefore, the prices of CVP water remained relatively low and the prices of SWB water were perceived by farmers as being very high.

The growing significance of water transfers for WWD. From 1989 through June 1993, the total annual amount of transferred water that was purchased by WWD and by individual users directly ranged between 36,000 AF and over 170,000 AF, or about 2.4% and 11.3%, respectively, of WWD's annual water requirements. WWD expects that it will continue to depend on water transfers to meet some of its water needs. It has estimated that it could obtain up to

100,000 AF of water annually from transfers during normal years of precipitation (Westlands Water District 1993a, 59, 63).

Water Conservation

In 1972, WWD implemented a water conservation program that provided farmers with information and technical assistance on water-use management. Two main objectives of the program were to supply information on crop water-use and to provide advising on irrigation techniques. The program was expanded in 1981 to further promote the efficient use of WWD's limited water supply. The list of objectives has since grown to include increasing seasonal water application efficiency, irrigation distribution uniformity, and crop yields, while decreasing deep percolation and the effects of soil salinity (Westlands Water District 1992a, xv, 47).

Future Water Needs

By the year 2010, the annual water requirement for the WWD service area is expected to reach approximately 1.52 MAF, which is 20,000 AF more than is currently needed (Westlands Water District 1992a, xix, 39-41). The growth in demand is anticipated even with continued water conservation and management efforts. The projection is based on the expectation that future irrigation systems will be designed to apply water more often to increase yields and on the expected cropping patterns of the future. The factors that will affect projected cropping patterns are reduced average farm size, higher water costs, a growth in acreage of high-value crops, a rise in double cropping, retirement of 30,000 acres of land from production, decreased agricultural and water subsidies, and no fallowed acreage. It is assumed that no land will be fallowed and double cropping will increase because of higher farming costs and the need for greater production from less acreage (Westlands Water District, 1992a, 39-40).

Crop Production

There are more than 40 commercial crops that are grown in the WWD service area, including grains, fruits, vegetables, nuts, and cotton. Over 60% of the irrigable acreage is used to grow two crops, which are cotton and processing tomatoes (Westlands Water District 1992a, 25-29). From 1978 to 1988, the acreage in cotton fluctuated between 230,000 and 301,000 acres. It declined after 1988, hitting a low of almost 208,000 acres in 1991 before recovering slightly to almost 225,000 acres in 1992. The acreage in processing tomatoes fluctuated between 27,800 and 37,600 acres from 1977 to 1981 before it increased to 45,000 acres in 1982. Another period of fluctuation occurred from 1983 to 1988 when the acreage in processing tomatoes varied between 51,500 and 58,600 acres. It increased dramatically during the following three years, peaking at almost 98,300 acres in 1991 before falling to almost 75,800 acres in 1992 (Westlands Water District n.d.d., 1977-1992; Westlands Water District 1992a, 28). The reduction in tomato acreage in 1992 was attributed to high inventories and the poor quality of available groundwater supplies (Bohigian n.d.c., 8).

Prior to the availability of CVP water to WWD, the primary crops produced in the area were cotton and grains. Between 1980 and 1988, the acreage planted in vegetable crops doubled to more than 140,000 acres (Westlands Water District 1989, 7). Subsequently, by 1990, the acreage in vegetables increased to over 169,000 acres. The rise in vegetable production has been partly attributed to urban development and water supply problems in other areas that have traditionally grown vegetables, such as the Salinas-Monterey and Central Coast regions of the state. During the same ten-year period, the acreage in grain crops decreased by about 85,000 acres (Westlands Water District 1992a, 26).

Farmers in the WWD service area are now using more water to grow higher-value vegetable crops on acreage where they had previously grown low-value, low-water-use crops such as wheat and barley. In efforts to produce high quality products that would satisfy consumers, the farmers have not only applied water on crops to meet the requirements for normal growth, they have also used additional water for cultural practices. These practices include weed control, climate control on grapes and orchards, and holding tomatoes for harvest. Still, the average annual amounts of water that were applied per acre to grow cotton and processing tomatoes were less in the WWD service area than in the whole San Joaquin Valley region during 1988 and 1989. Meanwhile, the yields for both crops were higher in the WWD service area. The WWD service area used 2.5 AF/acre to produce 1,338 pounds of cotton per acre and 2.3 AF/acre to produce 36 tons of processing tomatoes per acre, while the San Joaquin Valley region used 3.1 AF/acre to produce 1,143 pounds of cotton per acre and 2.7 AF/acre to produce 33 tons of processing tomatoes per acre. Furthermore, the average statewide yields for these two crops were even lower than those in the San Joaquin Valley (Westlands Water District 1989, 7; Westlands Water District 1992a, 25-26).

Crop production in the WWD service area has been an important part of the total crop production in California. In 1986, just prior to the drought, the area's farmers produced 40% of the cantaloupes, almost 20% of the tomatoes, and over 10% of the lettuce grown in the state (Westlands Water District 1989, 7). In 1990, during a drought year and a cutback of 50% in WWD's CVP water supply, the farmers grew 32% of the cantaloupes, 22% of the cotton, 10% of the lettuce, and 80% of the garlic in the state. They also harvested 32 million tons of processing tomatoes, comprising 34% of the state's production and supplying about one-third of the nation's total demand (Bohigian n.d.a., 6; Westlands Water District 1992a, 26).

Fallowed acreage in the WWD service area increased dramatically from 52,544 acres, which was almost 9% of total acreage in 1990, to 125,082 acres, which was almost 21% of total acreage in 1991. In 1991, the CVP water supply allocation was reduced to 25% of normal. In 1992, WWD again received a 25% allocation and the amount of idled land remained high at 112,718 acres (Bohigian n.d.b., 2, 7; Bohigian n.d.c., 4, 8; Westlands Water District 1992a, 28).

The total crop value in the WWD service area had been steadily increasing for several years both before and after the onset of the drought. In 1984, crop production was valued at almost $538.5 million; in 1987, it was worth almost $651.0 million; and in 1989, total crop value reached a peak of almost $707.7 million. The value declined to about $675.1 million during the first year of CVP water supply cutbacks in 1990, decreased even further to almost $585.7 million in 1991, and rose to a little over $614.8 million in 1992 (Westlands Water District n.d.d, 1984-1992). The rise by about $29 million in 1992 was attributed to the increased acreage of vegetable production (Bohigian n.d.c., 8).

CHAPTER 4

FACTORS AFFECTING CROP PRODUCTION AND ACREAGE

This chapter provides general information on elements that can influence the farmer's selection of a crop and decisions about production; the role that water plays in crop production; the effects that agricultural loan processes can have on crop production; and the effects that government support programs can have on crop acreage. Information on all these factors led to the development of the cross-sectional regression models in Chapters 6 and 7. Some of these factors were used as explanatory variables in estimating the impacts of the drought and the State Drought Water Bank on cropping patterns in the WWD service area.

Farm Enterprise Decision Making and Management

Management of a farm business involves decisions on what to produce, how many enterprises to engage in, the quantity or yield to be produced, the amount of resources or inputs to be committed to the enterprise, and how to market the product. If these decisions are primarily economic ones, then they are based on market demands, the differences between expected revenues and expected costs of alternative enterprises, and the various methods of producing a given commodity.

Selecting the enterprise. The decision to engage in a farm enterprise is based on the farmer's objectives, technical knowledge, experience, and personal preferences. The farmer's objectives may include any number of the following: generating a satisfactory income for the family, maximizing profits, producing an adequate level of return on a regular basis for the duration of the business or over the long-term, retaining independence, satisfying personal feelings of attachment to the land, producing food for consumers, expanding the business, acquiring capital assets or owning a business, and avoiding business risks (Calkins and DiPietre 1983, 5-6; Haines 1982, 4, 7-8, 64; Turner and Taylor 1989, 2). Striving toward maximum profit could merely be a way to achieve some of these objectives. Furthermore, a farmer's objective to maximize profits can be countered by desires to protect the land or other natural resources.

The selection of an enterprise is also encouraged or limited by the geographic, natural, social, political, legal, and economic environments. Factors in these environments include the costs and availability of natural and economic resources or inputs; physical conditions such as climate or soil quality; market demands; economic conditions in the national and international communities;

international trade relations; government price support payments, subsidies of production inputs, and acreage limitations; and the attitudes of various organized interest groups, which influence agricultural policy (Calkins and DiPietre 1983, 41; Haines 1982, 29, 31, 42-43, 64).

A farmer who contemplates a change from one enterprise to another will have additional factors to consider. Switching to another enterprise can be a major investment if it requires additional fixed resources. The transition will be easier if the proposed enterprise will utilize existing facilities, equipment, and technical knowledge and management skills of the farmer. A transition under these conditions will also enable the farmer to estimate his costs more accurately.

Additional factors will also need to be considered by a farmer who decides to produce more than one commodity. He will need to choose and coordinate the enterprises so that conflicts between them are kept at a minimum. Conflicts can arise if different crops require the use of limited fixed resources at the same time. On the other hand, different commodities that are produced on the same farm can complement each other. Examples include growing corn for feeding cattle or rotating a corn crop with legumes such as soybeans or alfalfa, which have beneficial nitrogen-fixation properties.

The gross margin system of analysis is often used in selecting an enterprise as well as in evaluating the performance of an existing enterprise. The gross margin for crop production is calculated by using the following equation. Gross margin = Gross output - Variable costs (Haines 1982, 65; Turner and Taylor 1989, 31). The three expressions in the equation usually represent values for a unit of land area such as an acre or hectare. The gross output is the amount of sales revenue or value of the crop. Variable or operating costs are costs that vary with the rate of output and the scale of the enterprise, so they are not incurred if production does not occur. For this reason, it has been argued that only variable costs, and not fixed costs, should be considered in deciding what, how, and how much to produce in the short-run (Boehlje and Eidman 1984, 88). Variable costs consist of the costs of resources or raw materials such as seed, fertilizer, fuel, chemical sprays, temporary labor, water, trucking, and marketing. In general, these resources can be applied in various quantities to a given unit of land area, are readily available at a price, can be purchased in various quantities, and are utilized on a short-term basis by the farmer.

Producing the commodity. The yield itself partially depends on the quantity of each variable input used. The farmer has to determine the optimal combination of inputs that will produce the level of output desired, or if there is a limiting resource, he will need to optimize the return to that resource. These decisions can be based on the technical (physical) relationship or the economic relationship between inputs and outputs.

Calkins and DiPietre (1983, 20-51), Boehlje and Eidman (1984, 91-107), and Osburn and Schneeberger (1983, 21-29) have presented thorough discussions on determining the optimal level of input use. It is based on the production function, which demonstrates how various amounts of inputs produce different levels of output when combined in a production process. The production function is divided into three stages. (Refer to figure 11 on page 153.)

Beginning at Stage I with zero input, as additional units of an input are applied to an acre, total yield for that acre will increase initially. However, equal additional units of input will not produce equal additional units of output. Stage II begins when the average units of output per unit of added input start to decline even though the total yield itself continues to rise. This point is called the point of diminishing marginal product. As more units of input are added, the total yield per acre will eventually begin to decrease. The point at which this begins signifies the beginning of Stage III. The technical and economic optimum will both be found within Stage II.

Boehlje and Eidman (1984, 100-105) made a few precautionary notes regarding the use of the production function model in choosing the optimal level of an input. First, they have warned that both increasing and decreasing marginal physical productivity do not always occur as a result of added input by a grower and therefore, all three stages of the production function model might not be observed in every situation. To some extent, certain types of inputs, such as soil nutrients and water, are naturally available to a crop; hence, some output can be produced without application of such inputs by the farmer. Second, in determining the optimal level of input to use, the price of the commodity used in the calculations should be based on its net value instead of its market price. Third, all costs associated with the use of an additional unit of input should be considered in addition to the cost of the input itself.

The volume of a crop that is produced on a farm depends on the yield produced per unit of land and the total area used to grow the crop. Therefore, a given volume can be achieved by a high yield produced on a limited area or a lower yield produced on a more extensive area. Any changes in input costs or product value might cause a farmer to make adjustments in the total volume of his production. He can respond by targeting a different level of yield or by changing the total area allocated to growing the crop. In the face of rising costs of inputs, he might either increase his total production or switch to an enterprise that gives a higher return (Haines 1982, 35, 74).

Marketing the commodity. An assessment of the market potential for various commodities is made by the farmer during the process of selecting an enterprise. He tries to determine what the market demands will be in terms of amount and quality. In preparing to sell his product, the farmer bases his marketing decision on the prices offered by different markets, the costs that may be incurred by the sale, the terms of the payment to be made to the farmer, and the convenience of making the product available to the market. These factors will determine who the buyer will be, how the product will be sold, and the timing of the sale. For some products, the marketing decision is made before production begins because the terms of the sale have previously been defined in a contract. These products include those that are purchased for freezing, dehydration, canning, and other forms of processing such as sugar beets and processing tomatoes.

The Role of Water in Crop Production

Water is necessary for the growth, development, and metabolism of plants. It is essential for maintaining tissue hydration, transpiration, and dry matter production (or yield). It is common for more than 90% of a plant's biomass to be composed of water, which helps to maintain the structure of the plant (Stewart and Nielsen 1990, 14). Water plays a key role in photosynthesis by supplying hydrogen atoms for the reduction of carbon dioxide. It acts as a transporter of ions and compounds through the plant.

Evapotranspiration. After water has been absorbed from the soil by the plant roots and transported through the tissues, it is released as vapor, mainly through the stomatal apertures of the leaves. This process of transpiration provides cooling to the plant and accounts for most (up to 99%) of the water used by the plant (Stewart and Nielsen 1990, 14). Transpiration is controlled by the vapor pressure gradient between the leaves and the air, as well as by the stomates. When moist cell surfaces are exposed to a dry atmosphere, carbon dioxide is absorbed through the stomates for use in photosynthesis. Environmental factors such as light, humidity, carbon dioxide concentration, and temperature affect stomatal response. Stomatal responses can differ among species and among cultivars within a species under similar environmental conditions (Teare and Peet 1983, 3, 80-81).

The amount of water that is lost by a crop through transpiration is difficult to determine separately from the amount of water that is evaporated from the soil surface. Therefore, these two processes are often discussed together and are collectively known as evapotranspiration (ET). Evapotranspiration depends on seasonal and climatic factors, field conditions, and crop characteristics (Stewart and Nielsen 1990, 11-12, 15; Teare and Peet 1983, 15-21).

The portion of ET that can be attributed to evaporation of water from soil and foliage surfaces is considered to be a loss because it does not contribute to plant growth. This factor can have major implications for planning the irrigation regime. Drip irrigation systems, which allow only a small proportion of the soil surface to become wet and avoids wetting the canopy, can be used to apply water frequently to crop roots and maintain low evaporation losses. In contrast, systems such as flood or sprinkler irrigation, which wet the entire soil surface or canopy, cause evaporation to increase with more frequent irrigation. Therefore, it might be necessary to sacrifice maximization of yields in the interest of water-use efficiency.

Effects of water use on yields. Most crop plants are easily affected by a lack of sufficient water, and they can suffer from water stress well before the soil moisture availability reaches the permanent wilting point. Due to stomatal closure, water deficits result in the limited uptake of carbon dioxide and a decrease in the rate of photosynthesis. Consequently, plant growth such as cell and leaf expansion, and dry matter production of the whole or part of the plant are often curtailed. However, other factors such as a lack of soil aeration or nutrients, pest infestations, and the type of genetic variety can act as constraints on crop yield (Stewart and Nielsen 1990, 14-18).

Due to reduced evaporative cooling, water deficits can also lead to a rise in the temperature of the crop canopy. This, in turn, impacts the crop in two ways. First, it leads to a rise in the rate of tissue respiration, which causes the plant to increase consumption of its reserves and, thus, contributes to further reductions in net yield. Second, it increases the vapor pressure gradient from the leaves to the atmosphere, which lowers the previous stomatal resistance to transpiration and causes further vapor loss through the stomatal apertures (Stewart and Nielsen 1990, 14-15).

There are critical stages of development during which water deficits can have the most adverse impacts on crop yield. These stages include flowering and grain formation for cereal crops, flowering and pod development for annual legumes such as beans and peas, development of first fruits for annual fruit crops such as tomatoes and peppers, and flowering for fiber and seed crops such as cotton and safflower (Stewart and Nielsen 1990, 337-338, 419-421).

When only part of the plant is marketable, the economic yield or the yield of individual plant organs might be a greater concern in crop production than total plant yield. In addition to the plant's stage of growth, the extent to which water deficits affect economic yield depends on the amount of stress imposed on the plant due to the lack of water, the previous history of deficits, and how sensitive the various plant organs are to stress (Teare and Peet 1983, 107-108).

Most crops use water more efficiently when they are well watered throughout the growing season than when they are subjected to periods of water stress. When a high plant-water-potential is maintained, dry matter production is maximized both in terms of yield per unit of land area of crop grown and yield per unit of water consumed. Therefore, crops generally do not benefit from water stress except in cases such as cotton where it is needed to initiate the development of the plant organ that will be harvested (Stewart and Nielsen 1990, 14-15).

The effects of water use on crop yields have been drawing increasing attention because of the growing scarcity and costs of water supplies for irrigation. Yet, no universal agreement has been reached on which criterion should be used to determine the optimal level of water use for crop production. The focus of agronomists tends to be on maximizing either the yield per unit of land area or the yield per unit of applied water. The focus of economists tends to be on the application of water for as long as the benefit is greater than the cost of applying the last additional unit of water. The issue of what constitutes an optimal level of applied water use is more complex than selecting one of these alternatives. There are other factors that need to be considered such as the relative costs of other inputs and the potential income that can be earned from the yield (Stewart and Nielsen 1990, 16-19).

Agricultural Financing

Capital is a principal resource for a farm business. It is used to purchase land, equipment, facilities, and stocks of variable inputs; to expand the farm business; to implement new or more efficient technologies; or to even out the effects of seasonal and annual fluctuations in income and expenditures. The amount of capital available to the farmer can determine the size of his business, and thereby, it can allow or prevent expansion and affect profitability.

Financing that is supplied by financial institutions play an important role in many farm businesses. The amount of money that will be lent to a grower depends on several factors. His technical skills and the ability of his business to generate enough of a positive cash flow to cover loan repayments are evaluated by the lender. An assessment is also made of potential environmental liability and other risks associated with the proposed enterprise. In determining loan eligibility, the farmer is often required to provide financial statements on income and net worth, information on past performance, and a farm plan that demonstrates future performance with estimated returns and cash requirements. This might be problematic if he wishes to switch to growing a different type of crop even if he never defaulted on previous loans (Turner and Taylor 1989, 192; University of California, Agricultural Issues Center 1994, 24-27, 39-41, 125-126, 134).

The type of loan that a farmer obtains from a lender can also affect the type of crops he can plant. For example, if he secures a revolving line of credit for a multi-year production loan, he will not be granted flexibility in what he plants. Thus, he might be prevented from shifting to other crops for the duration of the loan (University of California, Agricultural Issues Center 1994, 109).

Environmental and natural resource pressures have influenced the current lending environment in California (University of California, Agricultural Issues Center 1994, 206-207). Stricter regulations on pesticide use, growing resistance by insects, and the appearance of new pests have made pest control more difficult to achieve. The recent drought, regulations regarding water quality, and the uncertainty of future water supplies have added to the risks in agriculture (Ferguson 1993; Hoyt 1993; Polson 1993; Turnquist 1993; University of California, Agricultural Issues Center 1994, 6-7, 67-68, 72). Therefore, loan requirements are more restrictive today than they were in the past. Currently, lenders in California often include in their risk analysis of agricultural loans, an assessment of the reliability of the applicant's water supply, international markets, and the riskiness of certain crops. In the past, these factors were not routinely considered in risk analyses. In addition, there is an increasing trend among lenders to require risk management plans from producers as a part of the loan application process. As a result, some farmers have been finding it more difficult to secure loans today than in the past even though they have never defaulted on previous loans, are unable to borrow as much, or are facing higher interest rates than urban borrowers. Furthermore, borrowers who have been granted loans in the past may be unable to obtain them without a secure water supply (University of California, Agricultural Issues Center 1994, 7, 82, 222-224).

Another factor that adds to the difficulty in obtaining a loan in California is that agricultural borrowers are forced to compete with borrowers from other sectors in the state's economy. Most agricultural loans tend to be relatively small. Large commercial lenders have raised their minimum size of loans in order to generate higher profits, causing some borrowers to be dropped as customers while reducing the number of lenders that are available as sources of credit to farmers (University of California, Agricultural Issues Center 1994, 82, 224-225).

Risks in the Farm Business

A producer faces numerous potential risks and uncertainties in managing a farm business. Therefore, he must be prepared to engage in decision making with less than perfect knowledge (Boehlje and Eidman 1984, 439, 442; Haines 1982, 70-71; Calkins and DiPietre 1983, 9; May, Le Strange, Valencia, Klonsky, and Livingston n.d.a., 3; University of California, Agricultural Issues Center 1994, 185-189, 192, 195). The initial investments can be high, the cost and availability of credit can change over time, market demands can be unpredictable, crop yield is uncertain because it is dependent on weather conditions and prevention of infestation, and commodity prices are subject to the size of the world harvest and changes in government policies. There is uncertainty in the continued existence of farm support programs. Fresh fruits and vegetables are subject to perishability and this limits the producer's opportunity to wait and sell under better price conditions. Returns are not realized until many years later for long-term enterprises such as fruit and nut tree crops. The costs of inputs can be difficult to predict, and they can be subject to world events as they were for fuel supplies in the 1970s. In addition, future availability of inputs can be uncertain as in the case of water supplies in California. Use of machinery instead of manual labor can be capital-intensive and thus, it contributes to financial risks. Environmental and consumer interest groups that oppose the use of pesticides contribute to production risk and uncertainty over future liability for health damage. Finally, adopting a new technology may be risky until the farmer becomes proficient in its use.

A study conducted during the summer of 1993 by the University of California Agricultural Issues Center (UCAIC) included a survey of over 600 producers in California (University of California, Agricultural Issues Center 1994, 44, 54-55, 196-200). The majority of them ranked market price uncertainty as being the most important source of risk that affects profitability. Others felt that the most important sources of risk were adverse natural conditions. Of these respondents, drought was considered to be the greatest concern, followed by frost, disease, and pests. The risk management tool that was most widely used by the farmers was diversification of enterprises, followed by crop insurance. Farmers also dealt with drought-induced risks by implementing more efficient irrigation technologies, such as drip irrigation, and by utilizing groundwater supplies.

According to 75% of the lenders that were also surveyed in the UCAIC study, riskiness of the commodity does alter the loan process through tighter loan requirements, stricter underwriting standards, higher interest rates, and more proof by the borrower of knowledge or profitability of the commodity (University of California, Agricultural Issues Center 1994, 63, 136-139). For these reasons, the researchers speculated that shifts by farmers from producing field crops to growing higher-value fruit and vegetable crops could be hindered. Lenders use price and production history plus an analysis of the industry to determine commodity risk. They most frequently ranked the following as being the first or second riskiest commodities: vegetables, citrus, tomatoes, melons, strawberries, and grapes. Also, they ranked dairy, beef cattle, almonds, walnuts, and field crops (such as wheat, corn, alfalfa, and sugar beets) as being the first or second least risky commodities. The results were mixed for cotton, which was ranked as being among the most or the least risky crops by different lenders.

Government Support for Agriculture

Most of the countries of the developed world have given government support to the agricultural sector because of social, political, and economic reasons (Calkins and DiPietre 1983, 257-267; Haines 1982, 31-39). Farmers produce commodities that are obviously needed for human survival and governments have therefore acted on the behalf of the public's interest to ensure that sufficient food supplies are provided at affordable prices. Governments have encouraged domestic production as a means of increasing national self-sufficiency while decreasing reliance on the world market, as well as a means of expanding exports to achieve a balance of trade. Agriculture has been credited with having a positive impact on the rest of the economy by providing jobs in related industries. Governments support agriculture out of concern for the well-being of the rural community in terms of maintaining its social and economic stability and infrastructure. The political power of agricultural interests have sometimes served to further that concern.

Government policies and support for agriculture have been criticized for preventing prices from serving as true indicators of consumer demands, blocking producers from responding to consumer needs, using public funds that are generated from income taxes to subsidize farmers, preventing consumers from knowing the true cost of their food, and disrupting world competition. Opposition to government policies and support have come from organized interest groups such as consumer groups, conservationists, and foreign governments (Haines 1982, 37-39, 42-43).

Programs administered by the U.S. Department of Agriculture. The Agricultural Stabilization and Conservation Service (ASCS) of the USDA administers various farm programs (U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, California State ASCS Office n.d., 2). Among them are two major types of commodity programs, the Production Adjustment Programs and the Price Support Program. They exist for the purpose of improving the economic stability of agriculture and balancing supply with demand for selected agricultural commodities (Calkins and DiPietre 1983, 259-275; U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service 1993).

The Production Adjustment Programs include deficiency payments with a price guarantee to farmers who voluntarily participate in acreage reduction during the crop year for wheat, barley, oats, grain sorghum, field and silage corn, rice, or cotton. The deficiency payment is based on a target price minus either the national average market price or the basic loan rate, whichever is greater. The target price is set by Congress and is considered to be the value that the producer should receive for the crop. To be eligible for payment, the participant is required to reduce production acreage by an established ratio, which differs from year to year and from crop to crop (U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service 1993; U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service 1994; U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, California State ASCS Office n.d., 20-21; Yasui 1994).

As part of the Price Support Program, the ASCS manages the government-owned Commodity Credit Corporation (CCC), which offers operating loans, income support, or incentive payments to farmers who produce wheat, corn, grain sorghum, barley, oats, rye, soybeans, rice, peanuts, tobacco, milk, cotton, wool, mohair, sugar, honey, and oilseeds (such as sunflower, safflower, canola, rapeseed, mustard, and flax). When a loan is granted for crop commodities, the stored crop serves as collateral, and in most cases, the borrower is required to limit his production by participating in the acreage reduction, allotment, or quota program. When payment of the loan is due, the borrower may either choose to pay it off with interest and sell the commodity if the market prices are higher than the loan rate, or he may forfeit the commodity to the CCC as payment in full for the loan obligation if market prices fail to rise above the loan rate. Thus, the loans provide farmers with price protection and income before the commodity is sold (U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service 1993; U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, California State ASCS Office n.d., 31).

Price support loans have dropped nationally from $17 billion in 1986 to $4 billion in 1993, and the trend is expected to continue for two reasons. Loan rates for grains and oilseeds have usually been lower than domestic market prices in recent years, and the current federal policy climate indicates that the loan rates will generally remain as such (University of California, Agricultural Issues Center 1994, 164-165).

Commodity program payments play a less significant role in California than in other major farm states. They account for only about 1% of agricultural cash revenues in California with most of the program payments being made for cotton and rice (University of California, Agricultural Issues Center 1994, 164-165, 173).

CHAPTER 5

AN INVESTIGATION OF THE HISTORICAL CROPPING PATTERNS IN THE WESTLANDS WATER DISTRICT SERVICE AREA

The historical cropping patterns in the WWD service area, as measured by acreage harvested, are investigated in this part of the study. Water supply availability, CVP water supply costs, and crop values were expected to affect the number of acres of each crop grown in any given year. To test the possible effects that these and other variables had on crop acreage during the 1970-1992 and 1978-1992 time periods, time series multiple regressions were run for each selected crop, using two different model specifications.

The variables in the models are defined as follows:

ACRES	=	the no. of acres of crop production
CVP RATE	=	the rate charged by WWD for CVP water supplies
CVP SUP	=	the amount of CVP water supplies delivered by WWD
VALUE/AC	=	the crop's per-acre value
GW VOL	=	the amount of groundwater used by farmers in the WWD service area
TRANSFRS	=	a dummy variable: TRANSFRS=1 when water supplies were transferred to WWD from other water districts, 0 otherwise

WTR BNKS = a dummy variable: WTR BNKS=1 when water supplies were available from either the State Drought Water Bank or the Federal CVP Water Bank, 0 otherwise

WWD EXPN = a dummy variable: WWD EXPN=1 when WWD's service area was in the process of expansion, 0 otherwise

The following time series multiple regression models were developed:

Model 1A. ACRES = a1 + a2(CVP RATE) + a3(CVP SUP) + a4(VALUE/AC) + a5(GW VOL) + a6(TRANSFRS) + a7(WTR BNKS) + a8(WWD EXPN)

Model 2A. ACRES = a1 + a2(CVP RATE) + a3(CVP SUP) + a4(VALUE/AC) + a5(GW VOL) + a6(TRANSFRS) + a7(WTR BNKS)

The expansion of the WWD service area, which occurred from 1970 to 1977, was expected to have an impact on crop acreage. Therefore, the expansion was represented by the variable, WWD EXPN, in Model 1A. Model 2A was developed as a basis for comparison with Model 1A. The problem of expansion in Model 2A was treated by omitting the 1970-1977 time period.

Hypotheses

For each selected crop, hypotheses were developed about the relationships between each independent variable and the dependent variable. The hypotheses for the water supply and water price variables were based on the crop's evapotranspiration rate, which was used to represent the crop's water needs.

Table 1 on the following page provides a summary of the hypotheses by crop, level of crop water needs, and explanatory variable. A positive sign (+) indicates that the changes in the values of the explanatory and dependent variables were expected to be positively correlated. A negative sign (-) indicates that the changes in the values of the independent and dependent variables were expected to be negatively correlated. The presence of both positive and negative signs (+/-) indicates that, theoretically, the correlation could be either positive or negative.

CVP water rate. Assuming that the value of a crop remains constant, the gross and net margins from that crop will be reduced in the face of rising production costs. To protect his total gross or net margin, a grower can respond to rising costs in one of several ways. He can substitute the input with a less expensive one, or he can reduce the production input. These alternatives are discussed below.

CVP water supplies are among the cheapest sources of water that are available to farmers in the WWD service area. Groundwater and transferred water supplies generally cost more than CVP supplies, and rainfall in the area is limited. Therefore, in the face of rising CVP water rates, there are limits on the extent to which CVP water supplies can be substituted with less expensive water supply sources.

Reducing the total amount of water applied during

Table 1.--Hypotheses for Time Series Regressions Based on Level of Crop Water Needs

CROP	LEVEL	CVP RATE	CVP SUP	VALUE/AC	GW VOL	TRANSFRS	WTR BNKS	WWD EXPN
ALFALFA HAY	High	-	+	+	+	+	+	+/-
ALFALFA SEED	High	-	+	+	+	+	+	+/-
CORN-FIELD	High	-	+	+	+	+	+	+/-
COTTON (LINT & SEED)	High	-	+	+	+	+	+	+/-
ONIONS-DEHYDRATOR	High	-	+	+	+	+	+	+/-
SAFFLOWER	High	-	+	+	+	+	+	+/-
SUGAR BEET	High	-	+	+	+	+	+	+/-
PEPPERS	Inter	+/-	+/-	+	+/-	+/-	+/-	+/-
BARLEY	Low	+	-	+	-	-	-	+/-
BEANS-DRY	Low	+	-	+	-	-	-	+/-
CANTALOUPE	Low	+	-	+	-	-	-	+/-
GARLIC	Low	+	-	+	-	-	-	+/-
LETTUCE	Low	+	-	+	-	-	-	+/-
TOMATOES-PROCESSING	Low	+	-	+	-	-	-	+/-
WHEAT	Low	+	-	+	-	-	-	+/-

\+ Positive correlation between independent variable and acreage

\- Negative correlation between independent variable and acreage irrigation as a response to rising water costs can be accomplished by switching to a crop that requires less water per acre, reducing the amount of water applied to each acre of the existing crop, reducing the total acreage of the existing crop, or engaging in water conservation practices. Of these four choices, the first offers the grower the opportunity to protect his total gross and net margins and the quality of his product. The second can reduce the yield per acre and/or compromise the quality of the commodity. The third choice will decrease the total gross and net margins. Finally, the last choice often incurs added costs.

For all of the reasons presented above, the following hypothesis was developed for the CVP-water-rate variable. As the rates for CVP water rise, total acreage in the WWD service area would significantly increase for crops with relatively low water needs, while total acreage would significantly decrease for crops with relatively high water needs.

CVP water supply. A grower can respond to decreasing supplies of CVP water in one of two major ways. He can substitute or supplement reduced CVP water supplies with other, more expensive sources of water, or he can limit his water usage to the amount of decreased CVP supply that is made available to him. As discussed above in the subsection on the CVP water rate, a grower can reduce his water usage in one of four ways. For the same reasons given there, it seems likely that a grower who chooses to limit his entire water usage to the amount of water that is made available from dwindling CVP supplies would switch to growing crops that require less water.

The following hypothesis was developed for the CVP-water-supply variable. As CVP supplies become scarcer, total acreage in the WWD service area would significantly increase for crops that have relatively low water needs, while total acreage would significantly decline for crops that have relatively high water needs.

Crop value per acre. For any given crop, its acreage is expected to increase if its value or selling price rises. However, this is not expected to happen if the rise in the crop's value is also accompanied by increases in the values of other crops. The relative rise in a crop's value can determine whether its acreage will increase, decrease, or remain the same. Similarly, a crop's acreage might not necessarily decline in response to a decrease in its value if this value does not drop below the values of alternative crops or the decrease in its value is accompanied by decreases in the values of other crops. Concurrent changes in values among all selected crops are addressed in the cross-sectional investigations of this study in Chapters 6 and 7. For the purpose of this time series investigation, the assumption is made that the values of all other crops remain constant.

The following hypothesis was developed for the crop-value-per-acre variable. As a crop's value per acre increases, its total acreage would also increase significantly in the WWD service area. On the other hand, as a crop's value per acre decreases, its total acreage would also decrease significantly in the WWD service area.

Other water supply sources. Groundwater, transfers, and water banks are generally expensive sources of water. Faced with the prospect of having to depend on them either to replace or supplement cheaper sources of water that are growing scarcer, growers could be expected to decrease the acreage in crops that have high water needs as a way to protect their gross and net margins. However, in multiple regression analysis, the assumption is made that when a change occurs in one explanatory variable, all other explanatory variables remain constant. Therefore, the following hypothesis was developed for each of these other water supply sources. As growers increase their use of water supplies from groundwater, transfers, or water banks, total acreage in the WWD service area would significantly decrease for crops that have relatively low water needs, while total acreage would significantly increase for crops that have relatively high water needs.

Service area. The number of acres in the original service area of the WWD made up only a fraction of the total number of acres that were included after the service area was expanded. Therefore, significant changes in acreage were expected to occur for most, if not all, crops as the service area was expanded. A dummy variable is used to capture this possibility in Model 1A. In Model 2A, observations for the period 1970-1977 were excluded altogether.

Data

Selected crops. Of more than 40 crops that have been grown in the WWD service area, 15 were selected for this study through a process of elimination. It is preferable to include at least 30 observations for statistical purposes. One of the limits of this study was that an observation could not be included if the value of its dependent variable was 0, which was the case for a number of years for most crops. Crops were therefore excluded from this study if they did not have production acreage for at least 20 years during the twenty-three-year period from 1970 through 1992. Rice, for example, was one of the excluded crops. It has a high seasonal ET rate of 3.4 AF of water per acre. According to the data, the last year that rice had been planted in the WWD service area was during the beginning of the six-year drought in 1987, and it was not planted during the previous drought in 1977. All of the 15 included crops were produced during each of the 23 years except for field corn, dehydrator onions, and peppers. There were no acreages of field corn in 1989, 1991, and 1992; dehydrator onions in 1970 and 1973; and peppers in 1971 and 1972.

Perennial crops such as vines and trees were also excluded from this study. Switching to or from these crops would be hindered because of the length of time they require to become productive once they are established and because of their long productive lives. For these same reasons, comparisons of acreage changes between perennial and nonperennial crops are difficult to make. Although alfalfa is a perennial crop, it was included in this study. It becomes productive within the first year of its planting and it usually produces hay for a maximum of 4 years in the San Joaquin Valley.

The 15 crops that were included in this study consisted of seed crops such as alfalfa and cotton; processing crops such as dehydrator onions, processing tomatoes, and sugar beets; vegetable and fruit crops such as dry beans, garlic, lettuce, peppers, and cantaloupes; and field or grain crops such as alfalfa hay, barley, field corn, cotton, safflower, and wheat.

In a few cases, it was necessary to categorize the different varieties of a crop under their general crop name for the purpose of this study, due to the manner in which some of the data were presented in WWD's crop production reports. The cotton crop consisted of Acala lint, Pima lint, and cotton seed as the by-product of lint production. Data for the two lint varieties were presented separately for some years, but were combined for others. Similarly, the data for lettuce were not always separated for the spring and fall crops. The pepper crop was seldom listed according to its varieties, but it was most often labeled as "peppers" or "miscellaneous peppers."

The limitations in the available data indicate that caution should be exercised when drawing conclusions about each of the 15 crops. Similarly, it should also be exercised if the results of the 15 crops are used to make inferences about the rest of the crops that have been grown in the WWD service area.

Basis of hypothesis development. The level of crop water needs served as the basis for the development of hypotheses for each crop. Historical seasonal ET rates for crops grown in the WWD service area were available for 27 major crops. Their average seasonal ET rate was calculated to be 2.06 AF of water per acre. The average rate for the 15 selected crops was calculated to be 2.11 AF/acre. For the purposes of this investigation, each of the 15 crops was categorized as having a high, low, or intermediate level of water need according to its own seasonal ET rate, relative to this average. Peppers were classified as having an intermediate level of water need because their seasonal ET rate of 2.08 AF differed very little from this average.

The use of averages to define high and low levels of ET rates also defines how the results are interpreted. If other criteria were chosen to define these levels, the results would be interpreted accordingly.

Crop production acreage. WWD's crop production report sheets for 1970 through 1973, and for 1976 indicated that the data applied to all cropped acreage that received CVP water supplies. That acreage might or might not have been irrigated with additional water from groundwater sources, but the data did not include cropped acreage which had been irrigated exclusively with groundwater supplies. The report sheets for 1974, 1975, and 1977 did not specify whether the data applied to all cropped acreage or only to acreage irrigated by CVP supplies. After a request was made to receive data and information that were excluded from some of the report sheets, it was revealed that records on them had not been kept on file at WWD's office. The report sheets for 1978 through 1992 included data on all cropped acreage in the service area, regardless of the source of water used for irrigation. That time period coincides with the years after complete expansion of the WWD service area occurred. Therefore, the service-area variable can be used to deal with the inconsistencies among the report sheets as well as the differences in total cropped acreage that were due to the expansion.

Separate crop production data for each of the three Priority Areas were also unavailable, preventing separate regressions from being run for each area. Thus, the degree of specificity of the regression results was limited.

Factors other than the independent variables that were included in the models are known to affect crop acreage, but it was difficult to incorporate them into the models. The Federal Payment-In-Kind program in 1983 resulted in 55,000 acres of land being fallowed in addition to the 33,773 acres that were fallowed for other reasons. While more than 230,000 acres of cotton and over 49,000 acres of wheat were harvested that year, 45,000 acres that had normally been planted with cotton and 10,000 acres that had normally been planted with wheat in previous years were idled.

The adoption of water conservation measures is another factor that can affect crop acreage. Water that is conserved can be used to irrigate more land, irrigate more water-intensive crops, or increase yields of existing crop acreage. Although a water conservation program has been in operation by WWD since 1972, and participation by farmers increased after it was expanded in 1981, specific data on the quantities and uses of the conserved water were unavailable.

CVP water supply and rate. For the years 1970 to 1984, the period from October 1 through September 30 was designated as WWD's crop production-water supply year (crop-water year). In 1987, the crop-water year was changed so that it would coincide with the Bureau's water-contract year, which began on March 1 and lasted through the end of February. For the transitional period, the 1985 crop-water year coincided with the calendar year. The 1986-87 year consisted of a 14-month period, which began in January 1986 and ended in February 1987.

The CVP-water-supply variable represented the amounts of water, in AF of volume, that were purchased from the Bureau during each of the crop-water years. These amounts were limited to CVP supplies that were used for agriculture and did not include quantities for industrial or municipal uses.

The CVP-rate variable represented the average prices, in dollars per AF, that farmers in the WWD service area paid during each of the crop-water years for the delivery of CVP water supplies. WWD's operation and maintenance costs were included in the rates.

Crop value per acre. The crop-value-per-acre variable represented the crop values after they were adjusted against the 1977 base-year prices. The values, in dollars per acre, of a given crop were based on the average gross incomes that farmers in the WWD service area received for each acre of production during each of the crop-water years. Whenever the data for the different varieties of cotton, lettuce, or peppers were listed separately for a given year in WWD's crop production report sheets, the average values of the varieties were calculated before being adjusted. The value of the cotton crop included both the seed and lint values.

One limitation in using the per-acre value as a form of measurement to represent crop value is that it is dependent on the quantity produced on each acre as well as the crop's price per unit. Because the yield can be affected by the quantities and types of production inputs that are used, and by physical conditions in the environment, it can vary from one farm to the next or from one year to the next. Therefore, the per-acre crop value does not reflect the maximum price a farmer can receive if production occurred under optimal conditions. However, the per-acre value was chosen as a way to provide a uniform method of comparing the results of different crops. Use of the unit price would not have provided this, as some crops are measured by their weight, while others are calculated by container sizes (such as cartons and boxes).

A comparison of gross margins of various crops is often recommended when a producer is deciding which crop to grow. Every attempt was made to secure information on crop production costs from Federal and State agricultural agencies, WWD, and agricultural lending institutions. However, production costs were available for a limited number of crops and only for selected years. Therefore, the gross margins could not be computed for each of the 23 years for any of the 15 crops.

Groundwater volume. The variable for the groundwater volume represented the total quantities of groundwater that were used for agricultural irrigation by the WWD service area during each of the crop-water years. Because not all wells were metered, these amounts were estimated by WWD through surveys of the water table. Numerical estimates were provided for the crop-water years from 1976 through 1992. Although graphical estimates were provided for 1970 through 1975, numerical estimates were not kept on file by WWD. The numerical and graphical estimates were both used in the regressions.

Information about groundwater supplies was limited. Separate data on groundwater usage for each crop and Priority Area were not available. This made it difficult to determine the specific role that the differences in the quality of groundwater supplies in different parts of the service area had in affecting crop acreage. Detailed information was lacking about the costs of making groundwater supplies available, such as the amounts farmers in the service area paid to drill new wells, reactivate old wells, and operate them.

Water transfers. WWD has secured transferred water supplies from other water districts every year since 1985. Because this amounts to a total of 8 years, or a fraction of the 23 years that were included in this investigation, the water-transfers variable took the form of a dummy variable. A value of 1 was assigned to each year that water transfers from other districts occurred. A value of 0 was assigned to each year prior to 1985 as an indication that transfers did not occur.

Water banks. The water-banks variable took the form of a dummy variable because the SWB and the CVP Water Bank programs were in operation for a limited number of years. The CVP Water Bank existed only in 1977, while the SWB operated in 1991 and 1992. Model 2A excluded all years prior to 1978. Therefore, this model included just two years, as opposed to three years, of water bank operations. A value of 1 was assigned appropriately, in both models, to the years of water bank operations. A value of 0 was assigned to the remaining years.

WWD service area expansion. In Model 1A, the service-area-expansion variable also took the form of a dummy variable, namely, WWD EXPN. A value of 1 was assigned to each year prior to 1978 as an indication that expansion of WWD's service area was not yet completed. A value of 0 was assigned to each year since 1978. In Model 2A, the problem of expansion was handled by excluding all years prior to 1978.

Results

The results for each of the time series multiple regression models are presented in tables 2 and 3 on the following pages. Significant t-values are indicated by positive signs (+) or negative signs (-) to represent positive correlations or negative correlations, respectively, between the independent and dependent variables. Significant F-ratios are indicated by the letter S. Actual t-values and F-ratios are given in parentheses below these signs. Single and double asterisks (* and **) indicate significance for a two-tail test at the 5% and 10% levels, respectively. Zeros (0) are used to indicate the lack of significant t-statistics or F-ratios. N/A indicates that the variable was not applicable to the model.

The adjusted R-square values are also indicated for all regression equations. They can serve as a means for comparing the strengths of the various models for each crop. Each of these values gives the percentage of the variation in the dependent variable, or crop acreage, that can be explained jointly by all independent variables in the model.

Table 2.--Results for Time Series Regressions: Model 1A

CROP	CVP RATE	CVP SUP	VALUE/AC	GW VOL	TRANSFRS	WTR BNKS	WWD EXPN	F-RATIO	ADJ R-SQ
ALFALFA HAY	0	0	0	-	0	+	+	S	61.1
				(3.66)*		(1.84)**	(2.52)*	(5.94)*	
ALFALFA SEED	0	0	0	+	0	-	+	S	74.8
				(2.48)*		(3.43)*	(2.84)*	(10.34)*	
CORN-FIELD	-	0	0	0	+	0	-	0	28.6
	(2.94)*				(2.21)*		(2.25)*		
COTTON (LINT & SEED	0	0	0	-	0	+	-	S	80.4
				(3.21)*		(2.65)*	(3.74)*	(13.91)*	
ONIONS-DEHYDRATOR	0	0	0	-	+	0	-	S	80.9
				(2.29)*	(4.37)*		(1.78)**	(13.07)*	
SAFFLOWER	0	0	0	+	0	-	0	0	21.4
				(1.79)**		(2.06)**			
SUGAR BEET	0	0	0	0	0	-	0	S	56.9
						(3.17)*		(5.14)*	
PEPPERS	0	0	0	0	+	0	0	S	54.4
					(2.41)*			(4.40)*	
BARLEY	0	0	0	-	0	0	0	S	51.1
				(1.88)**				(4.28)*	
BEANS-DRY	0	0	0	0	+	0	0	S	60.4
					(3.14)*			(5.80)*	
CANTALOUPE	0	0	0	0	0	0	-	S	76.4
							(4.85)*	(11.18)*	
GARLIC	0	0	0	0	+	0	-	S	86.0
					(3.17)*		(2.61)*	(20.31)*	
LETTUCE	+	0	0	0	+	0	-	S	89.0
	(1.81)**				(3.93)*		(2.07)**	(26.40)*	
TOMATOES-PROCESSING	0	-	0	-	+	0	0	S	75.4
		(1.86)**		(2.55)*	(2.28)*			(10.63)*	
WHEAT	0	0	+	0	0	0	-	S	56.4
			(2.72)*				(2.89)*	(5.07)*	

+ Positive correlation

- Negative correlation

0 Not significant

S Significant F-ratio

* p<.05

** p<.10

Table 3.--Results for Time Series Regressions: Model 2A

CROP	CVP RATE	CVP SUP	VALUE/AC	GW VOL	TRANSFRS	WTR BNKS	F-RATIO	ADJ R-SQ
ALFALFA HAY	0	0	0	0	0	0	0	12.9
ALFALFA SEED	0	0	0	0	0	0	S	42.4
							(2.72)**	
CORN-FIELD	0	0	0	0	0	N/A	0	26.0
COTTON (LINT & SEED)	0	0	0	0	0	0	0	32.7
ONIONS-DEHYDRATOR	0	-	0	-	+	+	S	83.7
		(2.42)*		(4.37)*	(6.54)*	(3.73)*	(13.00)*	
SAFFLOWER	0	0	0	0	0	0	0	0.0
SUGAR BEET	0	0	0	0	0	0	0	7.4
PEPPERS	0	+	0	0	0	0	S	48.9
		(2.20)**					(3.23)**	
BARLEY	0	0	0	+	-	-	S	52.3
				(2.34)*	(3.38)*	(2.58)*	(3.56)**	
BEANS-DRY	0	0	0	0	+	0	0	36.4
					(2.11)**			
CANTALOUPE	0	0	0	0	0	0	0	36.7
GARLIC	0	-	+	-	0	+	S	89.3
		(3.30)*	(3.60)*	(3.87)*		(3.43)*	(20.49)*	
LETTUCE	+	+	0	0	0	0	S	79.4
	(3.09)*	(2.42)*					(10.00)*	
TOMATOES-PROCESSING	0	-	0	-	+	+	S	66.8
		(2.44)*		(2.15)**	(2.80)*	(1.95)**	(5.69)*	
WHEAT	0	0	+	0	0	0	S	44.9
			(2.14)**				(2.90)**	

+ Positive correlation

- Negative correlation

0 Not significant

S Significant F-ratio

* p<.05

** p<.10

N/A Not applicable

CVP rate. The CVP rate appears to have had a limited effect on cropping patterns. The t-values for this variable were significant for only two crops, field corn in Model 1A, and lettuce in Models 1A and 2A. An increase (or decrease) in the CVP rates corresponded to increased (or decreased) acreage in lettuce. An increase (or decrease) in CVP rates corresponded to decreased (or increased) acreage in field corn. These results lend limited support to the hypothesis that as the cost of CVP water goes up over time, more acreage would be planted in crops with relatively low water needs and less acreage would be planted in crops with relatively high water requirements.

The limited impact of the cost of CVP water on crop acreage in Models 1A and 2A might be due to the availability of other water supplies at prices comparable to CVP rates. The first model included a period of time before parts of the current WWD service area had any access to CVP supplies and during which they relied heavily on groundwater. Both models included a period of three years of heavy reliance on groundwater when there were reductions in CVP deliveries because of the six-year drought. Between these two time periods, some use of groundwater had been practiced routinely. The costs of groundwater supplies were probably low for farmers who used them routinely. Another possibility is that when they used groundwater supplies to supplement CVP supplies, their total water costs were not much higher than they would have been with the use of equal amounts of CVP supplies alone. For farmers who were in either or both of these situations, changes in CVP rates would not have had a major impact on their cropping decisions.

CVP supply. Significant t-values for the CVP-supply variable were found for garlic, lettuce, dehydrator onions, and peppers in Model 2A, while significant t-values were found for processing tomatoes in both models. The results for garlic and processing tomatoes give limited support to the hypothesis that as CVP water becomes scarce, more land would be planted to crops with lower water needs. However, the results for dehydrator onions indicate that as CVP supplies declined, more land was planted to crops with higher water needs. Furthermore, the positive correlation between the CVP-supply and acreage variables in Model 2A was unexpected for lettuce.

Perhaps other factors played a more important role than the level of crop water needs in influencing crop acreages when changes in CVP supplies occurred. Acreages in garlic, dehydrator onions, and tomatoes were negatively correlated with CVP supplies. All three crops are used to process food products. As CVP supplies declined, farmers could have chosen to use them to grow crops that had guaranteed demands. Quantities and prices for crops used for processing are most often specified in advance in contracts between processors and growers. In the case of lettuce, increased supplies of CVP water could have allowed expansion of lettuce production in WWD's service area as the decline in fresh vegetable production in other areas of California provided the incentive to do so. In addition, the absence of significant t-ratios for the CVP-supply variable for most crops in Models 1A and 2A might be due to the availability and use of other water supply sources, especially groundwater.

Crop value per acre. Significant t-ratios for the crop-value-per-acre variable were found for garlic in Model 2A, and wheat in Models 1A and 2A. This variable was positively correlated with crop acreage for both crops.

Crop values appear to have had little impact on acreage for most crops. The changes in values among all crops, over time, might be a more important determinant of crop acreage than the changes in values within a crop, over time. The changes in values among all crops are explored in the other two investigations in Chapters 6 and 7.

Groundwater volume. Significant t-statistics for the groundwater-volume variable were found for alfalfa hay, alfalfa seed, cotton, and safflower in Model 1A; garlic in Model 2A; and barley, dehydrator onions, and processing tomatoes in both models. Groundwater usage and crop acreage were negatively correlated for alfalfa hay, cotton, garlic, dehydrator onions, and processing tomatoes. The variables were positively correlated for alfalfa seed and safflower. While groundwater usage and crop acreage were negatively correlated for barley in Model 1A, they were positively correlated in Model 2A.

No clear pattern was revealed about the relationship between groundwater usage and crop acreage. The results provide evidence both to support and refute the hypothesis that as dependence on groundwater supplies increases, acreage would decrease for crops that have relatively low water needs, and it would increase for crops that have relatively high water needs.

It is possible that the results were ambiguous because groundwater usage is a more complex matter than the overall availability of groundwater supplies. Not only are groundwater supplies in the WWD service area generally of poorer quality than CVP supplies, but the groundwater supplies also differ in quality throughout the service area and according to the pumping depth. Unfortunately, the lack of specific data on groundwater costs, the use of groundwater supplies, and crop acreage for each of WWD's Priority Areas made it difficult to examine how other aspects of groundwater supplies might have affected crop acreage.

Water transfers. The water-transfers variable had significant t-values for field corn, garlic, lettuce, and peppers in Model 1A; barley in Model 2A; and dry beans, dehydrator onions, and processing tomatoes in both models. The use of transferred water supplies was positively correlated with crop acreage for all of those crops except barley. However, the results provide evidence both to support and disprove the hypothesis that when transferred water supplies are available, acreage would decrease for crops that have relatively low water needs, and it would increase for crops that have relatively high water needs.

Unlike CVP supplies and to some extent, groundwater supplies, water transfers are a secondary source of water for farmers. Perhaps farmers were willing to expand crop acreage by using transferred supplies, when available, to the extent that it was profitable to do so. Another possible explanation for the results is that water transfers occurred in only 8 of the years that were included in this investigation. That time period might have been too short for a distinctive pattern to be revealed about any relationship between the availability of transferred water supplies and crop acreage.

Water banks. The water-banks variable had significant t-values for alfalfa hay, alfalfa seed, cotton, safflower, and sugar beet in Model 1A; and barley, garlic, dehydrator onions, and processing tomatoes in Model 2A. The results provide evidence to both support and refute the hypothesis that when supplies are made available through temporary federal or state water bank programs, acreage would decrease for crops that have relatively low water needs, and it would increase for crops that have relatively high water needs. Similar explanations that were given for the results of the water-transfers variable could apply to the water-banks variable.

WWD service area expansion. The service-area-expansion variable was included in Model 1A only. Nine crops showed significant differences in acreage between the time period before expansion of WWD's service area was completed (1970-1977) and the time period after it was completed (1978-1992). During the prior time period, there was significantly more acreage in alfalfa hay and alfalfa seed, while there was significantly less acreage in cantaloupe, field corn, cotton, garlic, lettuce, dehydrator onions, and wheat. It is noteworthy that as the service area of WWD expanded, there was a general trend away from growing alfalfa hay and alfalfa seed, two crops that have very high water needs.

Comparison of models. Model 1A provided the highest adjusted R-square values for 12 crops, which were alfalfa hay, alfalfa seed, dry beans, cantaloupe, field corn, cotton, lettuce, peppers, safflower, sugar beet, processing tomatoes, and wheat. This model showed significant F-ratios for all crops except field corn and safflower. These two crops also had low adjusted R-square values. The results for field corn can be attributed to the exclusion of the three years during which there was no acreage of this crop. Factors other than the variables that were included in the models apparently account for changes in safflower acreage over time. The availability of shallow groundwater supplies that exist in parts of the WWD service area has been identified as being among those factors (Bohigian n.d.c., 8). Safflower is both a deep-rooted and salt-tolerant plant, so it is able to take advantage of low quality, shallow groundwater supplies. Under these circumstances, the crop's irrigation requirements would be reduced.

Model 2A claimed the highest adjusted R-square values for only 3 crops, which were barley, garlic, and dehydrator onions. However, the values provided by Model 1A followed closely behind for these crops. Model 2A had significant F-ratios for 8 crops, which were alfalfa seed, barley, garlic, lettuce, dehydrator onions, peppers, processing tomatoes, and wheat. The relatively poor results for Model 2A might have been caused by the coverage of a shorter time period of 15 years as opposed to the 23 years covered by Model 1A, substantially reducing the degrees of freedom.

Tests for Multicollinearity

Correlation matrices were prepared as a way of identifying problems of multicollinearity among the independent variables. For any given year, the values for the CVP rate and each of the water supply variables were the same for all crops, but the crop values per acre were not. Therefore, the discussions on multicollinearity are separated accordingly. Furthermore, the discussions focus on correlations that were greater than |.70|.

Correlations among CVP rate and water supply variables. Correlation coefficients among the independent variables, except for the crop-value-per-acre variable, can be found in tables 4 through 9 on the following pages. For all crops having complete sets of 23 years of data in Model 1A, the CVP-rate variable was correlated with the water-transfers variable, while the groundwater-volume variable was correlated with the CVP-supply and water-banks variables. Although the coefficients differed slightly, there were correlations among these same variables for dehydrator onions and peppers, which each had 21 years of data rather than 23. A correlation between the CVP-rate and water-transfers variables was also found for field corn, which had 20 years of data.

In comparison to Model 1A, higher levels of correlation, in absolute value terms, were generally found in Model 2A. Except for field corn, all crops had complete sets of data for 15 years in Model 2A. For those crops, the CVP-rate variable was correlated with the CVP-supply, groundwater-volume, and water-banks variables; the CVP-supply variable was correlated with the groundwater-volume

Table 4.--Multicollinearity Test for Independent Variables: Model 1A, Crops with 23 Years of Data

	CVP RATE	CVP SUP	GW VOL	TRANSFRS	WTR BNKS
CVP SUP	-0.467	1.000			
GW VOL	0.532	-0.800	1.000		
TRANSFRS	0.767	-0.219	0.349	1.000	
WTR BNKS	0.573	-0.636	0.804	0.259	1.000
WWD EXPN	-0.585	-0.242	0.104	-0.533	-0.012

Table 5.--Multicollinearity Test for Independent Variables: Model 1A, Dehydrator Onions

	CVP RATE	CVP SUP	GW VOL	TRANSFRS	WTR BNKS
CVP SUP	-0.542	1.000			
GW VOL	0.632	-0.788	1.000		
TRANSFRS	0.753	-0.260	0.409	1.000	
WTR BNKS	0.567	-0.674	0.872	0.240	1.000
WWD EXPN	-0.532	-0.217	0.059	-0.496	0.043

Table 6.--Multicollinearity Test for Independent Variables: Model 1A, Peppers

	CVP RATE	CVP SUP	GW VOL	TRANSFRS	WTR BNKS
CVP SUP	-0.541	1.000			
GW VOL	0.616	-0.811	1.000		
TRANSFRS	0.753	-0.263	0.401	1.000	
WTR BNKS	0.567	-0.667	0.847	0.240	1.000
WWD EXPN	-0.532	-0.199	0.048	-0.496	0.043

Table 7.--Multicollinearity Test for Independent Variables: Model 1A, Field Corn

	CVP RATE	CVP SUP	GW VOL	TRANSFRS	WTR BNKS
CVP SUP	-0.013	1.000			
GW VOL	0.052	-0.652	1.000		
TRANSFRS	0.710	0.102	0.079	1.000	
WTR BNKS	0.046	-0.304	0.549	-0.132	1.000
WWD EXPN	-0.625	-0.528	0.400	-0.471	0.281

Table 8.--Multicollinearity Test for Independent Variables: Model 2A, Crops with 15 Years of Data

	CVP RATE	CVP SUP	GW VOL	TRANSFRS
CVP SUP	-0.892	1.000		
GW VOL	0.858	-0.939	1.000	
TRANSFRS	0.676	-0.494	0.582	1.000
WTR BNKS	0.742	-0.833	0.930	0.367

Table 9.-- Multicollinearity Test for Independent Variables: Model 2A, Field Corn

	CVP RATE	CVP SUP	GW VOL
CVP SUP	-0.744	1.000	
GW VOL	0.726	-0.814	1.000
TRANSFRS	0.634	-0.296	0.704

and water-banks variables; and the groundwater-volume variable was correlated with the water-banks variable. For field corn, which had only 12 years of data, the groundwater-volume variable was correlated with the CVP-rate, CVP-supply, and water-transfers variables, while the CVP-rate variable was correlated with the CVP-supply variable.

It had already been anticipated that the CVP-supply variable would be negatively correlated with the other water supply variables to some extent because as CVP supplies become scarce, farmers would be expected to turn to other water supply sources. It was also anticipated that the rest of the water supply variables might be positively correlated with each other for the same reasons. All of these variables were intentionally included in the models because part of the purpose of conducting the time series regressions was to see how each type of water supply source would individually affect crop acreage, once the others were taken into account. Some of the regression results have demonstrated that more than one water supply source (independent variable) can be significantly correlated with crop acreage (dependent variable) at the same time. Such results were found for alfalfa hay, alfalfa seed, cotton, dehydrator onions, safflower, and processing tomatoes in Model 1A, and for barley, garlic, dehydrator onions, and processing tomatoes in Model 2A.

A correlation between the CVP-rate and CVP-supply variables was greater than |.70| in Model 2A, but not in Model 1A. Perhaps this reflects the large rise in the costs of CVP water as CVP supplies became scarcer during the drought years. Both variables were included in the models because the intent was to investigate the individual effect that each of them would have on crop acreage. In Model 2A, both variables had significant t-ratios for lettuce.

Except for the CVP-supply variable, no direct relationships are believed to have existed between each of the water supply variables and the CVP rate variable. Significant t-ratios were found for both the CVP-rate and water-transfers variables in Model 1A for field corn and lettuce.

Correlations between crop value and other explanatory variables. Correlation coefficients between crop value and other independent variables are presented in tables 10 and 11 on the following pages. While none of the correlations between the crop-value-per-acre variable and each of the other explanatory variables exceeded |.81|, positive correlations greater than .70 were found for only a few crops. Such correlations were found between the crop-value-per-acre and CVP-rate variables in Model 1A for cotton, and in Model 2A for peppers. As CVP rates increased, attempts could have been made to increase the

Table 10.--Multicollinearity Tests Between Crop Value and Independent Variables: Model 1A

CROP	CVP RATE	CVP SUP	GW VOL	TRANSFRS	WTR BNKS	WWD EXPN
ALFALFA HAY	0.079	0.424	-0.492	0.379	-0.433	-0.501
ALFALFA SEED	0.303	-0.128	-0.025	0.235	0.221	-0.094
BARLEY	-0.087	0.092	-0.293	-0.031	-0.211	0.094
BEANS-DRY	0.313	0.115	-0.139	0.421	-0.001	-0.286
CANTALOUPE	-0.050	-0.103	-0.219	0.104	-0.130	0.159
CORN-FIELD	0.096	0.056	-0.154	0.466	-0.093	-0.077
COTTON (LINT & SEED)	0.738	-0.275	-0.206	0.709	0.320	-0.651
GARLIC	-0.314	-0.048	0.250	-0.134	-0.015	0.614
LETTUCE	0.131	0.092	0.066	0.149	0.055	-0.280
ONIONS-DEHYDRATOR	0.462	-0.299	0.094	0.505	0.048	-0.324
PEPPERS	0.575	-0.591	0.607	0.602	0.268	-0.013
SAFFLOWER	-0.020	0.139	-0.174	0.286	-0.130	-0.103
SUGAR BEET	0.195	0.137	0.022	0.317	-0.022	-0.134
TOMATOES-PROCESSING	0.321	0.253	-0.080	0.435	0.028	-0.481
WHEAT	0.454	-0.013	-0.150	0.467	0.144	-0.449

Table 11.--Multicollinearity Tests Between Crop Value and Independent Variables: Model 2A

CROP	CVP RATE	CVP SUP	GW VOL	TRANSFRS	WTR BNKS
ALFALFA HAY	-0.337	0.589	-0.560	0.169	-0.606
ALFALFA SEED	0.377	-0.176	0.266	0.305	0.257
BARLEY	-0.074	0.160	-0.188	0.027	-0.304
BEANS-DRY	0.264	-0.125	0.068	0.572	-0.146
CANTALOUPE	0.091	0.186	-0.117	0.330	-0.102
CORN-FIELD	0.100	0.420	-0.129	0.591	N/A
COTTON (LINT & SEED)	0.656	-0.546	0.574	0.670	0.494
GARLIC	0.258	-0.099	0.260	0.808	0.099
LETTUCE	-0.081	0.102	-0.068	-0.001	-0.096
ONIONS-DEHYDRATOR	0.446	-0.393	0.366	0.515	0.168
PEPPERS	0.719	-0.658	0.554	0.737	0.265
SAFFLOWER	-0.166	0.264	-0.201	0.299	-0.351
SUGAR BEET	0.224	-0.120	0.106	0.416	0.037
TOMATOES-PROCESSING	0.021	-0.021	-0.014	0.338	-0.110
WHEAT	0.330	-0.188	0.253	0.400	0.299

N/A Not applicable

yield produced per acre, or in the case of peppers, farmers could have concentrated on growing the higher-value varieties. The crop-value-per-acre variable was also correlated with the water-transfers variable in Model 1A for cotton, and Model 2A for garlic and peppers. As the crop values rose, farmers could have been more willing to turn to transferred water supplies to supplement their water needs.

At the most, only one of the two explanatory variables in each of these correlations had a significant t-statistic when the regressions were run. For this reason, new regressions were run by eliminating each of the two variables separately from the models. Based on the adjusted R-square values, F-ratios, and significant t-statistics, the results were compared to those of the original models. For the cotton crop, the results for Model 1A improved when the CVP-rate and water-transfers variables were both excluded. Eliminating the water-transfers variable from Model 2A generally gave better results for garlic, and it also caused the CVP-rate variable to become significant. The removal of the crop-value-per-acre variable from Model 2A produced better results for peppers, including a higher F-ratio. The improved results are presented in tables 12 through 14 on the following pages.

Table 12.--Comparison of Results for Original and Revised Models: Cotton

MODEL	CVP RATE	CVP SUP	VALUE/AC	GW VOL	TRANSFRS	WTR BNKS	WWD EXPN	F-RATIO	ADJ R-SQ
1A	0.33	-0.29	-0.71	-3.21	0.27	2.65	-3.74	13.91	80.40
REVISED	N/A	-0.38	-0.54	-3.74	N/A	3.33	-5.36	21.32	82.20

N/A Not applicable

Table 13.--Comparison of Results for Original and Revised Models: Garlic

MODEL	CVP RATE	CVP SUP	VALUE/AC	GW VOL	TRANSFRS	WTR BNKS	F-RATIO	ADJ R-SQ
2A	1.18	-3.30	3.60	-3.87	0.95	3.43	20.49	89.30
REVISED	2.48	-3.19	6.52	-3.88	N/A	3.46	24.70	89.40

N/A Not applicable

Table 14.--Comparison of Results for Original and Revised Models: Peppers

MODEL	CVP RATE	CVP SUP	VALUE/AC	GW VOL	TRANSFRS	WTR BNKS	F-RATIO	ADJ R-SQ
2A	1.35	2.20	0.46	0.39	0.58	0.58	3.23	48.90
REVISED	1.53	2.33	N/A	0.49	0.88	0.41	4.21	53.40

N/A Not applicable

CHAPTER 6

AN INVESTIGATION OF THE EFFECTS OF THE 1987-1992 DROUGHT ON CROPPING PATTERNS IN THE WESTLANDS WATER DISTRICT SERVICE AREA

Changes that occurred in the total crop acreage in the WWD service area as a result of the six-year drought were examined in this part of the study. An investigation was conducted on the factors that were likely to encourage crop switching when water supplies became scarce. What factors encouraged increases in acreage for some crops and reductions in acreage for other crops during the drought? What factors accounted for why changes in crop acreage varied across individual crops during the drought?

The attempt was made to determine the effects that different crop characteristics had on the changes in the crop acreage during the drought in comparison to the previous six years. Crop characteristics or variables that were expected to affect these changes are the crops' values during the time period prior to the drought, the changes in their values between the two time periods, their water requirements, their eligibility to participate in agricultural support programs, and the agricultural loan risk posed by them.

The variables in the models are defined as follows:

%CHNG AC = the percentage change in the no. of acres of crop production from pre-drought period to drought period

VAL/A BE = the per-acre crop value before the drought

%CHNG VA = the percentage change in per-acre crop values from pre-drought period to drought period

ET RATE = the historical seasonal evapotranspiration of crops grown in the WWD service area

DEF PYMT = a dummy variable: DEF PYMT=1 for crops eligible to participate in the Deficiency Payment Program, 0 otherwise

PRCE SUP = a dummy variable: PRCE SUP=1 for crops eligible to participate in the Price Support Loan Program, 0 otherwise

RISK = a dummy variable: RISK=1 if the loan risk of a crop is high, 0 otherwise; cotton is not considered to be high in risk

RISK W/C = a dummy variable: RISK W/C =1 if the loan risk of a crop is high, 0 otherwise; cotton is considered to be high in risk

The following cross section, multiple regression models were developed:

Model 1B. %CHNG AC = b1 + b2(VAL/A BE) + b3(%CHNG VA) + b4(ET RATE) + b5(DEF PYMT) + b7(RISK)

Model 2B. %CHNG AC = b1 + b2(VAL/A BE) + b3(%CHNG VA) + b4(ET RATE) + b5(DEF PYMT) + b8(RISK W/C)

Model 3B. %CHNG AC = b1 + b2(VAL/A BE) + b3(%CHNG VA) + b4(ET RATE) + b6(PRCE SUP) + b7(RISK)

Model 4B. %CHNG AC = b1 + b2(VAL/A BE) + b3(%CHNG VA) + b4(ET RATE) + b6(PRCE SUP) + b8(RISK W/C)

The dependent variable in all models is expressed as percentage changes in the crop acreage that occurred between the pre-drought and drought periods. The Deficiency Payment Program and the Price Support Loan Program were two separate, but similar, types of agricultural support programs that were expected to affect crop acreage. Because of this, they were included in separate regression models so that their results could be compared. Also, there were two lines of thought among agricultural lenders in California as to which crops were considered high loan risks. These lines of thought were represented by two different variables, "RISK" and "RISK W/C", which were included in separate regression models.

Hypotheses

A summary of the hypotheses for all models are presented in table 15 on the next page. A positive sign (+) indicates that a positive correlation between the independent and dependent variables was expected. A negative sign (-) indicates that a negative correlation between the independent and dependent variables was expected. N/A indicates that the variable was not included and therefore, it was not applicable to the model.

Crop values before the drought. It was expected that farmers would make adjustments in their crop production after the onset of the drought because of the growing

Table 15.--Hypotheses for Cross Section Regressions: Drought Effects

MODEL	VAL/A BE	%CHNG VA	ET RATE	DEF PYMT	PRCE SUP	RISK	RISK W/C
1B	+	+	-	-	N/A	-	N/A
2B	+	+	-	-	N/A	N/A	-
3B	+	+	-	N/A	-	-	N/A
4B	+	+	-	N/A	-	N/A	-

\+ Positive correlation between independent variable and percentage change in acreage

\- Negative correlation between independent variable and percentage change in acreage

N/A Not applicable

scarcity of inexpensive sources of water. To protect their gross and net margins, farmers were expected to switch to crops that were higher in value. This response could have been based on their prior knowledge of crop values.

The following hypothesis was developed. The values that the crops held per acre, in dollars, during the time period before the drought would be positively correlated with changes in crop acreage that occurred from the pre-drought period to the drought period. The percentage changes in the total crop acreage in the WWD service area would be positive if the crop values were high. The percentage changes would be negative if the crop values were low.

Changes in crop values from pre-drought period to drought period. The farmer's response to the drought could also have been partially based on pricing information that currently existed at the time of the drought. A comparison of crop prices between the two time periods could have affected their decisions on crop production.

The following hypothesis was developed. The percentage changes that occurred in the per-acre crop values from the pre-drought period to the drought period would be positively correlated with the percentage changes that occurred in the crop acreage from the pre-drought period to the drought period. As the percentage changes in crop values increased, the percentage changes in the crop acreage would also increase in the WWD service area.

<u>Crop water needs</u>. Another way that farmers were expected to change their crop production in response to the drought was to switch to crops that had lower water requirements. As water supplies grew scarcer during the drought, it was expected that they would be used on a limited basis for crops that had relatively high water needs.

The following hypothesis was developed. The variable for the crop water needs would be negatively correlated with the percentage changes in crop acreage. As the seasonal ET rates increased (decreased) in acre-feet, the crop acreage in the WWD service area would decrease (increase) from the pre-drought period to the drought period.

<u>Agricultural support programs</u>. For some farmers, the prospects of receiving guaranteed prices and having to reduce production acreage because of decreased water supplies could have served as an incentive to participate in agricultural support programs during the drought. Therefore, it was expected that participation in agricultural support programs would increase from the pre-drought period to the drought period. Acreage reduction is a requirement for all crops that are eligible to participate in the Deficiency Payment Program, and it is

also a requirement for most crops that are allowed to participate in the Price Support Loan Program. Therefore, if participation in these agricultural support programs increased from the pre-drought period to the drought period, the acreage for these crops would decrease.

The following hypothesis was developed. The percentage changes in acreage in the WWD service area would be negative for crops that were eligible to participate in the agricultural support programs.

Agricultural loan risks. The agricultural loan process includes a consideration of the risks involved in producing and marketing the commodity. This process was expected to affect shifts in cropping patterns because loans are approved according to the specific crop that the farmer plans to produce. Furthermore, the scarcity of water supplies during a drought period is considered to increase the risks of production for all crops.

The following hypothesis was developed. The percentage changes in acreage from the pre-drought period to the drought period in the WWD service area would be negative for high-risk crops.

Data

Selected crops and changes in acreage. The 15 crops that were used in the time series regressions to study the historical cropping patterns in the WWD service area were also used in these cross section regressions.

The dependent variable was represented by percentage changes in acreage instead of absolute changes because the focus was on the acreage changes for all the crops, relative to each other. For each crop, calculations were made on the percentage change in acreage that occurred from the pre-drought period to the drought period. The average numbers of acres in each time period were used in the calculations. Except for field corn, these time periods included six years immediately preceding the drought (1981-1986) and six years during the drought (1987-1992). The average numbers of acres for field corn were based on three years from each time period because there were no corn acreages during three years of the drought (1989, 1991, and 1992).

Crop values before the drought, changes in crop values from pre-drought period to drought period. For each crop except field corn, the average values, in dollars per acre, were calculated for the six-year period immediately preceding the drought and for the six-year period of the drought. The average values for field corn were calculated for three years in each time period. All average values were derived from values that were adjusted by using 1977 as the base year. The changes in crop values from the pre-drought period to the drought period were calculated in percentage terms as a way of allowing an equitable comparison of the crops.

Crop water needs. The water needs of crops were represented by the seasonal evapotranspiration rates, in acre-feet per crop acre, that occurred historically in the WWD service area. The quantities of water that were applied to crops, used for cultural practices, used for leaching, or lost to deep percolation were not included as part of the crop water needs because they were subject to the individual farmer's decisions or actions, weather conditions, and soil conditions.

Agricultural support programs. The variables for the agricultural support programs are dummy variables. Crops that were eligible to participate in the Deficiency Payment and Price Support Loan Programs were assigned values of 1. Crops that were not included in these programs were assigned values of 0. The following crops were eligible for deficiency payments: barley, field corn, cotton, and wheat. These same crops were eligible for price support loans, but other crops that were also eligible for these loans included safflower and sugar beet.

Agricultural loan risks. The variables for loan risks are also dummy variables. Crops that were considered to be high in risk were assigned values of 1. Crops that were not considered to be high in risk were assigned values of 0. The loan-risk variable in Models 1B and 3B included the following as being high-risk crops: dry beans, cantaloupe, garlic, lettuce, dehydrator onions, peppers, and processing tomatoes. The loan-risk variable in Models 2B and 4B included these same crops as being high in risk and also included cotton.

Results

The results are summarized in table 16 on the next page. (Refer to page 90 for a description of the symbols.)

Comparison of models. Model 2B gave the best results in terms of the adjusted R-square value, F-ratio, and t-values. This model had two significant t-values, but the other three models had none.

While testing for problems of multicollinearity, the correlation matrix showed a correlation of -.764 between the Price-Support-Loan-Program variable and the loan-risk variable in Model 3B. This result suggests that one of these variables should be deleted from the regression model. However, Model 3B was developed for illustrative purposes.

Crop values before the drought. The t-values for the pre-drought-crop-values variable were not significant in any of the four models. These results do not support the claim that farmers would switch to growing higher-value crops as water supplies grew scarcer because of the drought.

Table 16.--Results for Cross Section Regressions: Drought Effects

MODEL	VAL/A BE	%CHNG VA	ET RATE	DEF PYMT	PRCE SUP	RISK	RISK W/C	F-RATIO	ADJ R-SQ
1B	0	0	0	0	N/A	0	N/A	S	56.9
								(4.70)*	
2B	0	0	0	-	N/A	N/A	+	S	69.1
				(2.82)*			(2.19)**	(7.25)*	
3B	0	0	0	N/A	0	0	N/A	S	46.2
								(3.41)**	
4B	0	0	0	N/A	0	N/A	0	S	45.5
								(3.34)**	

\+ Positive correlation

\- Negative correlation

0 Not significant

S Significant F-ratio

* p<.05

** p<.10

N/A Not applicable

Perhaps these results are due to a time lag in the farmers' responses to the drought and water supply conditions. Farmers might not have felt a need to make cropping changes during the first two or three years of the drought because there were no reductions in WWD's entitlements to the CVP supply until the fourth year, and the allocation for the third year was restored to the full contract amount after the Bureau initially announced a reduction in CVP supplies. Another explanation is that many farmers might have perceived the drought and water supply shortage as being a temporary situation. They might have felt that they would recover from temporary reductions in income after conditions returned to normal. Also, the number of observations, which consisted of 15 crops, might have been too small to reveal significant changes in acreage.

Changes in crop values from pre-drought period to drought period. The variable for the changes in crop values was not significant in any of the models. This suggests that any changes that occurred in the per-acre crop value between the pre-drought and drought periods did not affect changes in the crop acreage.

Again, the results could be attributed to a time lag in the farmers' responses. In this case, however, the delay in responses would have been to the changing crop values instead of the drought and water supply conditions.

A time lag might have occurred as some of the farmers were in the process of developing and implementing plans to shift to crops that were increasing in value. They might have also been waiting to see whether or not the changes in crop values were of a temporary nature before initiating any changes in crop production.

Crop water needs. The variable for the crop water needs had no significant t-values in any of the models. These results do not support the hypothesis that the water requirements of crops would be associated with changes in crop acreage between the two time periods.

The same explanations that were given for the results of the variable for the pre-drought crop values can also be applied here. In addition, the availability of groundwater supplies probably lessened the impact that crop water needs had on crop acreage.

Agricultural support programs. The variables for the agricultural support programs gave mixed results. The t-ratio for the Deficiency-Payment-Program variable in Model 2B supports the hypothesis that participation in this program would increase during the drought and therefore, acreage would decrease for the crops that were eligible for this program. However, the t-ratio for this variable in Model 1B was not significant.

The Price-Support-Loan-Program variable had no significant t-values in any of the models. These results are not totally surprising because the regressions included two crops for which acreage reduction was not a requirement for program eligibility.

Agricultural loan risks. While the loan-risk variable that did not include cotton was not significant in either Models 1B or 3B, the loan-risk variable that did include cotton was significant in Model 2B alone. However, the impact of the variable in Model 2B took the form of a positive correlation instead of a negative one. Hence, these results do not support the hypothesis that the percentage changes in acreage would be negative for high-risk crops.

Because there were other criteria that were considered in the agricultural loan approval process, these other criteria were probably either equally as important, or more important, than the risk level of crops in determining changes in acreage.

CHAPTER 7

AN INVESTIGATION OF THE EFFECTS OF THE STATE DROUGHT WATER BANK ON CROPPING PATTERNS IN THE WESTLANDS WATER DISTRICT SERVICE AREA

Changes that occurred in the total crop acreage in the WWD service area as a result of the formation of the State Drought Water Bank were examined in this part of the study. An investigation was conducted on the factors that were likely to encourage crop shifting when an expensive water supply source became available at the same time that inexpensive CVP water supplies became scarce.

An attempt was made to determine the effects that different crop characteristics had on the changes in the crop acreage during the two-year time period of the SWB's operation in comparison to the previous two years. Crop characteristics or variables that were expected to affect these changes are similar to those that were expected to affect the changes in the crop acreage because of the drought, as discussed in the previous chapter.

The variables in the models are defined as follows:

%ACHANGE = the percentage change in the no. of acres of crop production from the time period before the existence of the SWB to the time period during the existence of the SWB

VALUE BE	=	the per-acre crop value before the existence of the SWB
%VCHANGE	=	the percentage change in per-acre crop values from the period before the existence of the SWB to the period during the existence of the SWB
ET RATE	=	the historical seasonal evapotranspiration of crops grown in the WWD service area
RISK	=	a dummy variable: RISK=1 if the loan risk of a crop is high, 0 otherwise; cotton is not considered to be high in risk
RISK W/C	=	a dummy variable: RISK W/C=1 if the loan risk of a crop is high, 0 otherwise; cotton is considered to be high in risk

The following cross section, multiple regression models were developed:

Model 1C. %ACHANGE = c1 + c2(VALUE BE) + c3(%VCHANGE) + c4(ET RATE) + c5(RISK)

Model 2C. %ACHANGE = c1 + c2(VALUE BE) + c3(%VCHANGE) + c4(ET RATE) + c6(RISK W/C)

The dependent variable in all models is expressed as percentage changes that occurred in the total crop acreage between the period prior to the SWB's establishment and the period during the SWB's operation. The agricultural support programs were not included in the models listed here, and the reasons are discussed in the Results section of this chapter. As in the investigation on the effects of the drought, two different variables for agricultural loan risks were included in separate regression models in this investigation.

Hypotheses

A summary of the hypotheses for both models is presented in table 17 on the next page. (Refer to page 117 for a description of the symbols.)

Crop values before the SWB's existence, changes in crop values from the period before the SWB's existence to the period during its operation, crop water needs. Most farmers were expected to turn to other water supply sources to supplement their reduced CVP supplies during the drought. If they could not secure cheaper supplies elsewhere, some of them might have had no alternative but to purchase water from the SWB, which was an expensive source of water that existed during two of the six drought years. It was expected that those who relied on the SWB would have made adjustments in their crop production based on the crop values that existed prior to the establishment of the SWB, the percentage changes that occurred in the crop values from the time period before the SWB's existence to the time period during its operation, and the crop water requirements.

Agricultural loan risks. It has become common for agricultural loan applications to request information about a farmer's access to water supplies. The use of expensive water supply sources, such as the SWB, is considered to increase the risks of crop production because it reduces a farmer's profits. As farmers turned to the SWB to

Table 17.--Hypotheses for Cross Section Regressions: SWB Effects

MODEL	VALUE BE	%VCHANGE	ET RATE	RISK	RISK W/C
1C	+	+	-	-	N/A
2C	+	+	-	N/A	-

\+ Positive correlation between independent variable and percentage change in acreage

\- Negative correlation between independent variable and percentage change in acreage

N/A Not applicable

supplement their reduced CVP supplies, approvals for agricultural loans were expected to become even more difficult to obtain for high-risk crops.

Specific statements of the hypotheses. The hypotheses about the relationships between each of the explanatory variables and the dependent variable are similar to those that were developed in the previous chapter about the effects of the drought. Therefore, specific statements of the hypotheses are not presented here. However, in this investigation, the hypotheses pertain to the time period prior to the SWB's formation instead of the pre-drought period, and to the time period of the SWB's operation instead of the drought period.

Data

Most of the information that were presented in the previous chapter about the data that were used to investigate the effects of the drought, are also applicable to this investigation. However, there are two major differences between both investigations. The total time period in this case consisted of 4 years from 1989 through 1992, while the total time period in the drought investigation consisted of 12 years from 1981 through 1992. The second difference is that 14 crops, instead of 15, were included in this investigation. Field corn was excluded because there was no acreage of it during both years of the SWB program and one of the years prior to the program.

Results

The results are summarized in table 18 on the next page. (Refer to page 90 for a description of the symbols.)

Comparison of models. Model 2C did only slightly better than Model 1C in terms of the adjusted R-square values and F-ratios. Both models had significant F-values and significant t-ratios for the variable that represented the pre-SWB crop values. There were no significant t-ratios for the other explanatory variables in either model.

Crop values before the SWB's existence. The results for both models lend support to the hypothesis that the higher the crop value was during the period before the SWB's existence, the greater the percentage increase would be in the crop acreage; and the lower the crop value was during that same time period, the greater the percentage decrease would be in the crop acreage. There were severe cutbacks of 75% in the CVP water supply to WWD during both years of the SWB's operation. Although enough SWB supplies were provided to meet demands, these supplies were expensive. It appears that when farmers were forced to pay the full costs of their water supplies and cheaper supplies grew scarcer, the water was put to higher-value uses. Rather than use an expensive source of water to grow low-

Table 18.--Results for Cross Section Regressions: SWB Effects

MODEL	VALUE BE	%VCHANGE	ET RATE	RISK	RISK W/C	F-RATIO	ADJ R-SQ
1C	+	0	0	0	N/A	S	54.4
	(3.05)*					(4.88)*	
2C	+	0	0	N/A	0	S	58.0
	(2.79)*					(5.49)*	

+ Positive correlation

- Negative correlation

0 Not significant

S Significant F-ratio

* p<.05

N/A Not applicable

value crops, it appears that they chose to reduce production of those crops.

Changes in crop values from the period before the SWB's existence to the period during its operation. Based on the absence of significant t-ratios in both models, it appears that during dramatic reductions in cheap water supplies, farmers were not very concerned with the changes in values that occurred within a crop between the two time periods. Instead, they were probably more concerned about the relative differences in values among various crops and whether the levels of crop values were high, low, or intermediate.

Crop water needs. Based on the absence of t-values in both models, the results suggest that the farmers did not switch to growing crops that had lower water requirements at a time when some of them turned to an expensive water supply source. Again, they might have been more concerned about the relative values of the various crops. However, this does not necessarily mean that growers did not attempt to reduce their water usage; they could have done so by employing water conservation techniques.

Agricultural loan risks. The results for the two loan-risk variables in both models do not support the hypothesis that when farmers relied on expensive SWB water supplies, there would be a greater percentage of acreage decline in high-risk crops. Other factors that were analyzed during the loan approval process were probably equally as important, or more important, than the risk level of a crop.

The development and testing of other models. Variables for the agricultural support programs were originally included in the models, but they were dropped after the tests for multicollinearity showed a correlation of -.745 between the Price-Support-Loan-Program variable and the loan-risk variable that did not include cotton as a high-risk crop. Not only did the regressions show higher adjusted R-square values, F-ratios, and t-statistics when the Price-Support-Loan-Program variable was excluded from the models, but these values were also higher when the Deficiency-Payment-Program variable was removed. Therefore, the models were revised to exclude both of the agricultural-support-program variables.

Perhaps the variables for the agricultural support programs were not significant because limits were set on the numbers of acres that were allowed to be reduced, and perhaps participation in those programs had already peaked during previous years.

Additional models were tested by including the agricultural-support-program variables while simultaneously excluding the loan-risk variables. In general, the results for these additional models were slightly worse than the results for the revised models.

CHAPTER 8

CONCLUSIONS

Based on the results of this study, general statements cannot be made about the level of efficiency of agricultural water use under different conditions of water supply availability and pricing in the Westlands Water District service area. The results of all three investigations did not provide strong evidence that when water supplies grew scarcer or costlier, they would be used to expand the acreage in crops that were high in value or low in water needs. Neither did they provide strong evidence that under either of these conditions, acreage would decline for crops that were low in value or high in water needs. Depending on the individual case, statistically significant results gave, at best, very limited support to either position.

In the time series investigation in Chapter 5, the results for only two crops supported the hypothesis that as CVP rates increase, acreage would increase (decrease) for crops with relatively low (high) water requirements. Furthermore, the results for only two crops supported the hypothesis that crop values would be positively correlated with crop acreage. The results for the CVP-supply, groundwater-volume, water-transfers, and water-banks variables provided evidence both to support and refute the hypothesis that as water supplies become scarce, more (less) acreage would be planted in crops with relatively low (high) water needs.

In the cross-sectional investigation in Chapter 6, the results for the Deficiency-Payment-Program variable in one model supported the hypothesis that participation in the payment program would increase during the drought and therefore, acreage would decrease for program crops. The results for the loan-risk variable in one of the models, which included cotton as a high-risk crop, provided evidence to refute the hypothesis that percentage changes in acreage would be negative for high-risk crops.

In the cross-sectional investigation in Chapter 7, the results for both models supported the hypothesis that the higher (lower) the crop value was (during the period before the State Drought Water Bank existed), the greater the percentage increase (decrease) would be in acreage.

The general lack of statistically significant t-values in the results for all three investigations can be partially attributed to the limitations in the data and the short time periods that were included in the regressions. Further study is needed after more time has elapsed, not only for the purpose of including more data and observations, but also to allow water use issues to stabilize in the political arena and to allow more time for water policies or regulations to be implemented.

In addition to the variables that were included in the regression models, other factors might have influenced cropping patterns in the WWD service area. Crop rotations that were routinely practiced by some of the farmers would have caused changes in crop acreages. Saline shallow groundwater could have acted as either a water supply source or a threat to crop production. Water conservation practices could have increased the availability of limited water supplies. Differences in soil conditions could have limited the types of crops that were grown in different parts of WWD's service area. Reductions in the average farm size as a result of the Reclamation Reform Act of 1982 could have caused cropping patterns to change. Changes in a crop's acreage could have been related to changes in its per-acre yield. Limited production capacity by processing facilities in the region would have limited the extent to which farmers could expand acreage, over the short-term, in processing crops such as dehydrator onions, sugar beets, and processing tomatoes. These factors were not included in this study because data limitations did not make them amenable to statistical analyses, or because it would have been beyond the scope of this study to do so. Further research is needed to investigate the roles that these factors might have played in influencing cropping patterns in the WWD service area.

FIGURES

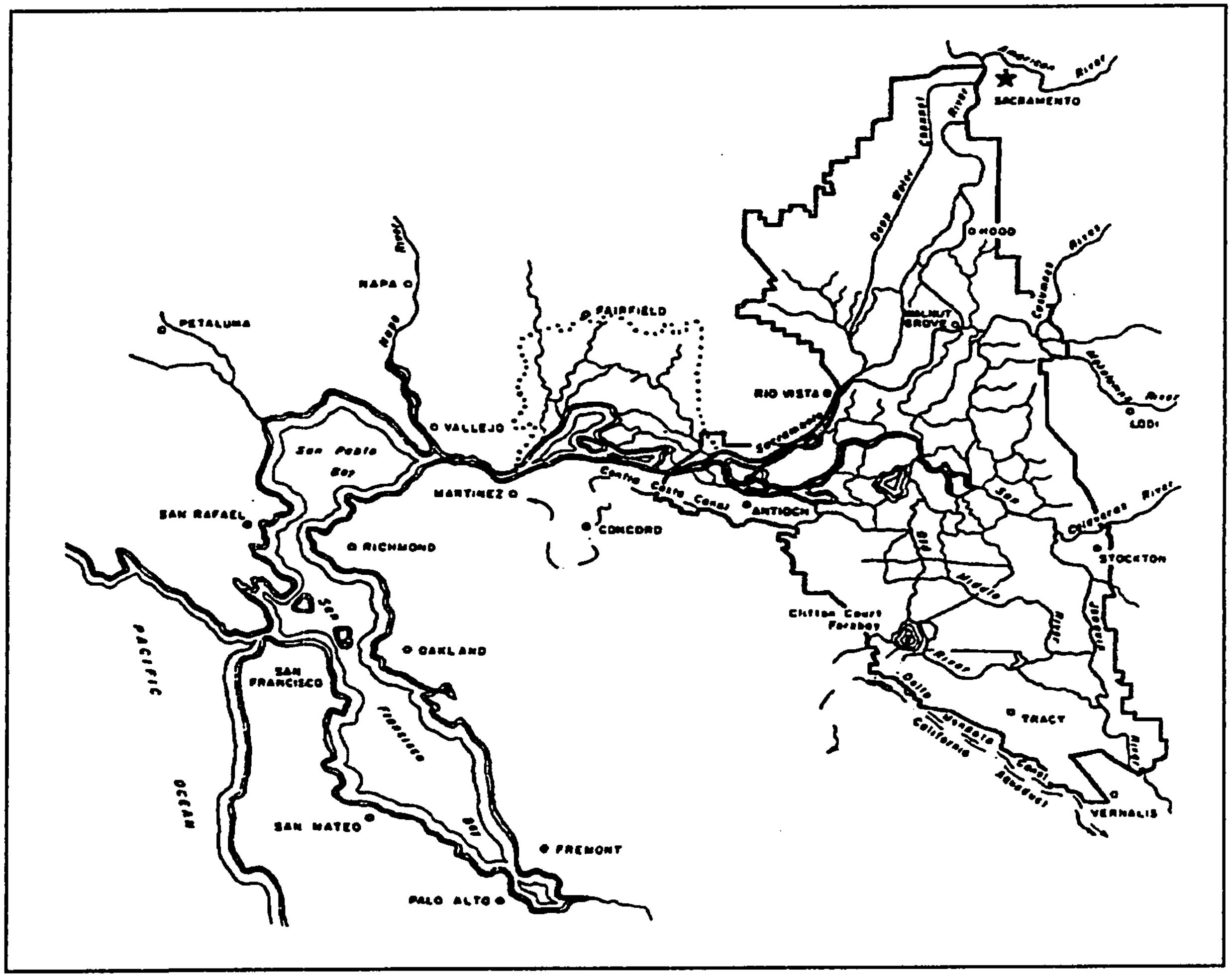

Fig. 1. San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Reprinted from State of California, Water Right Decision 1630 (Sacramento: 1992), cover page.

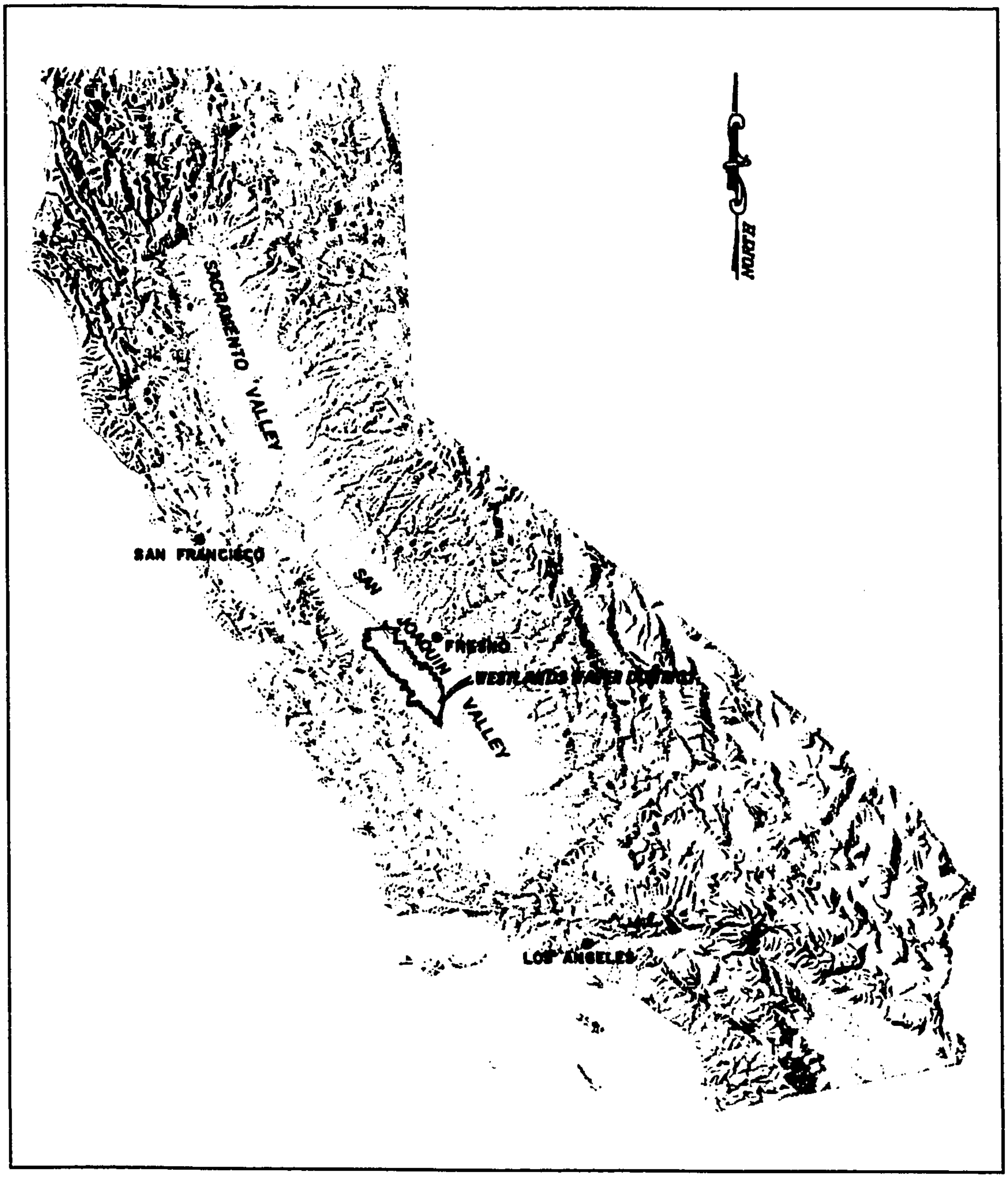

Fig. 2. Location of Westlands Water District Service Area in California. Reprinted, by permission, from Westlands Water District, Water Conservation Plan (Fresno: 1992), 2.

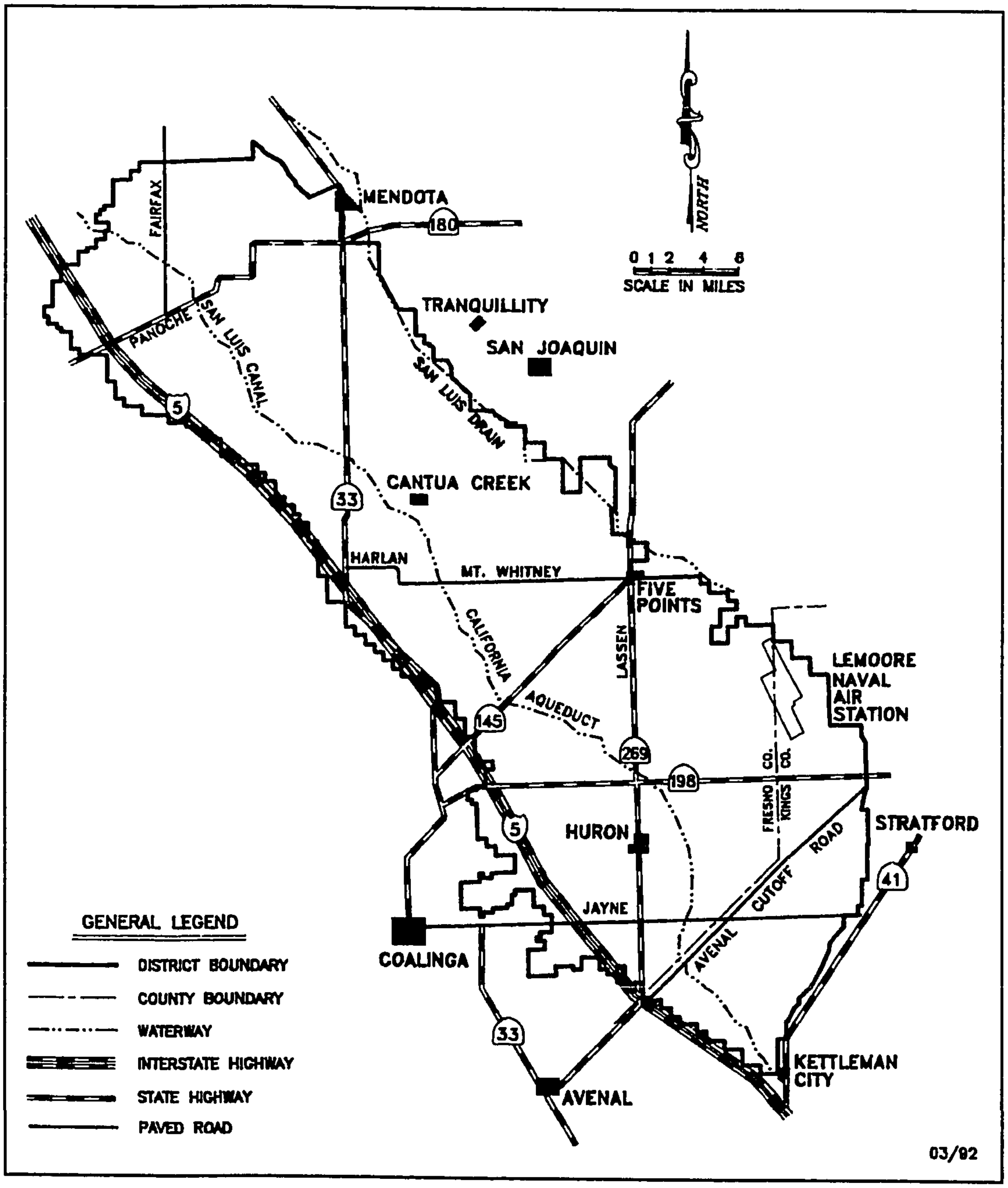

Fig. 3. Westlands Water District Service Area. Reprinted, by permission, from Westlands Water District, Water Conservation Plan, 3.

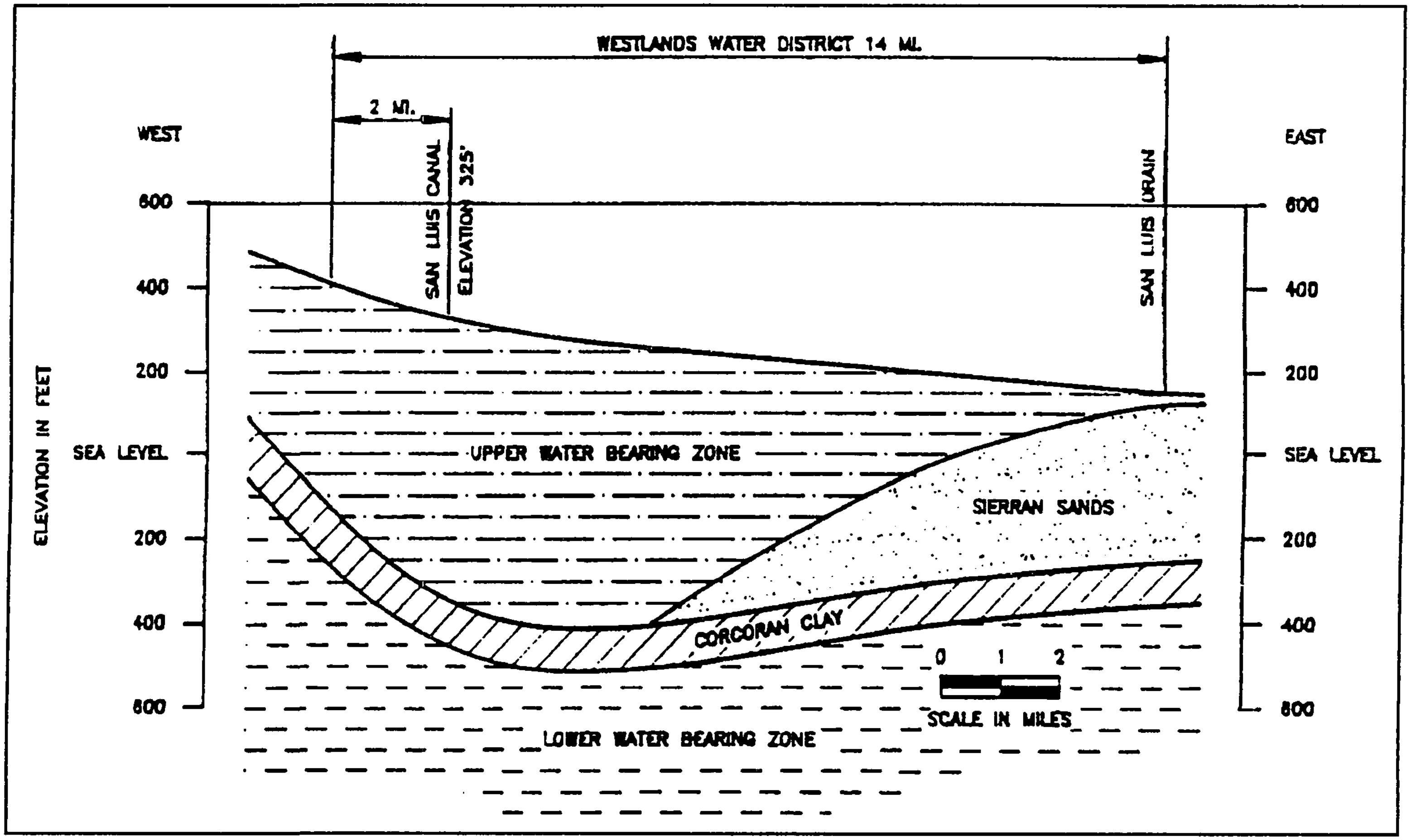

Fig. 4. Generalized Hydrogeological Cross Section of Westlands Water District Service Area. Reprinted, by permission, from Westlands Water District, Groundwater Conditions (1993), 1.

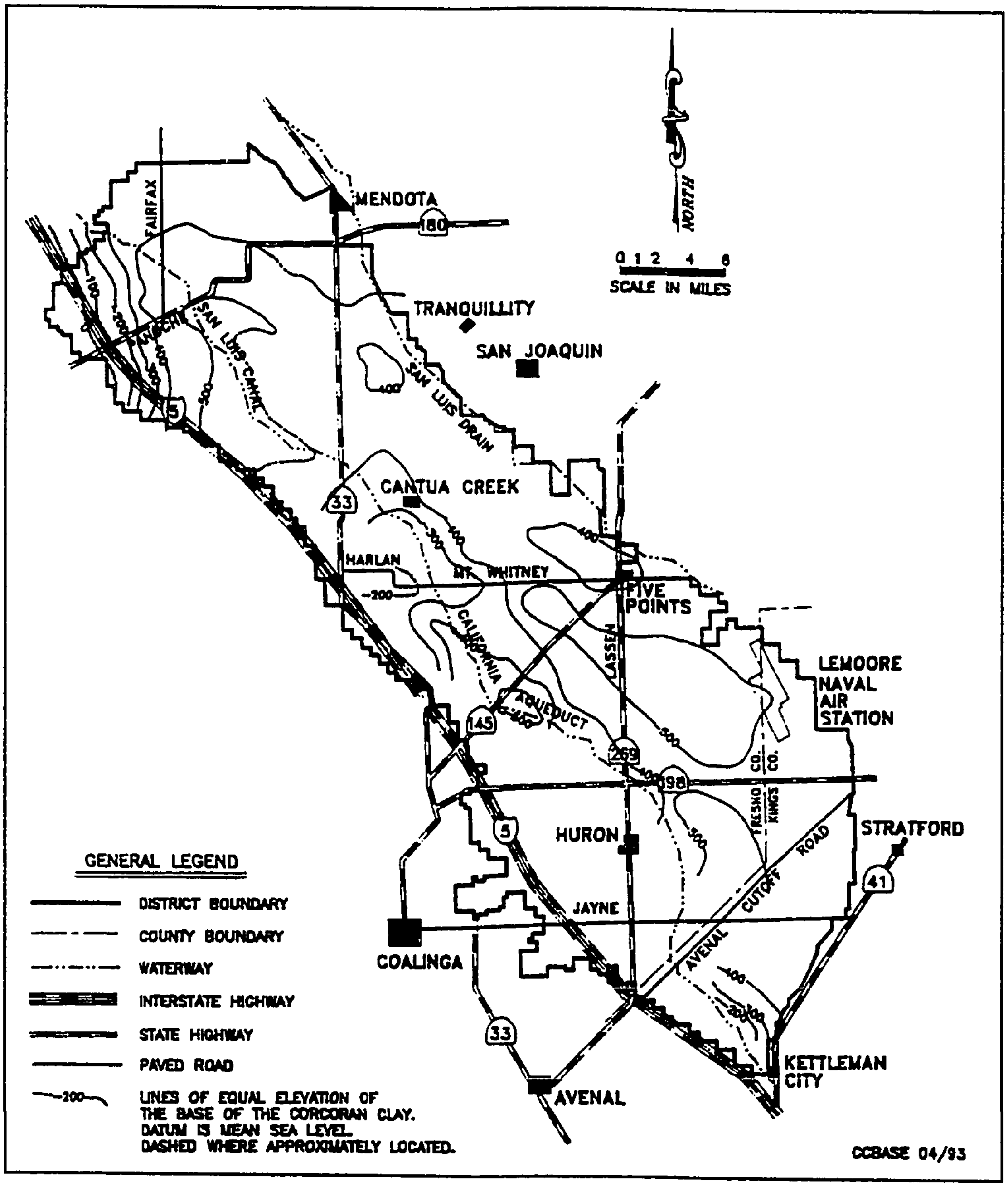

Fig. 5. Elevation of Base of the Corcoran Clay in Westlands Water District Service Area. Reprinted, by permission, from Westlands Water District, <u>Groundwater Conditions</u>, 3.

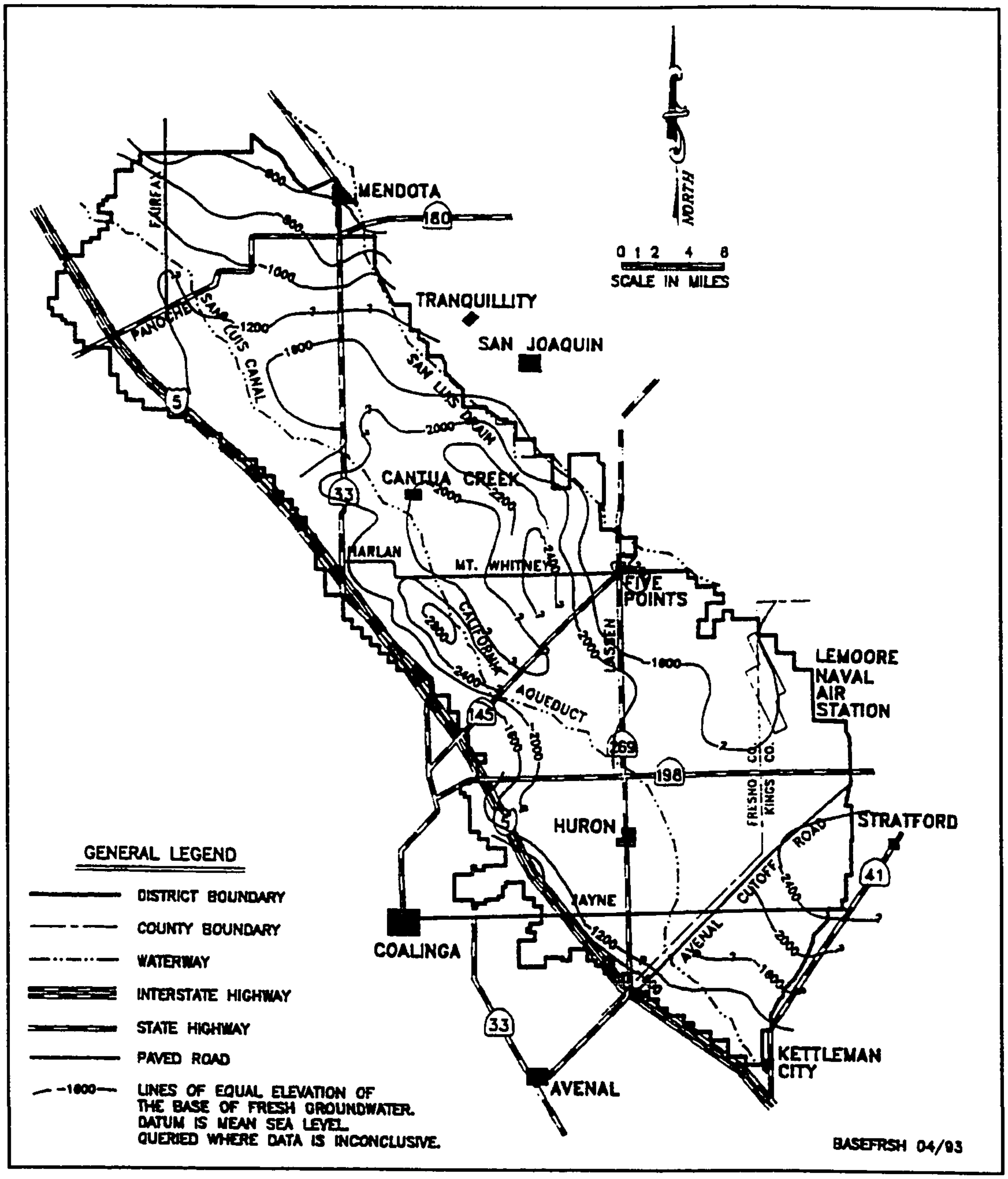

Fig. 6. Elevation of Base of Fresh Groundwater in Westlands Water District Service Area. Reprinted, by permission, from Westlands Water District, <u>Groundwater Conditions</u>, 5.

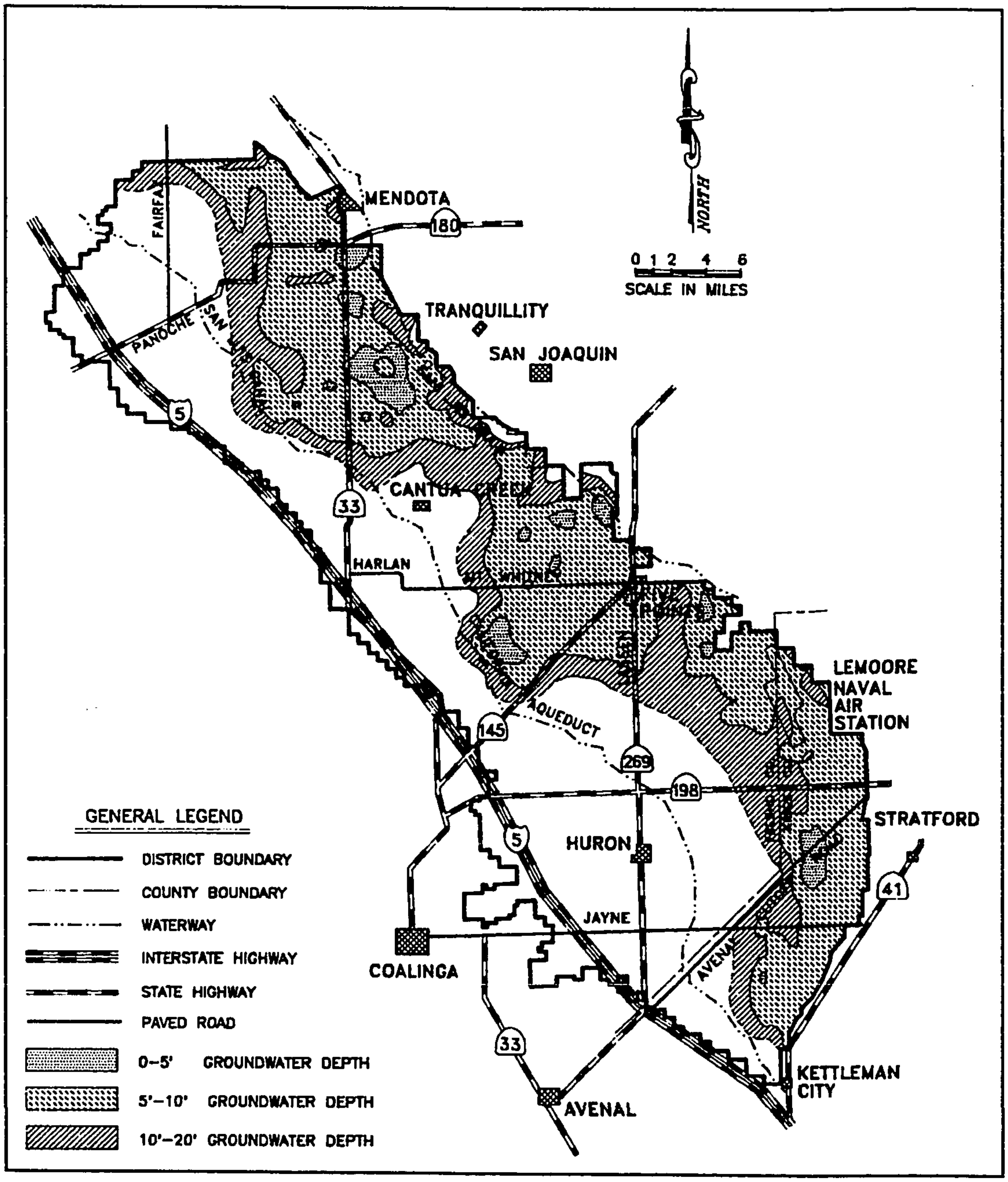

Fig. 7. Areas of Shallow Groundwater in Westlands Water District Service Area, October 1991. Reprinted, by permission, from Westlands Water District, <u>Water Conservation Plan</u>, 10.

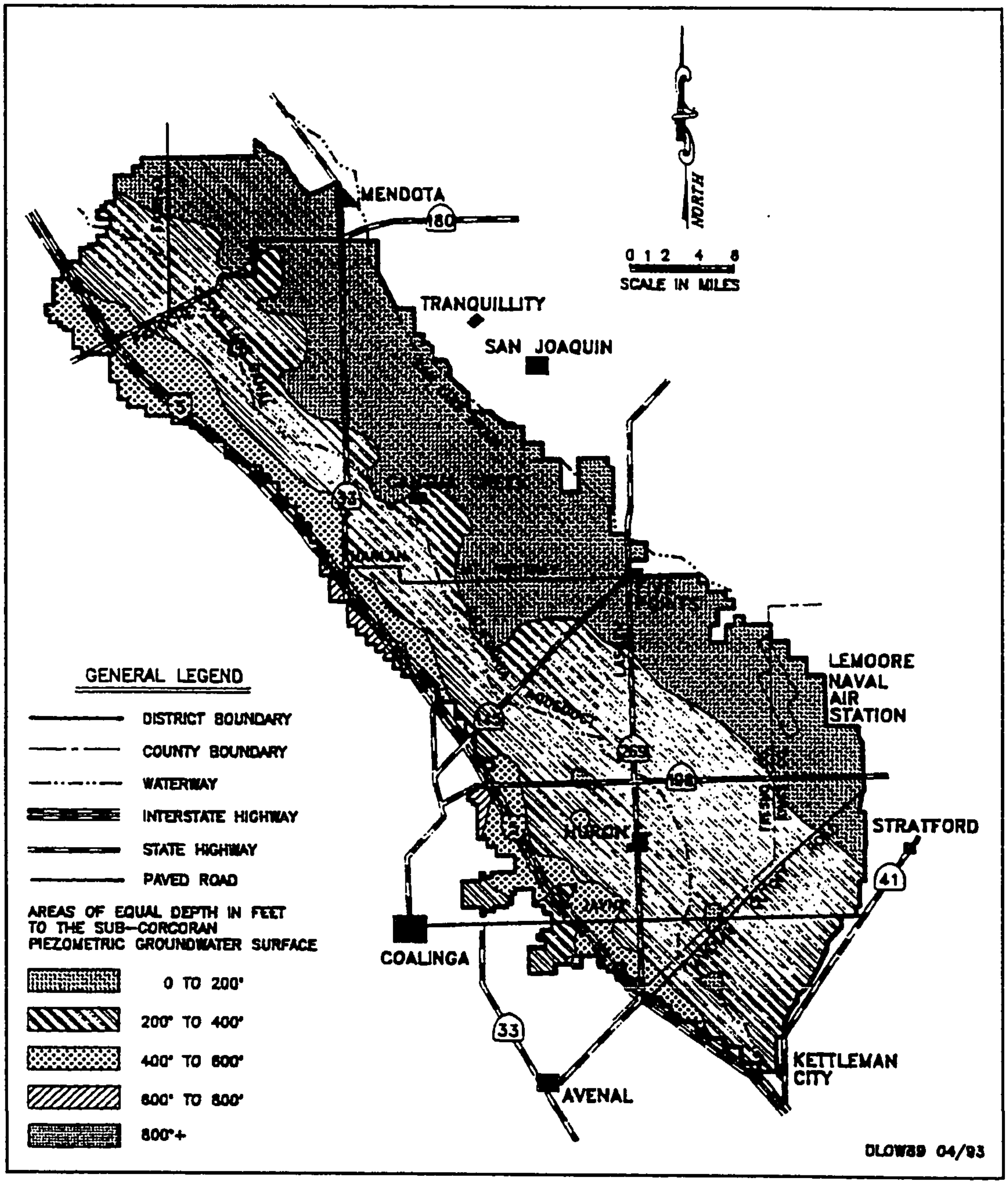

Fig. 8. Depth to Sub-Corcoran Piezometric Groundwater Surface in Westlands Water District Service Area, December 1989. Reprinted, by permission, from Westlands Water District, Groundwater Conditions, 8.

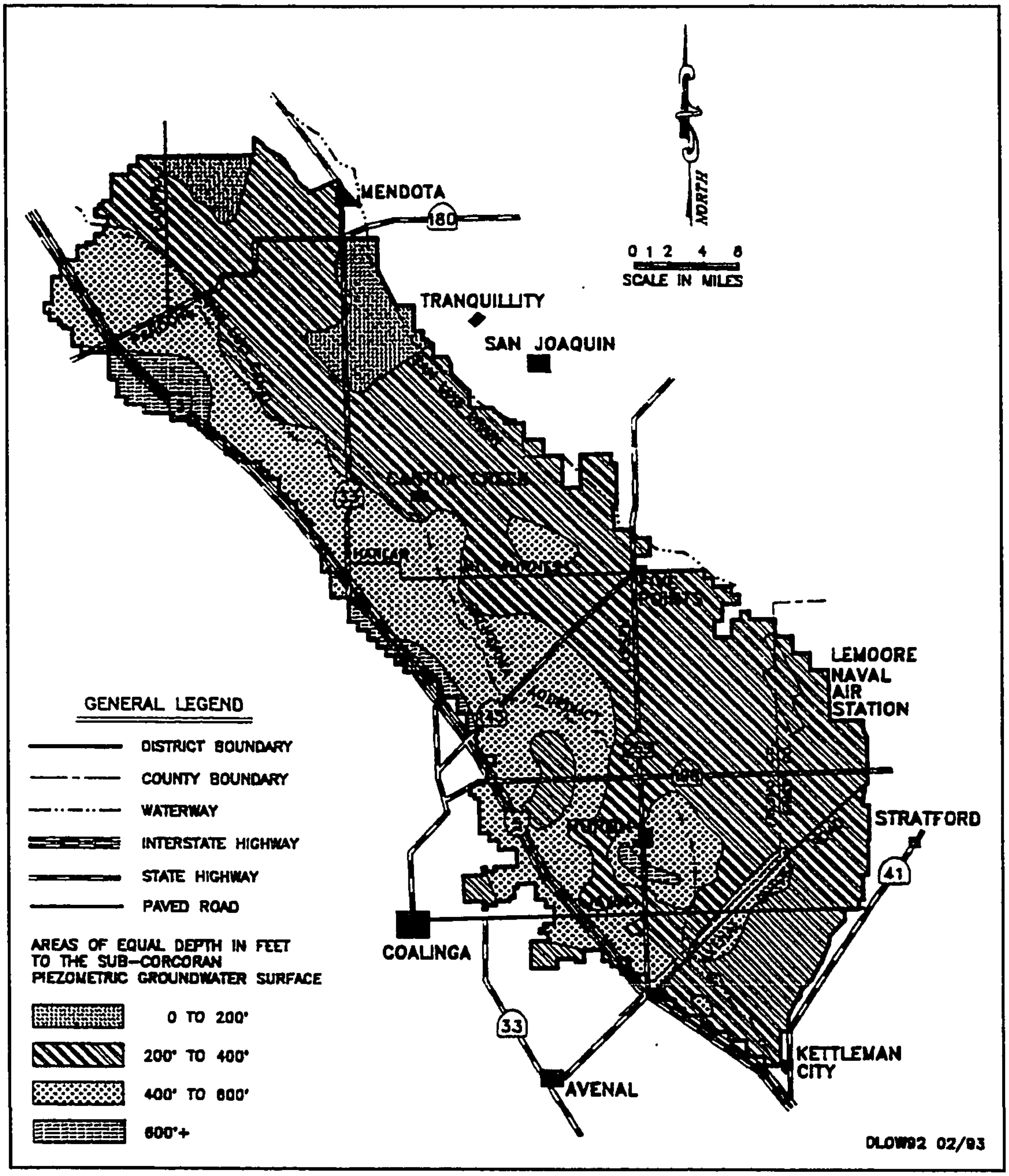

Fig. 9. Depth to Sub-Corcoran Piezometric Groundwater Surface in Westlands Water District Service Area, December 1992. Reprinted, by permission, from Westlands Water District, Groundwater Conditions, 9.

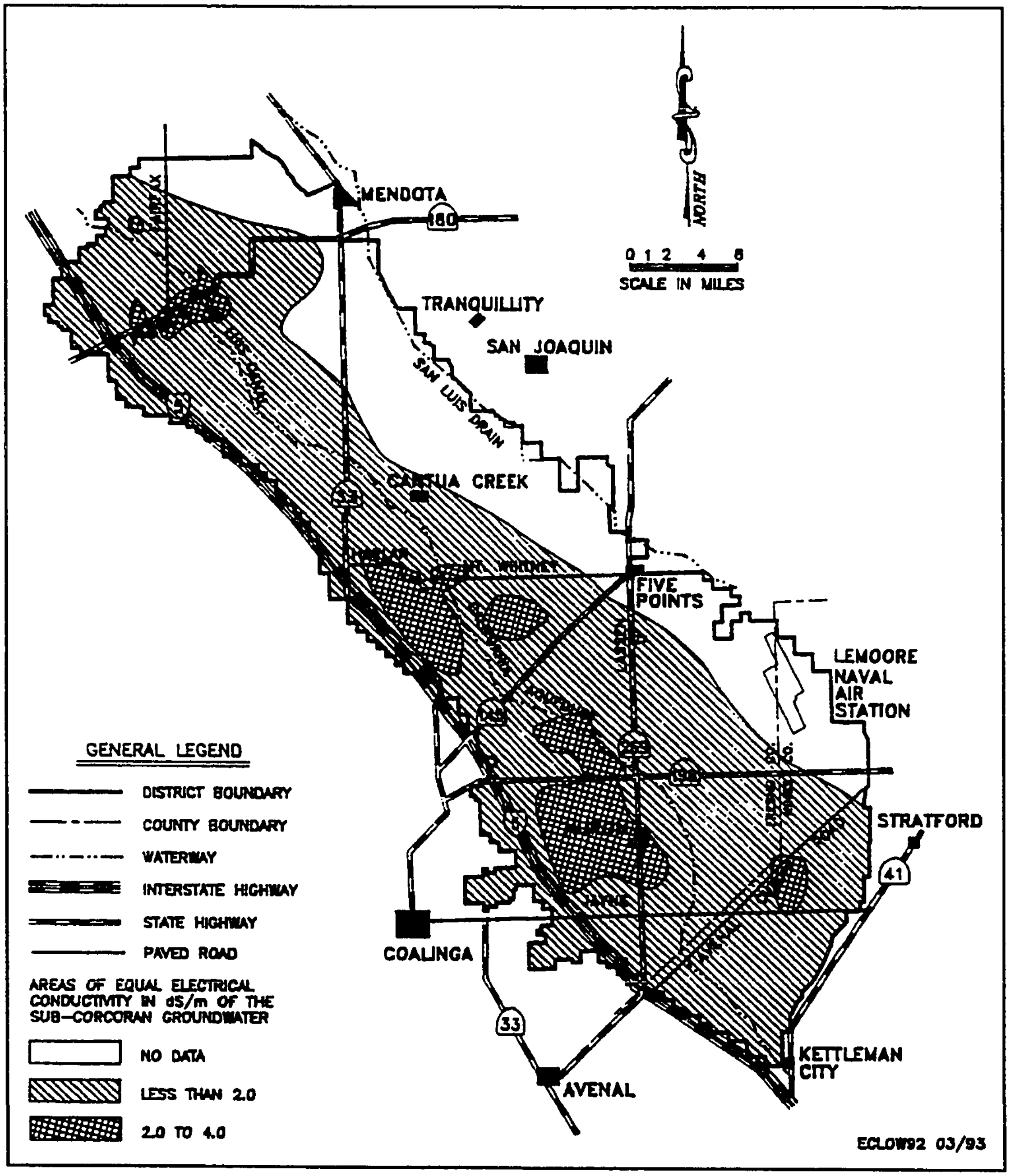

Fig. 10. Electrical Conductivity of Sub-Corcoran Piezometric Groundwater in Westlands Water District Service Area, December 1992. Reprinted, by permission, from Westlands Water District, Groundwater Conditions, 4.

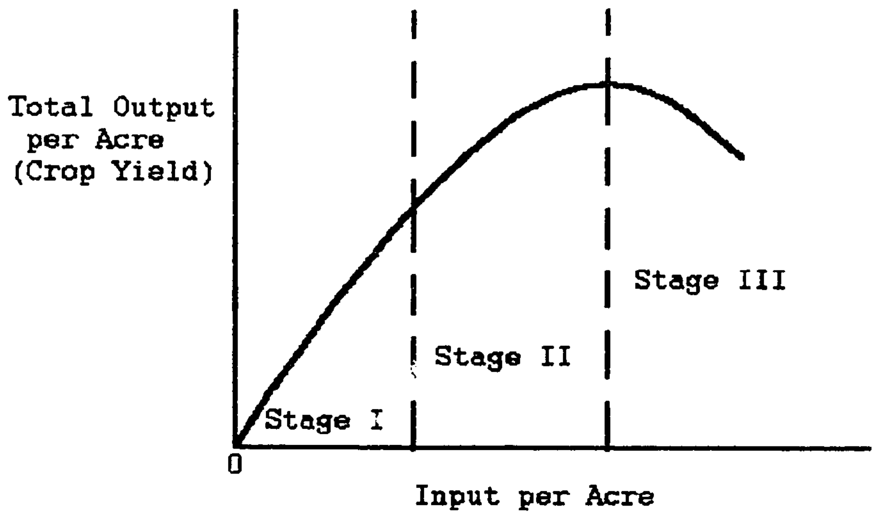

Fig. 11. Graph of Production Function Curve. Production inputs include water, seed, fertilizer, pesticides, and herbicides. The basic production function curve, shown here, was adapted from examples given in the following sources: Michael D. Boehlje and Vernon R. Eidman, Farm Management (New York: John Wiley & Sons, Inc., 1984), 93, 97; Peter H. Calkins and Dennis D. DiPietre, Farm Business Management (New York: Macmillan Publishing Co., Inc., 1983), 25; Michael Haines, Introduction to Farming Systems (London: Longman Group Limited, 1982), 73; Donald D. Osburn and Kenneth C. Schneeberger, Modern Agricultural Management (Reston, Virginia: Reston Publishing Company, Inc., 1983), 24.

APPENDIX A

TABLES ON GENERAL INFORMATION ABOUT WATER SUPPLIES AND CROPS GROWN IN THE WESTLANDS WATER DISTRICT SERVICE AREA

Table 19.--Average Water Rates Charged by Westlands Water District

YEAR	CVP RATE	TRANSFER RATE	CVP BANK RATE	SWB RATE
1970	8.05	N/A	N/A	N/A
1971	8.04	N/A	N/A	N/A
1972	8.54	N/A	N/A	N/A
1973	8.54	N/A	N/A	N/A
1974	9.15	N/A	N/A	N/A
1975	9.34	N/A	N/A	N/A
1976	9.63	N/A	N/A	N/A
1977	14.90	N/A	63.37	N/A
1978	16.10	N/A	N/A	N/A
1979	15.96	N/A	N/A	N/A
1980	12.89	N/A	N/A	N/A
1981	13.58	N/A	N/A	N/A
1982	13.47	N/A	N/A	N/A
1983	11.44	N/A	N/A	N/A
1984	12.96	N/A	N/A	N/A
1985	13.34	10.04	N/A	N/A
1986	14.92	10.69	N/A	N/A
1987	19.94	22.03	N/A	N/A
1988	25.67	26.35	N/A	N/A
1989	24.86	35.99	N/A	N/A
1990	29.38	66.25	N/A	N/A
1991	30.65	34.06	N/A	222.64
1992	39.35	69.82	N/A	126.11

Sources: Westlands Water District, Westlands Water District Average Water Cost--Specific Water Types: 1985 through 1992 Water Years (Fresno: 1993); Westlands Water District, Westlands Water District Average Water Cost: 1970 through 1984 Water Years (1993).

N/A Not applicable

Table 20.--Fallowed Acreage in WWD's Service Area

YEAR	ACRES FALLOWED
1970	N/A
1971	N/A
1972	N/A
1973	N/A
1974	14447
1975	4297
1976	N/A
1977	69548
1978	36335
1979	25743
1980	16527
1981	18203
1982	26128
1983	88773
1984	16340
1985	30579
1986	67829
1987	66236
1988	45632
1989	64579
1990	52544
1991	125082
1992	112718

Source: Westlands Water District, Westlands Water District [Annual] Crop Production Report, for years 1970 through 1992.

N/A Not available

Table 21.--Levels of Water Needs by Crops in WWD's Service Area

CROP	ET RATE	LEVEL
ALFALFA HAY	4.42	High
ALFALFA SEED	3.75	High
BARLEY	1.17	Low
BEANS-DRY	1.75	Low
CANTALOUPE	0.96	Low
CORN-FIELD	2.17	High
COTTON (LINT & SEED)	2.25	High
GARLIC	1.33	Low
LETTUCE	0.71	Low
ONIONS-DEHYDRATOR	2.17	High
PEPPERS	2.08	Inter
SAFFLOWER	2.58	High
SUGAR BEET	3.04	High
TOMATOES-PROCESSING	1.75	Low
WHEAT	1.50	Low

Source: Westlands Water District, Water Conservation and Drainage Reduction Programs: 1987-1988 (1989), 10.

Notes: ET rates > 2.11 AF/ac./yr. are high. ET rates < 2.08 AF/ac./yr. are low.

Table 22.--Indexes of Prices Received by Farmers in the U.S.

YEAR	CROP PRICE INDEX
1970	52
1971	56
1972	60
1973	91
1974	117
1975	105
1976	102
1977	100
1978	105
1979	116
1980	125
1981	134
1982	121
1983	128
1984	138
1985	120
1986	107
1987	106
1988	126
1989	134
1990	127
1991	129
1992	121

Sources: U.S. Department of Agriculture, Agricultural Prices: Annual Summary, 1980 (Washington, D.C.: 1981),9; U.S. Dept. of Agriculture, Agricultural Prices: Annual Summary, 1982 (1983), 7; U.S. Dept. of Agriculture, Agricultural Prices: 1992 Summary (1993), A-3.

Table 23.--Crop Rank by Average Historical Values in WWD's Service Area: 1970-1992

RANK	CROP	AVERAGE VALUE
1	Lettuce	2987.40
2	Peppers	1700.99
3	Cantaloupe	1637.20
4	Tomatoes-Processing	1301.70
5	Garlic	1268.40
6	Onions-Dehydrator	1006.55
7	Cotton (Lint & Seed)	734.75
8	Sugar Beet	701.34
9	Alfalfa Seed	542.77
10	Beans-Dry	500.53
11	Alfalfa Hay	464.50
12	Corn-Field	322.61
13	Safflower	291.85
14	Wheat	263.43
15	Barley	181.72

Source: Westlands Water District, Westlands Water District [Annual] Crop Production Report, for years 1970 through 1992.

Note: Average per-acre values were derived from source data.

APPENDIX B

DATA TABLES FOR TIME SERIES REGRESSIONS

Table 24.--Time Series Data for Independent Variables: All Crops

YEAR	CVP RATE	CVP SUP	GW VOL	TRANSFRS	WTR BNKS	WWD EXPN
1970	8.05	606249	450000	0	0	1
1971	8.04	847012	380000	0	0	1
1972	8.54	771946	210000	0	0	1
1973	8.54	1079218	120000	0	0	1
1974	9.15	1245524	90000	0	0	1
1975	9.34	1273094	110000	0	0	1
1976	9.63	410748	97000	0	0	1
1977	14.90	665895	472000	0	1	1
1978	16.10	1084386	159000	0	0	0
1979	15.96	1138994	140000	0	0	0
1980	12.89	1244446	106000	0	0	0
1981	13.58	1236630	99000	0	0	0
1982	13.47	1090888	105000	0	0	0
1983	11.44	1473883	31000	0	0	0
1984	12.96	1315548	73000	0	0	0
1985	13.34	1194113	228000	1	0	0
1986	14.92	1309252	145000	1	0	0
1987	19.94	1270213	159000	1	0	0
1988	25.67	1157908	160000	1	0	0
1989	24.86	920681	175000	1	0	0
1990	29.38	571152	300000	1	0	0
1991	30.65	277340	600000	1	1	0
1992	39.35	282942	600000	1	1	0

Sources: The Westlands Water District is the source of the following reports used for this table. Facts and Figures: 1987, 7; Facts and Figures: 1988, 7; Facts and Figures: 1989, 7, 10; Water Conservation Plan, 1, 34; Water Use and Supply--1991-92 Water Year (1992); Analysis of Water Requirements and Resources and Financial Obligations (1993), 45; Groundwater Conditions (1993), 11; Water Use and Supply--1992-93 Water Year (1993); Westlands Water District Average Water Cost--Specific Water Types: 1985 through 1992 Water Years (1993); Westlands Water District Average Water Cost: 1970 through 1984 Water Years (1993).

Notes: CVP supplies and groundwater volumes are in acre-feet. 0 and 1 are used to indicate absence or presence, respectively, of the independent (dummy) variable.

Table 25.--Time Series Data for Alfalfa Hay

YEAR	ACRES	VALUE/AC	VALUE/AC - ADJUSTED
1970	8913	212	407.69
1971	9265	165	294.64
1972	19187	205	341.67
1973	20783	285	313.19
1974	17150	475	405.98
1975	14793	387	368.57
1976	18250	572	560.78
1977	16855	326	326.00
1978	13771	383	364.76
1979	13450	698	601.72
1980	10182	593	474.40
1981	11438	585	436.57
1982	6256	631	521.49
1983	10887	769	600.78
1984	11136	581	421.01
1985	10768	640	533.33
1986	10134	639	597.20
1987	8738	810	764.15
1988	10042	759	602.38
1989	11482	868	647.76
1990	10716	582	458.27
1991	7812	438	339.53
1992	5350	365	301.65

Source: Westlands Water District, Westlands Water District [Annual] Crop Production Report, for years 1970 through 1992.

Notes: Adjusted values were derived by using the indexes of prices received by farmers in the U.S. 1977 served as the base year.

Table 26.--Time Series Data for Alfalfa Seed

YEAR	ACRES	VALUE/AC	VALUE/AC - ADJUSTED
1970	24256	170	326.92
1971	34063	183	326.79
1972	26974	213	355.00
1973	20511	735	807.69
1974	20070	528	451.28
1975	24943	514	489.52
1976	14675	828	811.76
1977	11841	608	608.00
1978	17337	272	259.05
1979	14162	613	528.45
1980	18925	760	608.00
1981	15103	867	647.01
1982	17552	335	276.86
1983	10832	746	582.81
1984	15235	894	647.83
1985	14486	648	540.00
1986	19130	449	419.63
1987	17839	795	750.00
1988	14321	787	624.60
1989	13453	601	448.51
1990	13049	862	678.74
1991	8942	723	560.47
1992	6297	889	734.71

Note: Refer to footnotes in Table 25.

Table 27.--Time Series Data for Barley

YEAR	ACRES	VALUE/AC	VALUE/AC - ADJUSTED
1970	27921	71	136.54
1971	40323	88	157.14
1972	65230	121	201.67
1973	89954	140	153.85
1974	101764	220	188.03
1975	113398	243	231.43
1976	120126	243	238.24
1977	104138	186	186.00
1978	126862	118	112.38
1979	78840	254	218.97
1980	76547	299	239.20
1981	54206	250	186.57
1982	45818	202	166.94
1983	21004	156	121.88
1984	22674	276	200.00
1985	24901	278	231.67
1986	22996	145	135.51
1987	12866	192	181.13
1988	10678	268	212.70
1989	15953	251	187.31
1990	8587	248	195.28
1991	3094	153	118.60
1992	10297	216	178.51

Note: Refer to footnotes in Table 25.

Table 28.--Time Series Data for Beans, Dry

YEAR	ACRES	VALUE/AC	VALUE/AC - ADJUSTED
1970	125	107	205.77
1971	300	104	185.71
1972	240	168	280.00
1973	555	250	274.73
1974	893	1350	1153.85
1975	1615	210	200.00
1976	3092	475	465.69
1977	661	520	520.00
1978	1873	459	437.14
1979	1090	454	391.38
1980	2149	407	325.60
1981	2755	429	320.15
1982	4033	621	513.22
1983	101	756	590.63
1984	3872	807	584.78
1985	7545	745	620.83
1986	6074	805	752.34
1987	3740	527	497.17
1988	8691	890	706.35
1989	10052	769	573.88
1990	4382	1186	933.86
1991	2958	634	491.47
1992	6836	590	487.60

Note: Refer to footnotes in Table 25.

Table 29.--Time Series Data for Cantaloupe

YEAR	ACRES	VALUE/AC	VALUE/AC - ADJUSTED
1970	15471	660	1269.23
1971	9426	940	1678.57
1972	10940	1013	1688.33
1973	15207	1900	2087.91
1974	10460	1800	1538.46
1975	11587	1260	1200.00
1976	13765	2898	2841.18
1977	11136	1501	1501.00
1978	19929	1914	1822.86
1979	19467	1163	1002.59
1980	18037	1500	1200.00
1981	16641	1846	1377.61
1982	17237	1626	1343.80
1983	21523	2291	1789.84
1984	21008	2419	1752.90
1985	20190	1648	1373.33
1986	25345	2509	2344.86
1987	23152	1657	1563.21
1988	18603	2574	2042.86
1989	21310	2367	1766.42
1990	20402	1864	1467.72
1991	17489	1612	1249.61
1992	15997	2122	1753.72

Note: Refer to footnotes in Table 25.

Table 30.--Time Series Data for Corn, Field

YEAR	ACRES	VALUE/AC	VALUE/AC - ADJUSTED
1970	1927	156	300.00
1971	2078	132	235.71
1972	150	300	500.00
1973	170	266	292.31
1974	740	305	260.68
1975	1025	252	240.00
1976	1300	404	396.08
1977	77	284	284.00
1978	298	145	138.10
1979	598	217	187.07
1980	1896	372	297.60
1981	152	372	277.61
1982	1175	378	312.40
1983	980	488	381.25
1984	7803	484	350.72
1985	7153	417	347.50
1986	6926	509	475.70
1987	791	470	443.40
1988	94	595	472.22
1989	0	0	0.00
1990	665	330	259.84
1991	0	0	0.00
1992	0	0	0.00

Note: Refer to footnotes in Table 25.

Table 31.--Time Series Data for Cotton (Lint & Seed)

YEAR	ACRES	VALUE/AC - LINT	VALUE/AC - SEED	VALUE/AC - TOTAL	TOTAL VALUE/AC - ADJUSTED
1970	38265	231.00	54.00	285.00	548.08
1971	78796	218.00	39.00	257.00	458.93
1972	126132	313.00	63.00	376.00	626.67
1973	149861	320.00	96.00	416.00	457.14
1974	215415	473.00	134.00	607.00	518.80
1975	145537	494.00	81.00	575.00	547.62
1976	174733	743.00	120.00	863.00	846.08
1977	193346	588.00	68.00	656.00	656.00
1978	272061	440.00	84.00	524.00	499.05
1979	300563	771.00	140.00	911.00	785.34
1980	284688	906.00	152.00	1058.00	846.40
1981	300309	876.00	95.00	971.00	724.63
1982	277064	853.00	101.00	954.00	788.43
1983	230307	814.00	170.00	984.00	768.75
1984	297174	738.00	120.00	858.00	621.74
1985	286169	776.00	121.00	897.00	747.50
1986	231142	804.00	121.00	925.00	864.49
1987	266483	928.00	121.00	1049.00	989.62
1988	290062	838.00	158.00	996.00	790.48
1989	241995	1065.00	130.00	1195.00	891.79
1990	241076	1079.50	126.00	1205.50	949.21
1991	207942	1055.00	168.00	1223.00	948.06
1992	224895	1047.50	192.00	1239.50	1024.38

Note: Refer to footnotes in Table 25.

Table 32.--Time Series Data for Garlic

YEAR	ACRES	VALUE/AC	VALUE/AC - ADJUSTED
1970	178	1385	2663.46
1971	123	1080	1928.57
1972	117	659	1098.33
1973	455	758	832.97
1974	871	2568	2194.87
1975	1499	2696	2567.62
1976	1396	940	921.57
1977	1737	1596	1596.00
1978	1856	770	733.33
1979	2670	915	788.79
1980	3427	1057	845.60
1981	4602	1074	801.49
1982	7510	1101	909.92
1983	9118	1190	929.69
1984	8132	1400	1014.49
1985	8670	1574	1311.67
1986	9011	1328	1241.12
1987	11583	1483	1399.06
1988	11345	1372	1088.89
1989	12338	1355	1011.19
1990	14500	1459	1148.82
1991	14466	1432	1110.08
1992	14647	1253	1035.54

Note: Refer to footnotes in Table 25.

Table 33.--Time Series Data for Lettuce

YEAR	ACRES	VALUE/AC	VALUE/AC - ADJUSTED
1970	1616	975.00	1875.00
1971	1756	2375.00	4241.07
1972	1309	1425.00	2375.00
1973	2968	1625.00	1785.71
1974	3627	2802.00	2394.87
1975	2693	1238.00	1179.05
1976	2744	1925.00	1887.25
1977	4079	3768.00	3768.00
1978	7358	8136.00	7748.57
1979	8876	1475.00	1271.55
1980	7490	2556.50	2045.20
1981	7330	2288.00	1707.46
1982	6491	4641.50	3835.95
1983	11510	5014.00	3917.19
1984	7971	3372.00	2443.48
1985	14692	3548.00	2956.67
1986	13426	3839.50	3588.32
1987	14603	5824.50	5494.81
1988	16112	3717.00	2950.00
1989	15231	3354.50	2503.36
1990	12811	3727.50	2935.04
1991	9313	4022.50	3118.22
1992	17768	3254.00	2689.26

Note: Refer to footnotes in Table 25.

Table 34.--Time Series Data for Onions, Dehydrator

YEAR	ACRES	VALUE/AC	VALUE/AC - ADJUSTED
1970	0	0	0.00
1971	515	350	625.00
1972	503	489	815.00
1973	0	0	0.00
1974	2407	780	666.67
1975	3173	1108	1055.24
1976	3591	1365	1338.24
1977	2047	806	806.00
1978	2433	1092	1040.00
1979	4320	1051	906.03
1980	3803	1059	847.20
1981	6393	1005	750.00
1982	8772	1354	1119.01
1983	9070	1230	960.94
1984	8921	1277	925.36
1985	9954	1270	1058.33
1986	11357	1001	935.51
1987	12230	1654	1560.38
1988	12704	1243	986.51
1989	12839	1245	929.10
1990	10069	1925	1515.75
1991	8043	1521	1179.07
1992	6749	1353	1118.18

Note: Refer to footnotes in Table 25.

Table 35.--Time Series Data for Peppers

YEAR	ACRES	VALUE/AC	VALUE/AC - ADJUSTED
1970	255	2000	3846.15
1971	0	0	0.00
1972	0	0	0.00
1973	160	360	395.60
1974	285	1025	876.07
1975	562	1590	1514.29
1976	453	871	853.92
1977	76	2499	2499.00
1978	532	694	660.95
1979	877	140	120.69
1980	972	260	208.00
1981	1321	132	98.51
1982	1110	182	150.41
1983	1498	163	127.34
1984	1039	163	118.12
1985	1392	2878	2398.33
1986	2320	1835	1714.95
1987	2202	1661	1566.98
1988	2253	2492	1977.78
1989	547	4308	3214.93
1990	993	9353	7364.57
1991	917	3207	2486.05
1992	1640	4269	3528.10

Note: Refer to footnotes in Table 25.

Table 36.--Time Series Data for Safflower

YEAR	ACRES	VALUE/AC	VALUE/AC - ADJUSTED
1970	15575	107	205.77
1971	21770	143	255.36
1972	20295	148	246.67
1973	23245	275	302.20
1974	7579	279	238.46
1975	14670	264	251.43
1976	2843	380	372.55
1977	5745	366	366.00
1978	9393	264	251.43
1979	14550	234	201.72
1980	9982	422	337.60
1981	7219	477	355.97
1982	10507	187	154.55
1983	9573	344	268.75
1984	8161	416	301.45
1985	3846	664	553.33
1986	13447	290	271.03
1987	4127	282	266.04
1988	4776	460	365.08
1989	8531	568	423.88
1990	13541	381	300.00
1991	4424	257	199.22
1992	19055	271	223.97

Note: Refer to footnotes in Table 25.

Table 37.--Time Series Data for Sugar Beet

YEAR	ACRES	VALUE/AC	VALUE/AC - ADJUSTED
1970	17702	433	832.69
1971	23999	287	512.50
1972	20973	401	668.33
1973	8826	436	479.12
1974	10357	1075	918.80
1975	18506	930	885.71
1976	16327	488	478.43
1977	3516	625	625.00
1978	6746	576	548.57
1979	9901	722	622.41
1980	11194	1114	891.20
1981	11455	780	582.09
1982	7046	857	708.26
1983	5203	868	678.13
1984	5699	817	592.03
1985	8841	938	781.67
1986	11880	658	614.95
1987	9730	918	866.04
1988	8337	878	696.83
1989	7806	1356	1011.94
1990	7393	866	681.89
1991	3182	927	718.60
1992	5045	890	735.54

Note: Refer to footnotes in Table 25.

Table 38.--Time Series Data for Tomatoes, Processing

YEAR	ACRES	VALUE/AC	VALUE/AC - ADJUSTED
1970	6834	538	1034.62
1971	11384	672	1200.00
1972	16177	717	1195.00
1973	23824	816	896.70
1974	24862	1560	1333.33
1975	40691	1579	1503.81
1976	43314	1072	1050.98
1977	32217	1293	1293.00
1978	30224	1361	1296.19
1979	37504	1407	1212.93
1980	27857	1683	1346.40
1981	29656	1662	1240.30
1982	45000	1924	1590.08
1983	55363	1719	1342.97
1984	57937	1617	1171.74
1985	51574	1654	1378.33
1986	55876	1494	1396.26
1987	55591	1758	1658.49
1988	58507	1563	1240.48
1989	76195	1994	1488.06
1990	91405	1804	1420.47
1991	98265	1782	1381.40
1992	75811	1535	1268.59

Note: Refer to footnotes in Table 25.

Table 39.--Time Series Data for Wheat

YEAR	ACRES	VALUE/AC	VALUE/AC - ADJUSTED
1970	10902	87	167.31
1971	2700	86	153.57
1972	1314	129	215.00
1973	1255	220	241.76
1974	7607	297	253.85
1975	38683	266	253.33
1976	29093	345	338.24
1977	3625	220	220.00
1978	1591	165	157.14
1979	16051	275	237.07
1980	55637	403	322.40
1981	60507	359	267.91
1982	62528	318	262.81
1983	49045	380	296.88
1984	50314	399	289.13
1985	49989	358	298.33
1986	36118	250	233.64
1987	26595	315	297.17
1988	24641	426	338.10
1989	23399	427	318.66
1990	26407	338	266.14
1991	8399	421	326.36
1992	12628	368	304.13

Note: Refer to footnotes in Table 25.

Table 40.--Coefficients for Time Series Regression Equations: Model 1A

CROP	CONSTANT	CVP RATE	CVP SUP	VALUE/AC	GW VOL	TRANSFRS	WTR BNKS	WWD EXPN
ALFALFA HAY	24339	-73.00	-0.0041	-8.42	-0.0306	2572	5674	5428
ALFALFA SEED	8604	-10.00	0.0067	-7.37	0.0263	-652	-13955	7148
BARLEY	80708	409.00	-0.0190	85.00	-0.1700	-38101	49774	33502
BEANS-DRY	4552	47.00	-0.0014	-0.84	-0.0083	4710	279	-546
CANTALOUPE	18172	-212.00	0.0005	2.06	0.0024	3061	-1208	-8311
CORN-FIELD	11749	-536.00	-0.0016	-2.24	0.0002	5027	1837	-3933
COTTON (LINT & SEED)	366870	756.00	-0.0138	-60.00	-0.3620	8072	112851	-113814
GARLIC	6977	147.00	-0.0033	1.83	-0.0121	4871	3492	-5445
LETTUCE	840	221.00	0.0038	-0.02	-0.0029	5351	847	-2954
ONIONS-DEHYDRATOR	6964	-22.00	0.0004	0.79	-0.0165	6680	3906	-2691
PEPPERS	214	6.50	0.0006	-0.12	0.0005	908	-158	-378
SAFFLOWER	-4170	495.00	0.0075	-18.40	0.0295	-4979	-13684	6709
SUGAR BEET	9306	-114.00	-0.0013	0.16	0.0189	237	-14114	5023
TOMATOES-PROCESSING	52306	682.00	-0.0282	17.10	-0.0901	22013	25474	-11433
WHEAT	-14271	-1632.00	0.0087	242.00	0.0491	-10023	-13568	-31635

Table 41.--Coefficients for Time Series Regression Equations: Model 2A

CROP	CONSTANT	CVP RATE	CVP SUP	VALUE/AC	GW VOL	TRANSFRS	WTR BNKS
ALFALFA HAY	905	89.00	0.0057	-1.62	0.0268	-2802	-11810
ALFALFA SEED	15922	-147.00	0.0025	-4.70	0.0105	639	-7744
BARLEY	-161843	1883.00	0.1300	-196.00	0.7040	-101585	-225767
BEANS-DRY	13574	27.00	-0.0060	-3.48	-0.0269	6626	3275
CANTALOUPE	19680	-205.00	-0.0011	2.62	-0.0026	3248	-1080
CORN-FIELD	-21045	-456.00	0.0058	43.40	0.0990	-9673	N/A
COTTON (LINT & SEED)	53237	2531.00	0.1320	-22.50	0.4550	-58162	-155261
GARLIC	16356	172.00	-0.0170	16.40	-0.0653	2429	16092
LETTUCE	-18729	518.00	0.0151	-0.17	0.0170	3209	-3033
ONIONS-DEHYDRATOR	26846	-143.00	-0.0114	2.65	-0.0695	10421	17020
PEPPERS	-4408	55.60	0.0037	0.08	0.0020	321	988
SAFFLOWER	-485	406.00	0.0051	-15.30	0.0256	-5054	-10524
SUGAR BEET	-6698	42.00	0.0081	2.55	0.0268	-1021	-9843
TOMATOES-PROCESSING	274652	-1507.00	-0.1230	-20.70	-0.3480	51198	84270
WHEAT	78515	-2624.00	-0.0434	232.00	-0.0760	2136	6260

N/A Not applicable

APPENDIX C

DATA TABLES FOR CROSS SECTION REGRESSIONS:

DROUGHT AND SWB INVESTIGATIONS

Table 42.--Cross-Sectional Data for Independent Variables: Drought and SWB Investigations

CROP	ET RATE	DEF PYMT	PRCE SUP	RISK	RISK W/C
ALFALFA HAY	4.42	0	0	0	0
ALFALFA SEED	3.75	0	0	0	0
BARLEY	1.17	1	1	0	0
BEANS-DRY	1.75	0	0	1	1
CANTALOUPE	0.96	0	0	1	1
CORN-FIELD	2.17	1	1	0	0
COTTON (LINT & SEED)	2.25	1	1	0	1
GARLIC	1.33	0	0	1	1
LETTUCE	0.71	0	0	1	1
ONIONS-DEHYDRATOR	2.17	0	0	1	1
PEPPERS	2.08	0	0	1	1
SAFFLOWER	2.58	0	1	0	0
SUGAR BEET	3.04	0	1	0	0
TOMATOES-PROCESSING	1.75	0	0	1	1
WHEAT	1.50	1	1	0	0

Sources: Westlands Water District, Water Conservation and Drainage Reduction Programs: 1987-1988 (1989), 10; University of California, Financing Agriculture in California's New Risk Environment (Davis: 1994), 138; U.S. Department of Agriculture, ASCS Programs for Farm Commodities and Resource Conservation (Washington, D.C.: 1993); U.S. Department of Agriculture, Farm Program Fact Sheet (Washington, D.C.: 1994); U.S. Department of Agriculture, 1992 Annual Report (Sacramento), 20, 31.

Notes: ET rates are in acre-feet/acre/year. 0 and 1 are used to indicate absence or presence, respectively, of the independent (dummy) variable.

Table 43.--Cross-Sectional Data for Crops: Drought Investigation

CROP	AC BEFORE DROUGHT	AC DURING DROUGHT	%CHANGE AC	VALUE/AC BEFORE DROUGHT	VALUE/AC DURING DROUGHT	%CHANGE VALUES
ALFALFA HAY	10103	9023	-10.7	518.40	518.96	0.108
ALFALFA SEED	15390	12317	-20.0	519.02	632.84	21.930
BARLEY	31933	10246	-67.9	173.76	178.92	2.970
BEANS-DRY	4063	6110	50.4	563.66	615.06	9.119
CANTALOUPE	20324	19492	-4.1	1663.72	1640.59	-1.390
CORN-FIELD	7294	517	-92.9	391.31	391.82	0.130
COTTON (LINT & SEED)	270361	245409	-9.2	752.59	932.26	23.874
GARLIC	7841	13147	67.7	1034.73	1132.26	9.426
LETTUCE	10237	14306	39.8	3074.85	3281.78	6.730
ONIONS-DEHYDRATOR	9078	10439	15.0	958.19	1214.83	26.784
PEPPERS	1447	1425	0.0	767.94	3356.40	3.371
SAFFLOWER	8792	9076	3.2	317.51	296.37	-6.658
SUGAR BEET	8354	6916	-17.2	659.52	785.14	19.047
TOMATOES-PROCESSING	49234	75962	54.3	1353.28	1409.58	4.160
WHEAT	51417	20345	-60.4	274.78	308.43	12.246

Source: Westlands Water District, Westlands Water District [Annual] Crop Production Report, for years 1970 through 1992.

Notes: All figures were derived from source data. Values were also adjusted, using 1977 as the base year.

Table 44.--Cross-Sectional Data for Crops: SWB Investigation

CROP	AC BEFORE SWB	ACRES DURING SWB	%CHANGE AC	VALUE/AC BEFORE SWB	VALUE/AC DURING SWB	%CHANGE VALUES
ALFALFA HAY	11099	6581	-40.7	553.01	320.59	-42.028
ALFALFA SEED	13251	7620	-42.5	563.62	647.59	14.898
BARLEY	12270	6696	-45.4	191.29	148.56	-22.338
BEANS-DRY	7217	4897	-32.1	753.87	489.54	-35.063
CANTALOUPE	20856	16743	-19.7	1617.07	1501.67	-7.136
COTTON (LINT & SEED)	241536	216419	-10.4	920.50	986.22	7.140
GARLIC	13419	14557	8.5	1080.01	1072.81	-0.667
LETTUCE	14021	13541	-3.4	2719.20	2903.74	6.787
ONIONS-DEHYDRATOR	11454	7396	-35.4	1222.43	1148.63	-6.037
PEPPERS	770	1279	66.0	5289.75	3007.08	-43.153
SAFFLOWER	11036	11740	6.4	361.94	211.60	-41.537
SUGAR BEET	7600	4114	-45.9	846.92	727.07	-14.151
TOMATOES-PROCESSING	83800	87038	3.9	1454.27	1325.00	-8.889
WHEAT	24903	10514	-57.8	292.40	315.24	7.811

Source: Westlands Water District, Westlands Water District [Annual] Crop Production Report, for years 1970 through 1992.

Notes: All figures were derived from source data. Values were also adjusted, using 1977 as the base year.

Table 45.--Coefficients for Cross Section Regression Equations: Drought Investigation

MODEL	CONSTANT	VAL/A BE	%CHNG VA	ET RATE	DEF PYMT	PRCE SUP	RISK	RISK W/C
1B	-1.3	0.0021	0.672	-4.8	-55.1	N/A	32.2	N/A
2B	-3.8	-0.0035	0.190	-3.1	-60.1	N/A	N/A	45.6
3B	-109.0	0.0133	0.231	20.7	N/A	17.0	89.5	N/A
4B	-50.3	0.0079	-0.300	10.2	N/A	-22.2	N/A	56.4

N/A Not applicable

Table 46.--Coefficients for Cross Section Regression Equations: SWB Investigation

MODEL	CONSTANT	VALUE BE	%VCHANGE	ET RATE	RISK	RISK W/C
1C	-40.5	0.0178	-0.310	-2.52	2.6	N/A
2C	-49.8	0.0156	-0.359	-0.34	N/A	14.3

N/A Not applicable

APPENDIX D

WATER MARKETING: THE SOLUTION TO MEETING WATER NEEDS?

WATER MARKETING: THE SOLUTION TO MEETING WATER NEEDS?

Water marketing is one type of water reallocation or transfer process that occurs in California and other western states. It involves transactions between willing buyers and sellers, or lessors and lessees, and includes the sale or lease of fee titles, water use permits, district shares, or contract rights. Water marketing can also take the form of conditional drought year leases or water right exchanges. Profits may be realized by a seller or lessor as a result of negotiating the price and terms of the transfer.

The Debate Over Water Transfers

Advantages and strengths of water markets. It has been argued that water markets have advantages and strengths over alternative allocation mechanisms (Anderson 1983; Brajer, Church, Cummings, and Farah 1989; Graff 1990; Howe, Schurmeier, and Shaw, Jr. 1986; Krautkraemer and Willey 1991; Schmidt and Cannon 1991). They allow flexibility in the allocation of existing water supplies over both the short-term and the long-term. Supplies can be transferred from one type of use to another and/or from one place to another as changes occur in climatic, demographic, or economic conditions. Security of tenure for established users can be maintained because participation is voluntary, while the buyer and seller each stands to gain from the transaction.

Proponents of water marketing claim that water can be allocated efficiently in a market system because it provides the mechanism for shifting water from low-value uses to high-value uses as competition for water supplies increases. The user is forced to take the real opportunity costs into account when deciding among alternative uses. Market prices reflect the value and scarcity of water supplies, and act to balance supply and demand. An increase in prices can encourage water conservation among urban and agricultural users. Expensive development of new supplies can therefore be avoided.

Another major argument in favor of water marketing is that it contributes toward environmental protection. The construction of dams and canals to develop new water supplies would be prevented along with the large-scale environmental degradation they would cause over the long-term. Transfers of water from those who reduce their use to those who are seeking new supplies would not increase the total stress on California's aquatic ecosystems that are caused by freshwater diversions and depletions. A market system would help to ensure that existing environmental standards are maintained during a drought because there would be no political pressure to relax those standards in order to satisfy demands. Improved surface water quality levels can be a consequence of decreased agricultural drainage water when transfers involve the fallowing of land. Owners of groundwater rights could store unused water in a groundwater basin during wet years and make it available for later use through market transactions during dry years. Such practices can contribute toward alleviating or arresting overdraft problems while managing water supplies for future use. Finally, environmental enhancement can occur by purchasing water for both instream and offstream benefits (such as wildlife refuges). However, some proponents of water marketing failed to acknowledge that government agencies might not have as much purchasing power as other buyers if funds are not available. Therefore, acquisition of water supplies through market systems for the purpose of environmental enhancement could be hindered. For example, the California Department of Fish and Game was able to purchase water from the State Drought Water Bank in 1991 only after funds were provided by the passage of Assembly Bill No. 12.

Disadvantages and weaknesses of water markets. Water market systems also have disadvantages and weaknesses that are acknowledged by proponents as well as opponents of these systems (Brajer, Church, Cummings, and Farah 1989;

Gould 1989; Howe, Schurmeier, and Shaw, Jr. 1986; Saliba and Bush 1987). Economic efficiency of water markets can be hindered by third-party effects or externalities, public goods characteristics of water resources, a lack of information, uncertainties involved in market processes, and public policies.

External or third-party impacts can occur when participants of a market transaction do not consider the effects that their decisions will have on those who are not involved in the transaction. One major group of external impacts consists of those that affect the environment. Interbasin water transfers can alter instream flows and water quality; thus, they can affect fish, wildlife, recreation, and the quality of drinking water. Transfers that involve the retirement of irrigated agricultural lands can decrease food sources and nesting sites for wildlife. In response to historical reductions in areas of their natural habitat, migrating and resident birds have become dependent on food that is provided by cultivated crops (such as waste grain that is left behind in the field after a harvest). Also, by being managed as wetlands, some rice fields and other farmlands that are flooded after harvest have provided waterfowl habitat. Furthermore, dust, weeds, and insects may become a nuisance to neighboring property owners if fallowed lands are left unmanaged. If surface supplies in an agricultural area are made available for transfer, either by fallowing land or using groundwater to replace surface supplies that had previously been used for irrigation, then groundwater recharge can be diminished. In the latter case, increased pumping of groundwater can lead to overdrafting and land subsidence.

Water transfers can affect the area from which water supplies are exported when individual farmers are allowed to reduce their irrigated acreage or fallow their land to make the water available to other areas. Local agri-businesses that sell farm supplies or equipment can suffer financial losses as a result of lower levels of business activity. Increases in welfare dependency and unemployment compensation can result from layoffs among farm and farm-related workers. At the same time, the local government can experience a reduction in its tax base and social services budget due to reduced farm incomes.

Third-party impacts can also be experienced by water right holders and water users. Surface water rights can be impaired if groundwater transfers impact the associated surface water system. Transfers that alter surface return flows can affect downstream users as well as wildlife refuges that depend on return flows from agricultural irrigation. Transactions that result in increased groundwater extraction or loss of recharge can increase the pumping costs to groundwater users.

Some uses of water have public goods characteristics that prevent market prices from reflecting the values of all those uses. Public goods properties include aesthetic, environmental, recreational, and instream flow benefits.

In a water market system, participants can be faced with uncertainties and imperfect information on water supplies, prices, and market opportunities. Access to complete and accurate information can be lacking if a centrally based network does not exist for communicating information on supply availability, demand, and prices. The reliability of obtaining supplies through a market system can be limited. On the other hand, nonmarket allocation mechanisms that utilize long-term contracts or water use permits can provide complete information and some level of predictability for water users.

Public policies can impair the efficiency of water market systems by affecting the prices that are charged to potential sellers. For example, when water is provided for agricultural irrigation through government subsidies, that water is made available to farmers at below the marginal cost of supplying it. Farmers who sell their share of subsidized water supplies may tend to set their market prices below the full opportunity costs of using that water.

Policies and approval procedures that are designed to protect third parties from negative impacts can be a major source of transaction costs for market participants. The process of determining the feasibility of a transaction often includes hydrological studies and legal advising, making it potentially lengthy as well as costly.

Legal Aspects Governing Water Transfers

A summary of California water transfer laws and regulations are provided by Gray (1989, 1990). It focuses on transfers involving appropriative rights that are held by permits or licenses which were issued by the Board, and those involving contract rights to water supplies that were developed by the Bureau and DWR. The written text of the laws and related discussions can be found elsewhere (Graff 1990; Saliba and Bush 1987; State of California, Department of Water Resources 1989; State of California, State Water Resources Control Board 1989; State of California, State Water Resources Control Board, Division of Water Rights 1987).

State laws, regulations, and policies. Prior to the 1980s, California State water transfer laws allowed a transfer to take place if it did not result in injuries to other appropriators or lawful water users because of a change in the point of diversion, place of use, or purpose of use of the water. Furthermore, transfer plans were subject to approval by the Board. However, interbasin water transfers between water districts rarely occurred in

California before 1981. These types of transfers have become increasingly common since legislative policies and directives were issued during the 1980s to encourage water transfers to take place.

In 1980, the State Legislature announced its findings that transfers of water and water rights are ways to promote efficient usage and meet new water demands. It also declared it a State policy to facilitate voluntary transfers of water and water rights where it would be consistent with the public welfare. In 1982, it ordered all appropriate State agencies to encourage such transfers and provide financial assistance for water conservation measures that will make additional water available for transfer.

In 1986, the Legislature directed DWR to establish an ongoing program to facilitate water exchanges or transfers, facilitate such transactions only if they involve water that is already developed or has been conserved, implement State laws pertaining to transfers, maintain a list of parties seeking to enter into transfer arrangements or other similar transactions, prepare a transfer guide, negotiate with the Bureau for the purchase and transfer of CVP water and the operation of all or part of the CVP, and make unused capacity in a water conveyance facility available to bonafide transferors (State of California, Department of Water Resources 1989). The last requirement also pertained to local agencies.

Every local or regional public agency that is authorized by law to supply water is also authorized to sell, lease, exchange, or otherwise transfer surplus water for use outside its service area. Surplus water can be water that the agency determines to be in excess of the needs of its users during the period of the transfer, or conserved water to which users agree to forego use for the duration of the transfer. An individual water user being served by an agency is also authorized to negotiate a transfer of water that is surplus to the user's needs, but the transaction is subject to the approval of both the user's water agency and the agency having jurisdiction over the area of import. Furthermore, transfers are ultimately subject to the Board's approval and to findings that they will not injure any legal water user; unreasonably affect fish, wildlife, or other instream beneficial uses; or unreasonably affect the overall economy in the area of export.

Due to amendments in 1988, short-term transfers require authorization by the Board. Although the statutes do not require such transfers to undergo environmental review procedures under the California Environmental Quality Act (CEQA), as they do for long-term transfers, the Board may exercise its power to hold public hearings and order the transferor to conduct environmental studies before it will grant its approval. One category of short-term transfers, called Temporary Changes, consists of transfers or exchanges of water or water rights that involve a change in the point of diversion of the water, its place of use, or the purpose of its use for a duration of up to one year. The amount of water that is allowed to be transferred is limited to that which would have otherwise been consumptively used or stored. Another category of short-term transfers, Temporary Urgency Changes, apply to situations in which a water right holder has an urgent need to transfer water and the Board finds the proposed change to be in the public interest such as during water supply emergencies. This type of transfer may last for a maximum of 180 days unless renewal is granted by the Board.

Long-term transfers of water or water rights are those which last for a period of over one year and there are no restraints on the maximum duration of the transfers. All rights automatically revert to the original holder when the transfer period ends. Long-term transfers involving a change in the point of diversion of the water, its place of use, or purpose of its use are subject to the Board's approval after a public hearing is conducted.

Transfers that involve the use of SWP facilities are subject to the approval of DWR, which evaluates each proposal separately (State of California, Department of Water Resources 1989). Potential impacts on the SWP system and third parties are analyzed before DWR will grant or deny its approval.

Federal laws, regulations, and policies. Water that is supplied by the Federal CVP is governed by Federal and State laws, and the regulations and policies of the U.S. Department of the Interior (Interior Department) and the Bureau. However, prior to 1992, water transfers were not specifically addressed by Federal law nor by legislation that established the CVP.

In early 1991, the Bureau adopted guidelines for CVP water transfers (U.S Department of the Interior, Bureau of Reclamation, Mid-Pacific Region 1991). They were developed for the 1991 water year to reduce the adverse impacts of California's drought conditions. Under these guidelines, transfers by contractors were subject to approval on an individual-case basis by the Bureau, must not have caused significantly adverse impacts on CVP supplies, and may only have involved what was considered to be "transferable water." Transferable water was defined as the average amount of water from the three highest years of beneficial use by the transferor from 1980 through 1989, and as water that would be beneficially used if the transfer did not occur. If water was made available for transfer by reducing the amount of CVP water that was used to irrigate crop lands, it was not allowed to be replaced by other surface supplies. Groundwater was allowed to be used as a substitute, but it must not come from stream underflow that adversely affects CVP surface water supplies. Prior to the passage of the CVPIA, CVP water was not allowed to be transferred to non-CVP users or service areas, and transfers between individual CVP users were not considered unless otherwise stated in their contracts. The transferor was allowed to charge the transferee an amount that was equal to or greater than the cost-of-service water rate. The transferor was required to pay this rate to the Bureau, but he was allowed to keep any amount that remained.

Water transfer provisions were included in section 3405 of the CVPIA. They allow individuals or districts to voluntarily transfer CVP water to other California water users or water agencies, or other State or Federal agencies. Therefore, CVP water may now be transferred to non-CVP users or service areas, but a transfer is subject to the approval of the Secretary of Interior and the contracting district or agency if the transfer involves more than 20% of CVP water that is under long-term contract within the district or agency. Furthermore, transfers must be consistent with State law, the amount of transferred water is limited to water that would have otherwise been consumptively used, a transfer must not have any long-term negative effect on groundwater conditions, and a transfer must not have any unreasonable adverse impact on the transferor's contracting district or agency.

Special Cases of Regulated Water Markets

The CVP Water Bank of 1977. Due to the drought conditions that were occurring in the western states, Congress enacted the Emergency Drought Act in 1977 to minimize agricultural losses for that crop year. To comply with the act, the Bureau established a temporary water bank program for the CVP in which the Bureau purchased water from willing sellers and sold it to willing buyers. The regulations restricted the sales to agricultural irrigators and prioritized them according to crop types.

The amount of water redistributed through the CVP Water Bank made up about 1.3% of the 3.3 MAF of water that the Bureau supplied to customers in 1977. The Bureau purchased 46,438 AF of water from seven water agencies at prices that ranged from $15 to $85 per AF, deducted 3,894 AF from that amount to account for reduced return flows and conveyance losses, and sold all of the remainder to twenty-six water agencies at prices that ranged from $56 to $143 per AF (Roos-Collins 1987, 863-867). The prices paid to suppliers were set at amounts that were meant to cover losses in agricultural production, incurred as a result of making supplies available to the CVP Water Bank. Buyers were required to pay the full costs of the water.

Different factors contributed to the limited participation by both buyers and sellers (Roos-Collins 1987, 864-865). The Emergency Drought Act required that any water transferred must be water developed by the CVP. Also, the act did not provide a way for the Bureau to pay the individual farmer if he had assigned his water rights to a water district. Furthermore, the Bureau chose not to purchase water that was held under riparian rights even though sales of such water were offered. The Bureau had obtained commitments from potential buyers before attempting to secure water supplies for the bank. Due to the experimental nature of the bank, potential buyers might have been reluctant to participate, and CVP contractors might not have been willing to purchase water at its marginal value. Also, the act was passed in April, which provided little time for negotiations to occur before the summer irrigation season began. Finally, irrigators in the San Joaquin Valley used groundwater supplies to compensate for shortages in surface supplies.

The State Drought Water Bank. On February 1, 1991, Governor Wilson signed Executive Order No. W-3-91, which created the Drought Action Team for the purpose of making recommendations in response to continued drought conditions in California (State of California, Department of Water Resources 1992, 1). One of the Drought Action Team's recommendations called for the temporary establishment of the State Drought Water Bank (SWB) by DWR in coordination with the Interior Department and the Board. They further called for (1) the water to be purchased from willing sellers; (2) the water to be allocated by the State for purposes of increasing urban supplies to minimum levels, meeting critical agricultural needs, preserving fish and wildlife, and providing carryover storage for 1992; and (3) the recognition and mitigation of third-party impacts (State of California, Drought Action Team 1991, viii-x). Given the prevailing drought conditions, the alternative to the SWB would have been an emergency declaration by the Governor. Water rights, contracts, and permits would have been suspended under his emergency powers and therefore, water would have been allocated administratively. The likely outcome would have been greater political conflict and lengthy litigation (Howitt, Moore, and Smith 1992, 1, 5, 38-39).

Assembly Bills No. 9 and No. 10 (AB 9 and AB 10) were passed by the State Legislature and signed into law by the Governor in April 1991 for the purpose of facilitating the creation of the SWB. AB 9 authorized water suppliers to transfer water outside their service areas, while AB 10 provided protection of water rights for those who would engage in transfers of water for drought relief in 1991 or 1992 (State of California, Department of Water Resources 1992, 15). Another bill, AB 12, was passed by the

Legislature in September and signed by the Governor in October 1991. It appropriated $16.3 million to the DFG for the purpose of minimizing the drought's impacts on fish and wildlife (Howitt, Moore, and Smith 1992, 2, 13). Part of the funds allowed the DFG to acquire water from the SWB.

The SWB took the form of a regulated water market (Howitt, Moore, and Smith 1992, 6-8, 14). Buyers were required to implement water conservation programs; to utilize fully their own total available water supplies, including groundwater and reclaimed water; and to make use of water exchange opportunities. DWR set the purchasing price at $125/AF, which reflected the amount of money that sellers would have to receive before they were willing to make water available for sale. The selling price was set at $175/AF, which reflected the amount of money that buyers were willing to pay and the costs incurred to acquire the water, such as legal, administrative, financing, and acquisition costs as well as the costs of conveyance losses through the Delta. In addition to the selling price, buyers were charged for the costs of delivering the water to their service area.

Water was purchased from water districts and individual farmers in Northern California, and it was sold to areas with critical water needs such as the urban regions in Southern California and the San Francisco Bay Area, and the agricultural regions in the Central Valley.

By the end of 1991, the SWB secured almost 821,000 AF of water from 351 contracts. That amount made up about 25% of the 3.3 MAF of water that was exported from the Bay/Delta Estuary by all sources in 1991. Almost half of the water secured by the SWB was made available from fallowing agricultural lands, approximately 33% was supplied by groundwater or growndwater exchange, and about 17% came from stored surface water (State of California, California Environmental Protection Agency, State Water Resources Control Board 1992, 86; State of California, Department of Water Resources 1992, 2, 5-8). Because the Bureau generally did not allow CVP water to be sold to the SWB except for water that was held under preexisting rights prior to the building of the CVP, the acquisition of water was restricted geographically. Over 338,000 AF were supplied by the Delta region, and more than 336,000 AF came from the Yuba and Feather River areas (Howitt, Moore, and Smith 1992, 27; State of California, Department of Water Resources 1992, 2).

The amount of water secured by the SWB was more than enough to satisfy demands. A total of almost 418,000 AF were allocated to twelve water suppliers, and for fish and wildlife purposes. Through funds provided by AB 12, the DFG received 28,000 AF (Howitt, Moore, and Smith 1992, 2, 13; State of California, Department of Water Resources 1992, 6, 9, 12). Approximately 265,000 AF were available for carryover storage for 1992 (University of California 1993, 6).

The SWB was reinstated by Governor Wilson during March 1992. This time, water was not made available from fallowing, but was supplied by groundwater exchange and stored surface water instead. DWR was able to purchase the water at $50/AF and sell it for $90/AF. By the end of May, 90,000 AF had been secured (Marty 1992; McClurg 1992b, 9).

A study that was funded by DWR but conducted by a team of consultants (Howitt, Moore, and Smith 1992) found that the 1991 State Drought Water Bank created economic gains for California's agricultural sector as well as the statewide economy. Net benefits were estimated at $32.6 million for the agricultural sector and $91.4 million for the state as a whole. Other benefits included the profits made by those who sold water to the SWB, the value of increased carryover storage for 1992, a net gain of over 990 jobs in the agricultural sector, increased Delta flows that benefitted fish and wildlife due to the delivery of transferred water, and the acquisition of 28,000 AF of water by the DFG for the protection of fish and wildlife from the effects of the drought (Howitt, Moore, and Smith 1992, 1-2, 13, 19-20, 43, 61, 63, 73).

The study also found that adverse economic impacts caused by the SWB's operations were small in the regions that exported water compared to total statewide gains.

Land fallowing was proportionately the largest in the Counties of Sacramento, San Joaquin, and Yolo where the fallowed acreage ranged from 13.1% to 19.9% of the five-year average acreage for 1987-1991. Even in these areas, economic impacts were small compared to the overall county economies. Reductions in county personal income ranged from 0.04% to 0.28%, while net losses in total employment ranged from 0.0% to 0.48% (Howitt, Moore, and Smith 1992, 2, 19-20, 44).

Although the study concluded that major economic benefits resulted from the SWB's activities and that adverse impacts to water-exporting regions were small, it did acknowledge that significantly adverse economic effects were experienced by some individuals such as suppliers and farm workers. Suppliers included those in the seed, fertilizer, oil supply, and harvester businesses. Furthermore, because the Bureau did not allow CVP water to be sold to the SWB, the geographic range for acquiring water was limited. This led to a weakening of the economic effectiveness of the SWB and a geographic concentration of adverse impacts in non-CVP service areas (Howitt, Moore, and Smith 1992, 2, 25-27, 42-44, 60).

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