CALIFORNIA AGRICULTURE
ISSUES AND CHALLENGES

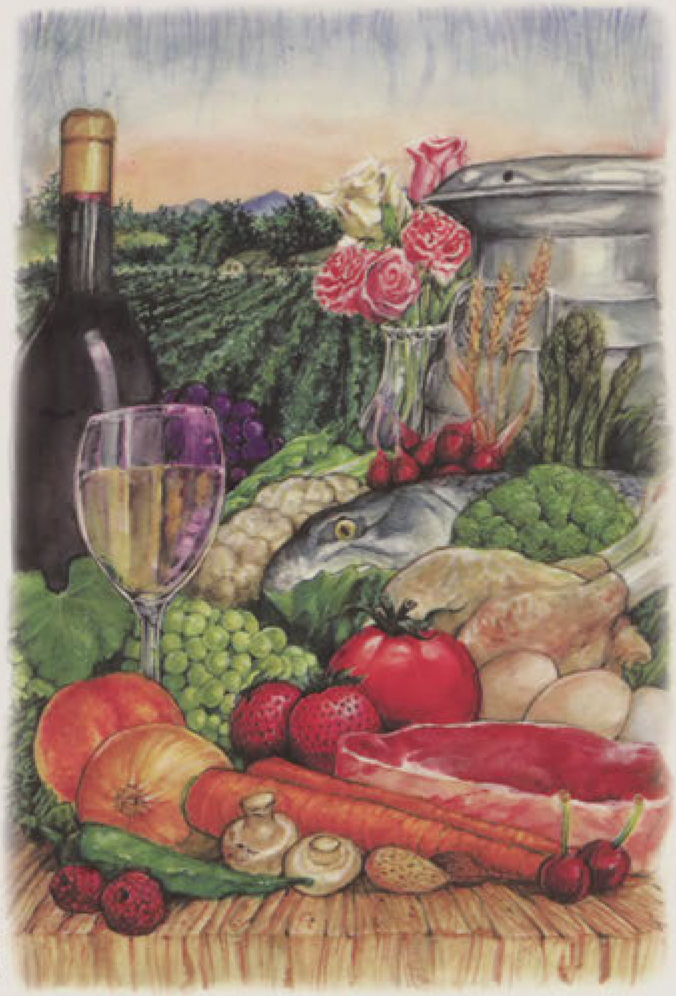
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TABLE OF CONTENTS

INTRODUCTION

Agriculture in California is a complex and diverse industry, characterized by high levels of technology and value-added. Its impact on the state's economy is significant, contributing over 60 billion dollars, or 8.5 percent of all personal income, and supporting 1.2 million jobs, or nearly 9 percent of all employment. Its productivity and sophistication are world-famous—agriculturalists and agribusinesses from all over the globe come here to learn new modes of organization and management, as well as advanced technologies and methods of production.

The keys to agriculture's success in California are many, and almost as various as the more than 250 commodities produced here. This book provides an overview of the industry, beginning with the state's historical agricultural development and continuing with analysis of present conditions and the outlook for the future. As global economic and political changes have taken place, California agriculture has continued to adapt its mix of products and its methods for handling them. The chapters in this book review the changes, the factors that led to them, and the resulting impacts. These pages reflect a dynamic and ever changing agricultural and agribusiness sector and recognize the institutions and policies that assist it in remaining viable and competitive in the world economy.

California agriculture is blessed with an almost ideal climate for growing farm commodities, along with an abundance of superb natural resources that include fertile land and high quality water for irrigation. Almost equally important is the availability of adequate supplies of labor for producing high-value, labor-intensive products. Crucial, too, though often overlooked, are the highly skilled agricultural management personnel willing to take risks, the well organized input sector, the availability of adequate credit, the world-renowned research and education system, the efficient marketing system, and the supportive state and federal government policies that work hand in hand with agriculture in promoting its competitiveness.

The current situation might sound like a utopian dream. Obviously, an appropriate question is, "What could go wrong?" The answer is, "Plenty!" The success of California agriculture has come through the hard work and creativity of its participants; but the surrounding context is changing rapidly. Urbanization is taking up prime agricultural land in significant blocks and in an irregular fashion, and is competing with agriculture for another precious resource as well—water. Air quality is being seriously degraded through air pollution caused by an increased population. Exotic pest eradication has become increasingly more difficult to undertake because of the loss of chemical weapons or limitations on their use. Successive budget cuts and priority shifts threaten the state's famed agricultural research system; other parts of the world are today not only borrowing California technology and management systems but improving on them, and in some cases taking over the leadership.

All of these problems seem to gravely threaten California agriculture. Nevertheless, some forecasts made in the past have not come true. It is possible for California agriculture to maintain its excellence and stay competitive. This book, written by members of the Giannini Foundation of Agricultural Economics, provides some insights into the current situation and discusses some future prospects.

Chapter 1, by Olmstead and Rhode, reviews the history and development of California agriculture by focusing on the major transformations of California agriculture, from the wheat economy of the nineteenth century to the intensive row, vine, and orchard crops of today, along with the emergence of modern livestock operations. This historical treatment provides the foundation for further analysis of California agriculture and an understanding of its current agricultural structure and institutions.

In the second chapter, Carter and Goldman provide a statistical overview of California agriculture, its role in the state's economy, and its use of resources. The third chapter, by Johnston, gives a cross sectional view of California agriculture to reflect its diversity and complexity, and shows how it differs from other states in its geographic, resource, and commodity dimensions.

Because science and technology have played an important role in the development and competitiveness of California agriculture, Alston and Zilberman in Chapter 4 provide an overview of the technological changes that have taken place, and the factors and institutions that brought about those changes. They also look at the investment, both public and private, that is needed to sustain productivity growth, and the special challenges brought on by the advent of biotechnology and computer/information systems.

California has long been known for its advanced marketing expertise and organizations. Chapter 5 by Carman, Cook, and Sexton documents the significance of marketing in both U.S. and California agriculture and highlights the important institutions that have emerged. It also focuses on the strategies pursued by California's food marketing sector to compete effectively in the new global environment.

Labor has always been an important input to California agriculture and is an integral part of its success story. However, some of the most contentious battles between agriculture and an increasing urban society have been waged over farm labor. In Chapter 6, Martin and Perloff review the farm labor situation, some of its history, labor's role in California agriculture, and the outlook for the future.

Water is a key element to California agriculture's success and future. Without irrigation, California agriculture could not be in its current pre-eminent position. Today this resource is under increasing pressure from population growth, escalating costs, environmental regulation, and deteriorating quality. In Chapter 7, Parker and Howitt review the water situation in California and the issues affecting agriculture, offering insight into the future.

Despite its remarkable successes, California agriculture has had serious impacts on the natural environment and resource base. Chapter 8, by Zilberman, Siebert, and Zivin, reviews some of the major environmental issues facing California agriculture and describes the policy environment. Case studies are used as examples of how California agriculture has worked within the policy framework to mitigate environmental impacts while remaining competitive. Chapter 9, by the same authors, gives an overview of the competition to agriculture from a growing urban population and suggests the likely outcomes under various policy scenarios.

As agricultural markets become more globalized and international trade barriers are reduced, California agriculture is sure to have both opportunities and challenges. In Chapter 10, Carter focuses on the broad dimensions of agricultural trade and California's role in a changing world economy. He identifies trends in commodity and processed food trade and discusses current issues vis-à-vis the major trading partners in the Pacific Rim.

Finally, Chapter 11, by Sumner and Hart, reviews some of the most significant policy and governmental influences on California agriculture, with their main focus on farm commodity and other support programs. An interesting part of this chapter deals with estimates of the value of governmental support to California agriculture, in the form of "Producer Subsidy Equivalents."

Overall, the chapters in this book provide a comprehensive summary of California agriculture from an economic and policy perspective. The book provides both a foundation and a reference point for anyone interested and involved in the evaluation and analysis of change in the agricultural and agribusiness sector.

We are grateful to the University of California Giannini Foundation and the Division of Agriculture and Natural Resources for their support of this project. Especially to be thanked are the various authors who devoted significant time and effort to writing their respective chapters. Of special note is the editorial help provided by Ann Scheuring. Our collective thanks to the indispensable Geralyn Unterberg, who spent numerous and long hours in the preparation of the book for printing.

Jerry Siebert, Editor
Berkeley, June 1997

Chapter 1

AN OVERVIEW OF THE HISTORY OF CALIFORNIA AGRICULTURE

Alan L. Olmstead and Paul W. Rhode

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Agriculture is big business in California. In recent years, this one state alone has accounted for about 10 percent of the value of the nation's agricultural output. What distinguishes California from other regions more than the volume of output, however, is the wide diversity of crops, the capital intensity, the high yields, and the special nature of the state's agricultural institutions. This chapter analyzes major developments in California's agricultural history to provide a better understanding of how and why the state's current agricultural structure and institutions emerged.

We will focus on major structural transformations: the growth and demise of the extensive wheat economy of the nineteenth century; the shift to intensive orchard, vine, and row crops; and the emergence of modern livestock operations. Intertwined with our discussion of sectional shifts will be an analysis of some of the special institutional and structural features of California's agricultural development. Here we offer a brief look at the subjects of farm power and mechanization, irrigation, the labor market, and farmer co-operatives. In all of these areas, California's farmers responded aggressively to their particular economic and environmental constraints to create their own institutional settings.

CALIFORNIA EMERGES: THE WHEAT ECONOMY OF THE 19TH CENTURY

When disgruntled miners left the gold fields, they found an ideal environment for raising wheat: great expanses of fertile soil and flat terrain combined with a climate of rainy winters and hot, dry summers. By the mid-1850s, the state's wheat output exceeded local consumption, and California's grain operations began to evolve into a form of agriculture quite different from the family farms of the American North. The image of lore is of vast tracts of grain, nothing but grain, grown on huge bonanza ranches in a countryside virtually uninhabited except at harvest and plowing time. While this picture is clearly overdrawn, it contains many elements of truth. California grain operations were quite large by contemporary standards and extensively employed labor-saving, scale-intensive technologies.[1] Most of the wheat and barley was shipped to European markets, setting a pattern of integration into world markets that has characterized California agriculture to the present. Large scale operations, mechanization, and a reliance on hired labor would also become hallmarks of the state's farm sector.

The rise and fall of grain growing is graphed in Figure 1, which shows the acreage of barley and wheat harvested annually in California from 1867 to 1929. Land in wheat steadily climbed from the mid-1860s until the early 1880s, when it stabilized at around 2.8 million acres. By 1889, California was the nation's second leading wheat-producing state with about 3.5 million acres harvested, and a large-scale exporter with shipments totaling over 28 million bushels. Over the 1890s, the area of wheat harvested contracted gradually to about 2.2 million acres. An abrupt collapse began shortly after the turn of the century. By the end of the 1900s, only about 0.5 million acres of wheat were cut, and the state became a net importer of wheat.[2] Measured from the 1899–1901 average to that of 1909–1911, wheat acreage plunged by about 76 percent. Total acreage in small grains fell roughly 50 percent between 1899–1901 and 1909–1911.

Grain acreage remained around the 1.6 million level throughout the 1910s and 1920s (with the sole exception of a brief war-related boom during 1918–1919). This was nearly the same level as in 1870 and far below the 3.5 million acre level of the heyday of the grain trade in the late 1880s. Most of the land withdrawn from wheat production was apparently left completely idle for a period of years, not immediately shifted into orchards as is sometimes supposed. According to contemporary accounts, decades of monocrop grain farming, involving little use of crop rotation, fallowing, fertilizer, or deep plowing, mined the soil of nutrients and promoted the growth of weeds. Complaints that the land no longer yielded paying wheat crops became common from the 1890s. It was also asserted that the grain had deteriorated in quality, becoming starchy and less glutinous. It is interesting to note that "soil mining" cultivation practices may well have been "economically rational" under the high interest rates prevailing in the state in the mid-nineteenth century.

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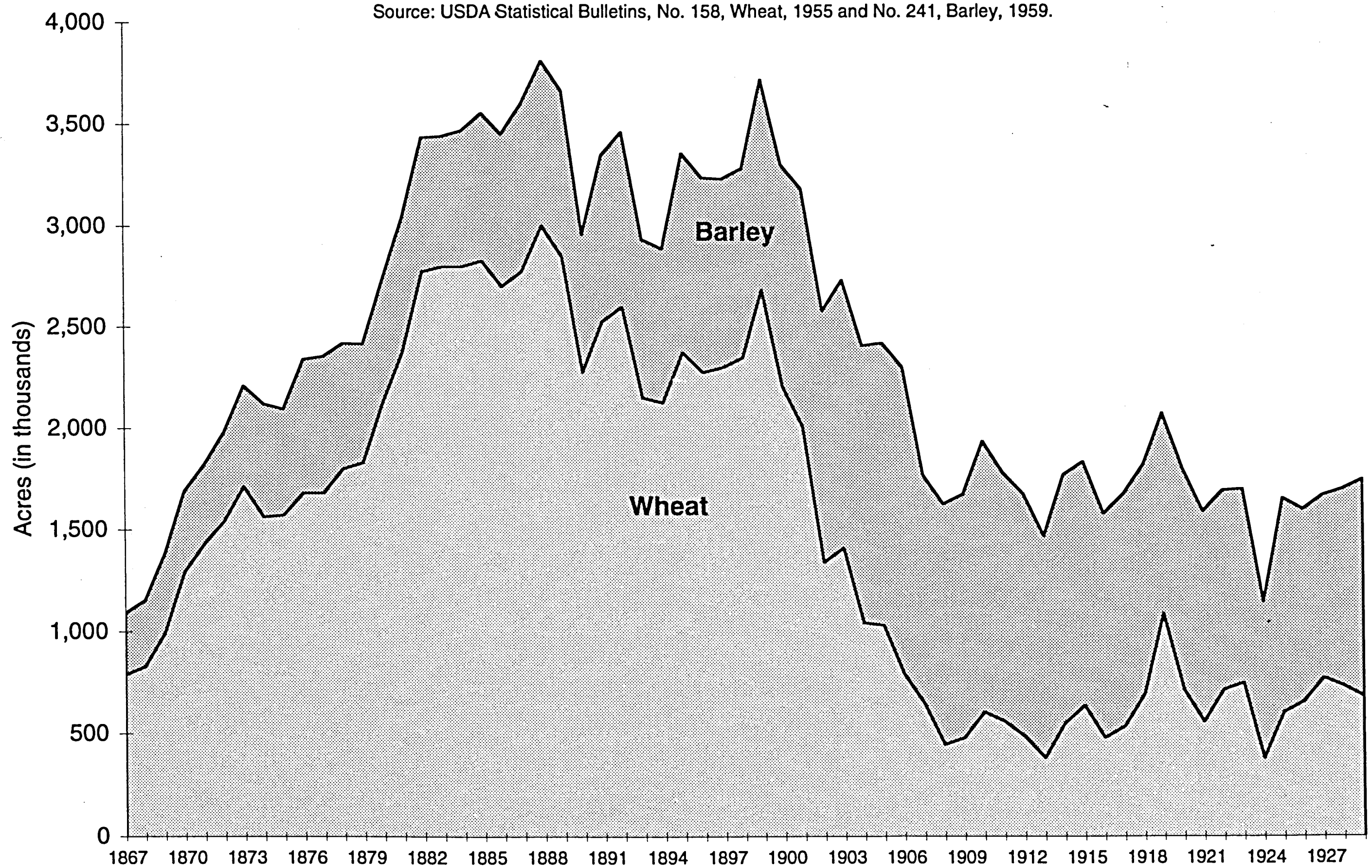
[1] As we note later in this essay, ranchers vigorously pursued the development of technologies and production practices suited to early California's economic and environmental conditions. This search for economic large-scale, labor-saving technologies culminated in the perfection of the combined grain harvester by local agricultural implements' producers in the early 1880s and its widespread diffusion among the region's grain growers in the late 1880s and the 1890s. See Alan L. Olmstead and Paul Rhode, "An Overview of California Agricultural Mechanization, 1870–1930," *Agricultural History*, Vol. 62, No. 3, 1988.

[2] Frank Andrews, "Marketing Grain and Livestock in the Pacific Region," *Bureau of Statistics, Bulletin 89*, 1911; G.W. Shaw, "A Preliminary Progress Report of Cereal Investigations, 1905–1907," *California Agricultural Experiment Station Circular No. 28*, January 1907; Henry F. Blanchard, "Improvement of the Wheat Crop in California," *USDA Bulletin No. 178*, 1910.

Figure 1. Small Grain Acreage in California, 1867-1929.

Source: USDA Statistical Bulletins, No. 158, Wheat, 1955 and No. 241, Barley, 1959.



THE GREAT TRANSFORMATION

Between 1890 and 1914, the California farm economy fundamentally and swiftly shifted from large-scale ranching and grain-growing operations to smaller-scale, intensive fruit cultivation. By 1910, the value of intensive crops equaled that of extensive crops, as California emerged as one of the world's principal producers of grapes, citrus, and various deciduous fruits. Tied to this dramatic transformation was the growth of allied industries, including canning, packing, food machinery, and transportation services.

A vantage point on the state's transformation is offered in Table 1, which provides key statistics on the evolution of California agriculture between 1859 and 1987. Almost every aspect of the state's development after 1880 reflected the ongoing process of intensification. Between 1859 and 1929, the number of farms increased about 700 percent. The average size of farms fell from roughly 475 acres per farm in 1869 to about 220 acres in 1929, and improved land per farm dropped from 260 acres to about 84 acres over the same period. Movements in cropland harvested per worker also point to increased intensity of cultivation after the turn of the century. The land-to-labor ratio fell from about 43 acres harvested per worker in 1899 to 20 acres per worker in 1929. The spread of irrigation broadly paralleled the intensification movement. Between 1869 and 1889, the share of California farmland receiving water through artificial means increased from less than 1 percent to 5 percent. Growth was relatively slow in the 1890s, but expansion resumed over the 1900s and 1910s. By 1929, irrigated land accounted for nearly 16 percent of the farmland.

Table 1. California's Agricultural Development.

	No. of Farms	Land in Farms	Improved Land	Cropland Harvested	No. of Farms Irrigated	Irrigated Land	Ag. Labor Force
	(1,000)	--------*(1,000 Acres)*--------			*(1,000)*	*(1,000 Acres)*	*(1,000)*
1859	19	8,730	--	--	--	--	53
1869	24	11,427	6,218	--	--	60-100	69
1879	36	16,594	10,669	3,321	--	300-350	109
1889	53	21,427	12,223	5,289	14	1,004	145
1899	73	28,829	11,959	6,434	26	1,446	151
1909	88	27,931	11,390	4,924	39	2,664	212
1919	118	29,366	11,878	5,761	67	4,219	261
1929	136	30,443	11,465	6,549	86	4,747	332
1939	133	30,524	--	6,534	84	5,070	278
1949	137	36,613	--	7,957	91	6,599	304
1959	99	36,888	--	8,022	74	7,396	284
1969	78	35,328	--	7,649	51	7,240	240
1978	73	32,727	--	8,804	56	8,505	311
1987	83	30,598	--	7,676	59	7,596	416

Sources:
Taylor and Vasey, "Historical Background," in Rhode, 1995.
U.S. Bureau of the Census: *Fifteenth Census 1930*, Vol. 4; *Census of Agriculture 1959*, California, Vol. 1, Part 48; *1980 Census of Population*, California, Vol. 1, Part 6; *Census of Agriculture 1987*, California, Vol. 1, Part 5; *1990 Census of Population*, California, Section 1.
Thomas Weiss, Unpublished data.

Data on the value and composition of crop output put California's agricultural transformation into sharper relief. Between 1859 and 1929, the real value of the state's crop output increased over 25 times. Growth was especially rapid during the grain boom of the 1860s and 1870s, associated primarily with the expansion of the state's agricultural land base. But improved acreage in the state peaked in 1889, and cropland harvested peaked in 1899. Subsequent growth in crop production was mainly due to increasing output per acre and was closely tied to a dramatic shift in the state's crop mix. After falling in the 1860s and 1870s, the share of intensive crops in the value of total output climbed from less than 4 percent in 1879 to over 20 percent in 1889. By 1909, the intensive share reached nearly one-half, and by 1929, it was almost four-fifths of the total.[3]

Table 2 illustrates the dramatic rise in the state's fruit industry in the 19th century. It shows an index of the value-weighted shipments of California fresh, dried, and canned fruits and nuts. From spectacular growth rates exceeding 25 percent per year

[3] After 1909, cotton and sugar beets became important, contributing to the impressive rise of the intensive share in the 1910s and 1920s. For a more complete treatment of these issues, see Paul W. Rhode, "Learning, Capital Accumulation, and the Transformation of California Agriculture," *Journal of Economic History*, Vol. 55, No. 4, December 1995.

in the 1870s and 1880s (no doubt, in part, reflecting the small base), shipments continued to grow at robust rates of about 8 percent per annum over the 1890s and 1900s. By 1919, California produced 57 percent of the oranges, 70 percent of the prunes and plums, over 80 percent of the grapes and figs, and virtually all of the apricots, almonds, walnuts, olives, and lemons grown in the United States. In addition, California produced significant quantities of apples, pears, cherries, peaches, and other lesser crops.

Table 2. California Fruit Shipments and Prices, 1870-1914.

Year	Value-Weighted Shipments	Year	Value-Weighted Shipments
	(1890 = 100)		*(1890 = 100)*
1870	0.2	1893	157.7
1871	0.3	1894	181.8
1872	0.3	1895	198.9
1873	0.6	1896	164.1
1874	0.8	1897	222.5
1875	1.0	1898	247.8
1876	1.4	1899	256.3
1877	1.5	1900	288.2
1878	1.0	1901	352.6
1879	2.7	1902	395.3
1880	2.3	1903	413.5
1881	6.7	1904	450.2
1882	9.6	1905	411.1
1883	10.2	1906	381.9
1884	8.6	1907	504.1
1885	18.9	1908	427.0
1886	22.7	1909	514.1
1887	42.6	1910	540.3
1888	43.8	1911	473.0
1889	65.3	1912	556.7
1890	100.0	1913	367.6
1891	108.7	1914	435.3
1892	114.2		

Source: Paul W. Rhode, "Learning, Capital Accumulation, and the Transformation of California Agriculture," *Journal of Economic History*, Vol. 55, No. 4, December 1995.

The spectacular growth in California production had important international consequences as traditional Mediterranean exporters of many crops were first driven from the lucrative U.S. market and then faced stiff competition from the upstart Californians in their own backyard of northern Europe. California production significantly affected the markets and incomes of raisin growers in Málaga and Alicante, prune growers in Serbia and Bosnia, and citrus growers in Sicily.[4]

Explanations for the causes and timing of California's structural transformation have long puzzled and eluded scholars. The traditional literature yields numerous causal factors, including: (1) increases in demand for income-elastic fruit products in eastern urban markets; (2) improvements in transportation, especially the completion of the transcontinental railroad; (3) reductions in the profitability of wheat due to slumping world grain prices and falling local yields; (4) the spread of irrigation and the accompanying breakup of large land holdings; (5) the increased availability of "cheap" labor; and (6) the accumulation of knowledge about California's environment and suitable agricultural practices. Yet a careful investigation of the transformation yields a surprising result: much of the credit for the shift to intensive crops must be given to exogenous declines in real interest rates and to "biological" changes as farmers learned more about how to grow new crops in the California environment.

Isolated from America's financial markets, California farmers faced high, even astronomical, interest rates, which discouraged capital investments. Rates fell from well over 100 percent during the Gold Rush to about 30 percent circa 1860. The downward trend continued with real rural mortgage rates approaching 8 to 12 percent by 1890. The implications of falling interest rates for a long-term investment such as an orchard were enormous. As one Bay Area observer noted in the mid-1880s, the conversion of grain fields to orchards "has naturally been retarded in a community where there is little capital, by the cost of getting land into orchard, and waiting several years for returns."[5] Calculations indicate that the break-even interest rate for the wheat-to-orchard transition was about 10 to 13 percent (at rates above 15 percent the value of investments in orchards started to turn negative). These estimates conform fairly closely to the interest rate levels prevailing in California when horticulture began its ascent.

A second key supply-side force was the increase in horticultural productivity associated with biological learning. Yields for leading tree crops nearly doubled between 1889 and 1919. When the Gold Rush began, the American occupiers knew little about the region's soils and climate. As settlement continued, would-be farmers learned to distinguish the better soils from poorer soils, the more amply watered land from the more arid, the areas with moderate climates from those suffering greater extremes. Occasionally overcoming deep-seated prejudices, farmers learned which soils were comparatively more productive for specific crops.[6] California fruit growers engaged in a similar time-consuming process of experimentation to find the most appropriate plant stocks and cultural practices. Existing varieties were introduced from around the world, and new varieties were created. In the early 1870s, USDA plant specialists established the foundation for the state's citrus industry with navel orange budwood imported from Bahia, Brazil. Plums and prune trees were brought in from France and Japan; grape vines from France, Italy, Spain, and Germany; and figs (eventually together with the wasps that facilitated pollination) from Greece and Turkey. Plant

[4] Alan L. Olmstead and Paul W. Rhode, "The Impact of the Commercialization of Mediterranean Agriculture on Traditional Producers, 1880-1930," Working Paper, Institute of Governmental Affairs, University of California, Davis, 1996.
[5] J. Burns, "A Pioneer Fruit Region," *Overland Monthly*, 2nd Series, Vol. 12, No. 67, 1888.
[6] U.S. Weather Bureau, *Climatology of California*, Bulletin L, 1903; U.S. Bureau of the Census, *Tenth Census, 1880*, Vol. 6, Cotton Production, Part 2, 1884.

breeders also got in on the act. The legendary Luther Burbank, who settled in California in 1875, developed hundreds of new varieties of plums and other fruits over his long career.[7]

In part, the growth of horticultural knowledge occurred through the informal "folk process" highlighted in William Parker's classic treatment of American agriculture. Over time, the process of research and diffusion became increasingly formalized and institutionalized. Agricultural fairs served to demonstrate new practices and plants. As an example, a series of major citrus expositions, held annually in Riverside from the late 1870s on, helped popularize the new Bahia orange variety. An emerging group of specialty farm journals, such as the *Southern California Horticulturist*, *California Citrograph*, and *California Fruit Grower*, supplemented the stalwart *Pacific Rural Press* to spread information about fruit growing.[8] The California State Board of Horticulture, formed in 1881, provided an active forum for discussion of production and marketing practices, especially through its annual convention of fruit growers. The Agricultural College of the University of California, under the leadership of Eugene Hilgard and Edward Wickson, intensified its research efforts on horticultural and viticultural problems after the mid-1880s. By the early 1900s, the USDA, the state agricultural research system, and local cooperatives formed an effective working arrangement to acquire and spread knowledge about fruit quality and the effects of packing, shipping, and marketing on spoilage and fruit appearance. These efforts led to the development of pre-cooling and other improved handling techniques, contributing to the emergence of California's reputation for offering higher-quality horticultural products. This learning process eventually propelled California's horticultural sector to a position of global leadership.[9] More generally, the example of the state's horticultural industry highlights the important, if relatively neglected, contribution of biological learning to American agricultural development before the 1930s.

A second major transformation took place in the early twentieth century with the increased cultivation of row crops including sugar beets, vegetables, and most notably cotton. These changes represented an intensification of farming with significant capital investments and often led to shifts onto what had been marginal or under-utilized lands. The advent of cotton, which by 1950 had become the state's most valuable crop, offers another important case study in the continuing evolution of California agriculture.

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[7] Warren Tufts, *Rich Pattern of California Crops*, University of California Press, Berkeley, 1946; Robert Hodgson, "California Fruit Industry," *Economic Geography*, Vol. 9, No. 4,1993.

[8] William Parker, "Agriculture," In *American Economic Growth: An Economist's History of the United States*, Lance Davis et al., Editors, Harper and Row, New York, 1972; Charles Teague, *Fifty Years A Rancher: The Recollections of Half a Century Devoted to the Citrus and Walnut Industries of California and to Furthering the Cooperative Movement in Agriculture*, Ward Ritchie, Los Angeles, 1944; Robert Cleland and Osgood Hardy, *March of Industry*, Powell, Los Angeles, 1929.

[9] The initially high cost of capital helps explain why the learning process concerning the best practice in fruit cultivation was so prolonged. The discovery process involved both actual investment in learning, and learning by doing, utilizing a capital-intensive production process. The high initial rates of interest almost surely reduced the amount of investment undertaken and lengthened the learning process. Edward Wickson, *California Fruit*, Pacific Rural Press, San Francisco, 1900, p.50, notes one interesting response of early fruit growers to the high value of capital and time: orchardists in the 1850s frequently planted dwarf trees, which began bearing sooner than standard stocks.

The Rise of Cotton

From Spanish times, visionaries attempted to introduce cotton into California on a commercial basis. A variety of factors, including the high cost of labor, the distance from markets and gins, and inadequate knowledge about appropriate varieties, soils, etc. doomed these early efforts. The real breakthrough came during World War I when high prices coupled with government research and promotional campaigns encouraged farmers in the Imperial, Coachella, and San Joaquin Valleys to adopt the crop. Figure 2 illustrates acres harvested, bales produced, and yields per acre, from 1910 to 1964. The tremendous absolute increase in California's cotton acreage since the 1920s contrasts with the absolute decline nationally. California's acreage in cotton ranked 14th out of 15 cotton-producing states in 1919; by 1959 it ranked second.

Several factors distinguished California's cotton industry from other regions. First, cotton yields were typically more than double the national average. High yields resulted from the favorable climate, rich soils, controlled application of irrigation water, use of the best agricultural practices and fertilizer, adoption of high quality seeds, and relative freedom from pests. Second, the scale and structure of cotton farms was remarkably different in California. From the mid-1920s through the 1950s, the acreage of a California cotton farm was about five times that of farms in the Deep South. As an example of the structural differences between California and other important cotton states, in 1939 farms producing 50 or fewer bales grew about 17 percent of the output in California, but in other leading cotton states, farms in this class produced at least 80 percent of all cotton output. One-half of the output in California was grown on farms producing more than 200 bales. For the nation as a whole, one-half of the output was raised on farms producing fewer than 13 bales. Thus, it is not surprising that California's gross income per cotton farm was almost nine times the national average.[10]

Other distinctive features of California cotton farms were their more intensive use of power and their earlier mechanization of pre-harvest activities. In 1929, a California farm was almost 20 times more likely to have a tractor than a Mississippi farm.[11] The *Pacific Rural Press* in 1927 offered a description of the highly mechanized state of many California cotton farms: "[M]en farm in sections....By the most efficient use of tractor power and tools, one outfit with a two-man daylight shift plants 100 acres per day, 6 rows at a time, and cultivates 70 acres 4-rows at a time."[12] The more rapid adoption of tractors (besides reducing pre-harvest labor demands) created a setting favorable to further modernization. When picking machines became available, farmers already possessed the mechanical skills and aptitudes needed for machine-based production.

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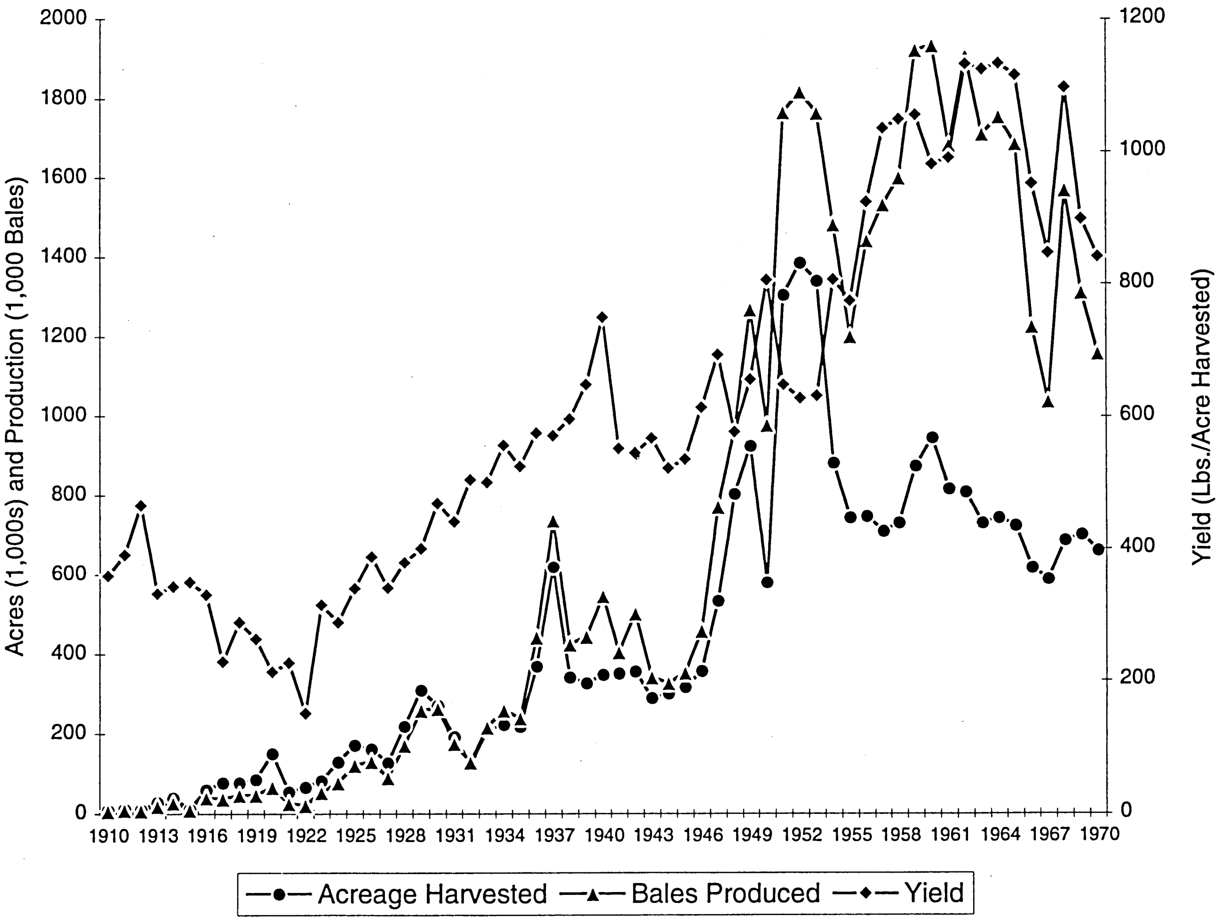
[10] Moses S. Musoke and Alan L. Olmstead, "The Rise of the Cotton Industry in California: A Comparative Perspective," *Journal of Economic History*, Vol. XLII, No. 2, June 1982.

[11] U.S. Bureau of the Census, *U.S. Census of Agriculture: 1959*, General Report: Statistics by Subjects, Vol. II.

[12] *Pacific Rural Press*, April 2, 1927. One of the more notable growers in Kern County was Herbert Hoover, who regularly raised 400 acres of cotton on his 1,200 acre farm during the 1920s. See *Los Angeles Times, Farm and Tractor Section*, May 8, 1921; *California Cotton Journal*, April 1926.

Figure 2. California Cotton, 1910–1970.



The larger size of cotton operations in California and the more intensive use of tractors reflected a fundamentally different form of labor organization than that which dominated the South. By the 1940s, on the eve of cotton harvesting mechanization, most cotton in California was picked on a piece-rate basis by seasonal laborers under a contract system.[13] Although conditions varied, a key ingredient was that a labor contractor recruited and supervised the workers, and dealt directly with the farmer, who might have had little or no personal contact with his laborers. This type of arrangement implied different class and social relationships from those that prevailed in much of the South. The California farm worker was more akin to an agricultural proletarian than to a rural peasant. The proverbial paternalism of southern planters toward their tenants had few parallels in California.

As with many crops, California cotton growers also led the way in harvest mechanization. Many of the factors discussed above, including pre-harvest mechanization (and familiarity with machines), relatively high wages, large-scale operations, high yields, a flat landscape, and a relative absence of rain during the harvest season all aided in the adoption of the mechanical harvester. Spindle picking machines first appeared on a commercial basis following World War II. In 1951, over 50 percent of the California crop was mechanically harvested compared to about 10 percent for the rest of the nation. At that time, about 50 percent of all the machines in operation in the United States were at work on California farms.[14]

THE LIVESTOCK ECONOMY

Similar forces—early adoption of large-scale operations and advanced technologies—characterized California's livestock economy. The broad trends in livestock production in California since 1850 are reflected in Figure 3, which graphs the number of head on various types of livestock in the state as aggregated into a measure of animal units fed.[15] The region emerged from the Mexican period primarily as a cattle producer. A series of droughts and floods in the 1860s devastated many herds, and when recovery occurred in the 1870s, sheep-raising had largely replaced cattle-ranching. Indeed, by 1889, the state became the nation's leading wool producer, with almost 13 percent of national output.[16]

Many of the livestock ranches of the nineteenth century operated on extremely large scales. Examples of these operations include Miller-Lux, Tejon, Kern County Land Company, Flint-Bixby, Irvine, Stearns, and Hearst. With the intensification of crop production in California, livestock activities tended to grow slowly. Although the smaller family-sized farms began to replace the large bonanza grain farms and livestock ranches, "general" or "mixed" farms modeled on midwestern prototypes

[13] California Committee to Survey the Agricultural Labor Resources, *Agricultural Labor in the San Joaquin Valley: Final Report and Recommendations*, Sacramento, March 15, 1951; Lloyd H. Fisher, *The Harvest Labor Market in California*, Cambridge, 1953.
[14] Musoke and Olmstead, 1982.
[15] This measure combines livestock into dairy-cow-equivalents using the following weights: dairy cows=1; non-dairy cows=0.73; sheep=0.15; goats=0.15; hogs=0.18; horses and mules=0.88; chickens=0.0043. The weights are derived from FM 64. There may be slight discrepancies arising from their application to census-based animal stock.
[16] U.S. Bureau of the Census, *Census of Agriculture 1959*, General Report, Vol. II.

remained rare. This is reflected in the relatively small role of swine production in Figure 3.

The chief exceptions to the generalized pattern of slow growth over the early 20th century were dairy and poultry raising. These activities steadily expanded, primarily to serve the state's rapidly growing urban markets. In 1993, California replaced Wisconsin as the nation's number one milk producer.[17] Between 1900 and 1960, the number of milk cows grew at a rate of 1.5 percent per annum and the number of chickens at a 3.3 percent rate. Output growth was even faster as productivity per animal unit expanded enormously, especially in the post-1940 period. From the 1920s, California was a leader in output per dairy cow. For example, in 1924 milk production per dairy cow in California was 5,870 lbs., while similar figures for Wisconsin and the U.S. were 5,280 and 4,167 lbs. respectively.[18] A similar pattern is found more recently. In 1994, California dairy cows produced an average of 20,258 lbs. of milk. The U.S. average was 16,128 lbs., while Wisconsin lagged behind with an average of 15,001 lbs.[19]

The post-1940 period also witnessed a dramatic revival of the state's cattle sector outside dairying. The number of non-milk cows in California increased from about 1.4 million head in 1940 (roughly the level prevailing since 1900) to 3.8 million in 1969. This growth was associated with a significant structural change that was pioneered in California and Arizona—the introduction of large-scale commercial feed-lot operations.[20] By 1953, large feed lots had emerged as an important feature of the California landscape, with over 92 percent of the cattle on feed in lots of a capacity of 1,000 or more head. Between 1953 and 1963, the number of cattle on feed in California and the capacity of the state's feed lots tripled. At the same time the average size of the lots soared. By 1963, almost 70 percent of the cattle on feed were in mega-lots of 10,000 or more head. A comparison with other areas provides perspective. In 1963, there were 613 feed lots in California with an average of about 3,100 head per lot. By contrast, Iowa had 45,000 feed lots with an average of less than 63 head per lot; Texas had 1,753 feed lots with an average of 511 head per lot. More generally, by the 1960s the size of cattle herds in California far exceeded the national average. Employment of state-of-the-art feed lots and modern science and veterinary medicine along with favorable climatic conditions allowed ranchers in California and Arizona to achieve significant efficiencies in converting feed to cattle weight. In the 1960s, larger commercial feed-lots started to become more prevalent in the Southwest and in the Corn Belt.[21] Thus, as in other cases, technologies developed in California spread to reshape agricultural practices in other regions.

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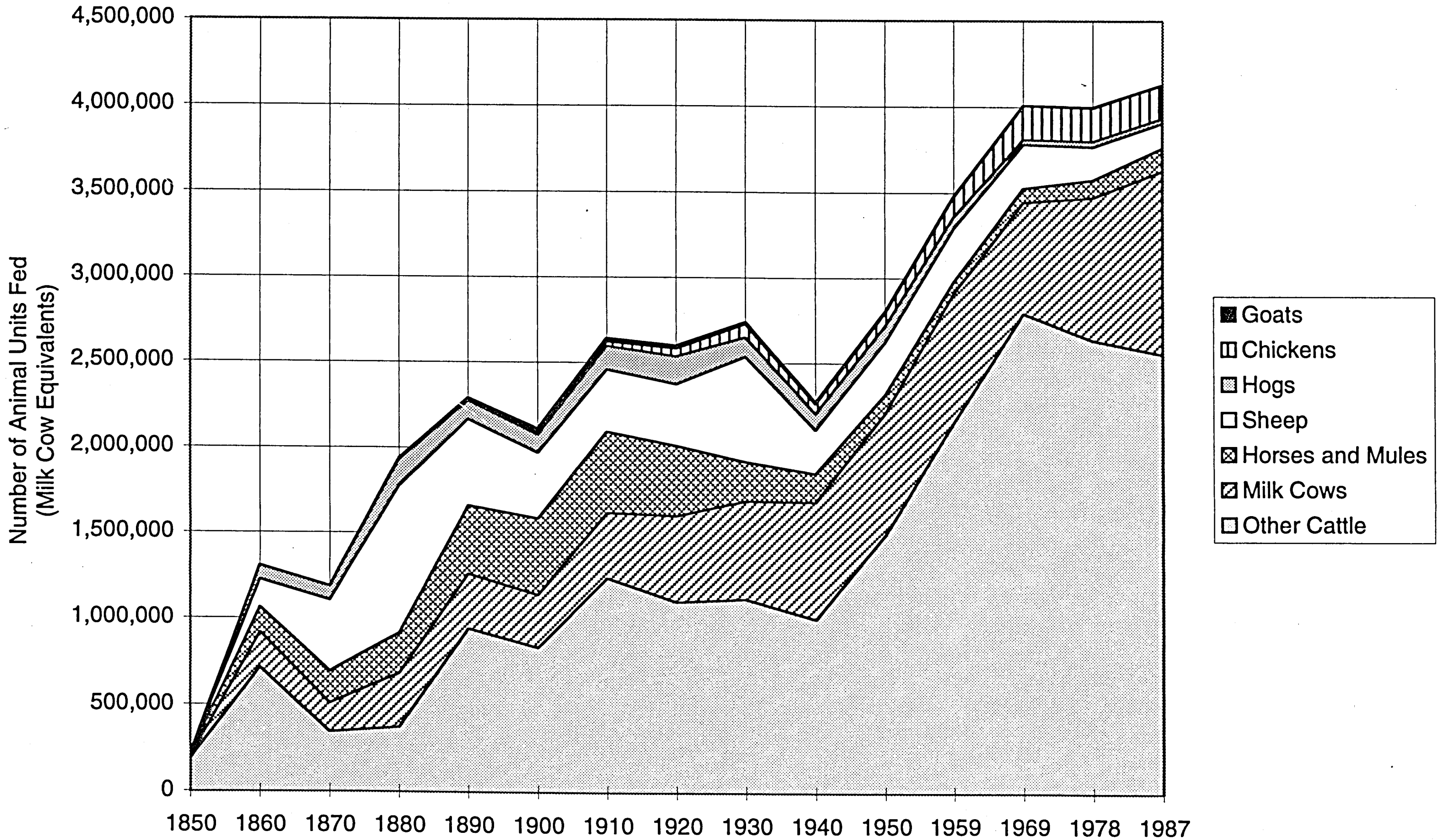
[17] U.S. Department of Agriculture, *Agricultural Statistics* ,1995.
[18] U.S. Department of Agriculture, *Statistics Bulletin 218*, 1957.
[19] U.S. Department of Agriculture, 1995. These data are preliminary.
[20] Committee on Agriculture, Nutrition, and Forestry, U.S. Senate, "Farm Structure: A Historical Perspective on Changes in the Number and Size of Farms," April 1980.
[21] Dr. John A. Hopkin and Dr. Robert C. Kramer, *Cattle Feeding in America*, Bank of America, San Francisco, February 1965.

Figure 3. California Livestock Inventories, 1850-1987.

Source: U.S. Bureau of the Census, Census of Agriculture, 1959 and 1987.



MECHANIZATION

A hallmark of California agriculture since the wheat era has been its highly mechanized farms. Nineteenth-century observers watched in awe as cumbersome steam tractors and giant combines worked their way across vast fields. In the twentieth century, California farmers led the nation in the adoption of gasoline tractors, mechanical cotton pickers, sugar beet harvesters, tomato harvesters, electric pumps, and dozens of less well-known machines.

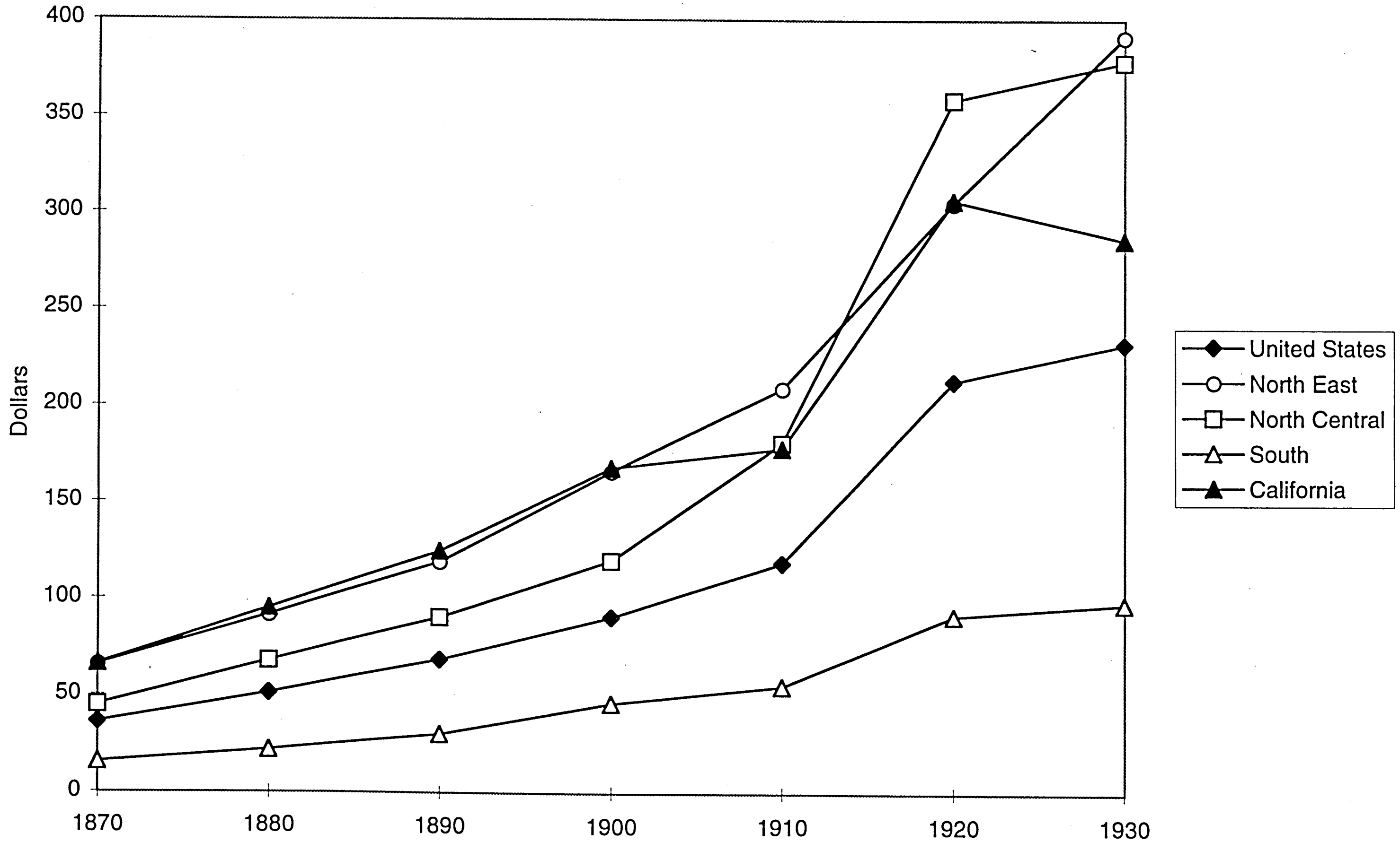
The story of agricultural mechanization in California illustrates the cumulative and reinforcing character of the invention and diffusion processes. Mechanization of one activity set in motion strong economic and cultural forces that encouraged further mechanization of other, sometimes quite different, activities. On-farm mechanization was closely tied to inventive efforts of local merchants. Specialized crops and growing conditions created demands for new types of equipment. Protected by high transportation costs from competition with large firms located in the Midwest, a local farm implement industry flourished by providing Pacific Coast farmers with equipment especially suited to their requirements. In many instances the inventors designed and perfected prototypes that later captured national and international markets. Grain combines, track-laying tractors, giant land planes, tomato pickers, and sugar beet harvesters, to name but a few, emerged from California's shops.

Several factors contributed to mechanization. In general, California farmers were more educated and more prosperous than farmers in many areas of the country. These advantages gave them the insight and financial wherewithal to support their penchant for tinkering. Nowhere was this more evident than on the bonanza ranches which often served as the design and testing grounds for harvester prototypes. The large scale of many California farms allowed growers to spread the fixed cost of expensive equipment. The scarcity of labor in California meant relatively high wage rates and periods of uncertain labor supply. The climate and terrain were also favorable. Extensive dry seasons allowed machines to work long hours in near-ideal conditions, and the flat Central Valley offered few obstacles to wheeled equipment. In the cases of small grains and cotton, mechanization was delayed in other regions of the country because free-standing moisture damaged the crops. Such problems were minimal in California. All things considered, the state's climatic and economic conditions were exceptionally conducive to mechanization.

As an index of the level of mechanization, Figure 4 shows the real value of implements per farm in California and other major regions. Over the years 1870 to 1930 the average value of implements per California farm was about double the national average. The new generation of farm equipment of the nineteenth century relied increasingly on horses and mules for power. Horses on any one farm were essentially a fixed asset. A stock of horses accumulated for a given task was potentially available at a relatively low variable cost to perform other tasks. Thus, once a farmer increased his pool of horses, he was more likely to adopt new power-intensive equipment. For these reasons, an examination of horses on California farms will yield important insights into the course of mechanization. In 1870 the average number of horses and mules on a California farm was almost three times the national average, and the number of horses and mules per male worker was more than twice the national average.

Figure 4. Real Value of Implements per Male Worker

Source: U.S. Bureau of the Census, Census of the United States, 1870 - 1930.



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Throughout the nineteenth century, California farmers were using an enormous amount of horsepower.[22]

California was a leader in the early adoption of tractors. By 1920, over 10 percent of California farms had tractors compared with 3.6 percent for the nation as a whole. In 1925, nearly one-fifth of California farms reported tractors, proportionally more than in Illinois or Iowa, and just behind the nation-leading Dakotas. These figures actually understate the power available in California, because the tractors adopted in the West were, on average, substantially larger than those found elsewhere.[23] In particular, western farmers were the predominant users of large track-laying tractors, which were invented in California. The state's farmers were also the nation's pioneers in the utilization of electric power. The world's first purported use of electricity for irrigation pumping took place in the Central Valley just before the turn of the century. Consistent data on rural electricity use are not available until 1929. At that time, over one-half of California farms purchased electric power compared with about one-tenth for the United States as a whole.[24] One of the best proxies for electrification is the number of agricultural pumps. Over the period 1910 to 1940, the state accounted for roughly 70 percent of all of the nation's agricultural pumps.[25]

The abundant supply of power on California farms encouraged local manufacturers to produce new types of equipment, and in turn, the development of new and larger implements often created the need for new sources of power. This process of responding to the opportunities and bottlenecks created by previous technological changes provided a continuing stimulation to innovation. Tracing the changes in wheat farming technology will illustrate how the cumulative technological changes led to a distinctly different path of mechanical development in the West as compared to that which occurred elsewhere.[26]

Almost immediately after wheat cultivation began in the state, its farmers developed a distinctive set of cultural practices. Plowing the fertile California soil was nothing like working the rocky soils in the East or the dense sod of the Midwest. In California, ranchers used two, four, and even eight-bottomed gang plows, cutting just a few inches deep. In the East, plowing one-and-one-half acres was a good day's work in 1880. In most of the prairie regions, two-and-one-half acres was the norm. In California, it was common for one man with a gang plow and a team of eight horses to complete six to ten acres per day. The tendency of California's farmers to use larger plows continued into the twentieth century. After tractors came on line, the state's farmers were also noted for using both larger models and larger equipment. This pattern influenced subsequent manufacturing and farming decisions.[27]

The preference for large plows in California stimulated local investors and manufacturers who vied to capture the specialized market. As evidence of the different focus of their innovative activity, the U.S. Agricultural Commissioner noted that "patents granted on wheel plows in 1869 to residents of California and Oregon

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[22] Alan L. Olmstead and Paul Rhode, 1988.
[23] U.S. Bureau of the Census, *Sixteenth Census of the United States: 1940,* Agriculture Vol. 1, Part 6.
[24] *Electrical Times* , January 2, 1948; U.S. Bureau of the Census, *Fifteenth Census of the United States: 1930,* Agriculture Vol. 11, Part 3.
[25] In the early period many of these pumps were driven by steam and internal combustion engines.
[26] For further development of these general themes, see Nathan Rosenberg, *Inside the Black Box: Technology and Economics*, Cambridge University Press, Cambridge, 1982.
[27] U.S. Bureau of the Census, *Tenth Census of the United States: 1880,* Agriculture Vol. 3; U.S. Department of Agriculture, *Monthly Crop Report*, 1918.

largely exceed in number those granted for inventions of a like character from all the other states of the Union."[28] Between 1859 and 1873 California accounted for one-quarter of the nation's patenting activity for multi-bottom plows. By way of contrast, the state's contribution to the development of small single-bottom plows was insignificant.[29] The experience with large plows directly contributed to important developments in the perfection and use of listers, harrows, levelers, and earth-moving equipment.

The adoption of distinctive labor-saving techniques carried over to grain sowing and harvest activities. An 1875 USDA survey showed that over one-half of midwestern farmers used grain drills, but that virtually all California farmers sowed their grain.[30] California farmers were sometimes accused of being slovenly for using sowing, a technique which was also common to the more backward American South. However, the use of broadcast sowers in California reflected a rational response to the state's own factor price environment, and bore little resemblance to the hand-sowing techniques practiced in the South. Among the broadcasting equipment used in California were advanced high-capacity endgate seeders of local design. By the 1880s improved models were capable of seeding up to 60 acres in one day. By contrast, a standard drill could seed about 15 acres per day and a man broadcasting by hand could seed roughly 7 acres per day.[31] The use of labor-saving techniques was most evident on the state's bonanza wheat ranches, where some farmers attached a broadcast sower to the back of a gang plow and then attached a harrow behind the sower, thereby accomplishing the plowing, sowing, and harrowing with a single operation.[32]

California wheat growers also followed a different technological path in their harvest operations by relying primarily on headers instead of reapers. This practice would have serious implications for the subsequent development of combines in California. The header cut only the top of the straw. The cut grain was then transported on a continuous apron to an accompanying wagon. Headers typically had larger cutting bars and, hence, greater capacity than reapers, but the most significant advantage was that headers eliminated the need for binding. The initial cost of the header was about 50 to 100 percent more than the reaper, but its real drawback was in humid areas where the grain was not dry enough to harvest unless it was dead ripe. This involved huge crop risks in the climate of the Midwest; risks that were virtually nonexistent in the dry California summers. For these reasons California became the only substantial market for the header technology.

The header technology evolved in an entirely different direction from the reaper, leading directly to the development in California of a commercial combined harvester. From the starting point of the header, it was quite simple and natural to add a thresher pulled along its side. There had been numerous attempts in the East and Midwest to perfect a machine that reaped and threshed in one operation. Among those which

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[28] U.S. Department of Agriculture, *Agricultural Report*, 1869.
[29] U.S. Patent Office, *Subject-matter Index of Patents for Inventions Issued by the United States Patent Office from 1790 to 1873, inclusive*, Government Printing Office, Washington, D.C., 1974.
[30] U.S. Department of Agriculture, *Agricultural Report*, 1875.
[31] Leo Rogin, *The Introduction of Farm Machinery in its Relation to the Productivity of Labor in the Agriculture of the United States During the Nineteenth Century*, University of California Publications in Economics, Vol. 9, University of California Press, Berkeley, 1931; R.L. Adams, *Farm Management Notes for California*, UC Associated Students' Store, Berkeley, 1921.
[32] For example, Reynold Wik, *The Mechanization of Agriculture and the Grain Trade in the Great Central Valley of California*, Pioneer Museum Project Grant Proposal, 1974. A copy is held in the F. Hal Higgins Library of Agricultural Technology at UC Davis; Rogin, 1931.

came closest to succeeding was Hiram Moore's combine built in Kalamazoo, Michigan, in 1835. But in the humid Midwest, combining suffered from the same problems with moisture that had plagued heading. In 1853 Moore's invention was given new life when a model was sent to California, where it served as a prototype for combine development.[33] After several decades of experimentation in California, workable designs were available by the mid-1880s and the period of large-scale production and adoption began. Most of the innovating firms, including the two leading enterprises—the Stockton Combined Harvester and Agricultural Works and the Holt Company—were located in Stockton.

During the harvest of 1880 "comparatively few" machines operated in California, and agricultural authorities, such as Brewer and Hilgard, clearly suggest that even those machines should be considered as experimental. In 1881 about 20 combines were being built in Stockton.[34] By 1888, between 500 and 600 were in use. The first truly popular model was the Houser, built by the Stockton Combined Harvester and Agricultural Works. In 1889, its advertisements claimed that there were 500 Houser machines in use, and that they outnumbered all of the competitors put together.[35] Soon thereafter, the Houser was overtaken by machines in the Holt line. The innovative products of the Holt company, which included in 1893 the first successful hillside combine, became dominant on the West Coast. By 1915 Holt's advertisements boasted that over 90 percent of California's wheat crop was harvested by the 3,000 Holt combines in the state.[36] It is important to recognize that the adoption of combine-harvesters east of the Rockies was only in its infancy at this date.

Combine models that eventually were adopted in the Midwest and Great Plains were considerably smaller than West Coast machines. The primary reasons for the differences were undoubtedly cost and scale considerations, but the prejudice in the East that large teams of horses were unworkable and the lack of practice probably played important roles.[37] In California the opposite attitudes were said to prevail. The *Pacific Rural Press* boasted "(i)f one man could drive all the mules in the State it would be the acme from one point of view."[38] California farmers had gradually developed their ability to manage large teams as a result of their experience with gang plows and headers.[39]

The difficulties associated with controlling large teams induced Holt and others to perfect huge steam tractors to pull their even larger harvesters. While steam-driven combines never came into vogue, these innovative efforts did have one highly important by-product—the track-laying tractor. The first practical track-laying farm tractors (identified with Holt's first test in 1904) were initially developed to operate on the soft soil of the Sacramento-San Joaquin Delta.[40] Although the crawlers were first designed to solve a local problem, this innovation was of global significance. The Caterpillar Tractor Company (formed by the merger of the Holt and Best enterprises)

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[33] F. Hal Higgins, "John M. Horner and the Development of the Combine Harvester," *Agricultural History*, Vol. 32, 1958; *Farm Implement News*, 1888.
[34] U.S. Bureau of the Census, 1883.
[35] Rogin, 1931; William H. Brewer, "Cereal Report," U.S. Census of 1880, *Agriculture*, Vol. 3, 1883.
[36] *Economist*, Nov. 28, 1914.
[37] Alan L. Olmstead and Paul W. Rhode, "The Agricultural Mechanization Controversy of the Interwar Years," *Agricultural History*, Vol. 68, No. 3, Summer 1994.
[38] Wesley Buchele and Graeme Quick, *The Grain Harvesters*, American Society of Agricultural Engineers, St. Joseph, 1978.
[39] Olmstead and Rhode, 1983.
[40] Caterpillar Tractor Company, *Fifty Years on Tracks,* Caterpillar Tractor Co., Peoria, Illinois, 1954.

would build larger, more powerful equipment that rapidly spread throughout the world.

The reoccurring pattern of one invention creating new needs and opportunities that led to yet another invention offers important lessons for understanding the lack of development in other times and places. The key to explaining the progression of innovations in California was the close link between manufacturers and farmers that facilitated constant feedback between the two groups and the keen competition among producers that spurred inventive activity. Entrepreneurs seeking their fortunes were in close tune with their potential customers' needs and vied with one another to perfect equipment that would satisfy those needs. Where these forces were not at work, the burdens of history severed the potential backward linkages that are so critical for economic development.

IRRIGATION

Just as there were major investments in mechanical technologies to increase the productivity of labor, there were also substantial investments to increase the productivity of California's land. These included agro-chemical research, biological learning concerning appropriate crops and cultural practices, and land clearing and preparation, but the most notable were investments in water control and provision. These took two related forms. The first consisted of measures primarily intended to drain and protect agricultural land. In this realm, Californians literally re-shaped their landscape as individual farms leveled the fields and constructed thousands of miles of ditches. In addition, individual farms, reclamation districts, and the Army Corps of Engineers built several thousand miles of major levees to tame the state's inland waterways.

The second form consisted of a variety of measures to supply the state's farms with irrigation water. Table 1 details the growth in the state's irrigated acreage between 1890 and 1987. Expansion occurred in two main waves: the first lasting from 1900 through the 1920s and the second, linked to the Central Valley Project, during the decade after World War II. Much of the historical growth of irrigation was the result of small-scale private initiatives rather than large-scale public projects that have attracted so much scholarly attention. Up until the 1960s, individuals and partnerships were the leading forms of organization supplying irrigation water. These forms accounted for roughly one-third of irrigated acres between 1910 and 1930, and over one-half by 1950.

These small-scale irrigation efforts were closely associated with the rising use of groundwater in California over the first half of the twentieth century. Between 1902 and 1950, the acreage irrigated by groundwater sources increased more than thirty-fold, whereas that watered by surface sources only tripled. Groundwater, which had supplied less than 10 percent of irrigated acreage in 1902, accounted for over 50 percent of the acreage by 1950. This great expansion was reflected in the growing stock of pumping equipment in the state. Underlying this growth were significant technological changes in pumping technology and declining power costs. During the 1910s and 1920s, the number of pumps, pumping plants, and pumped wells doubled each decade, rising from roughly 10,000 units in 1910 to just below 50,000 units in 1930. Pumping capacity increased two-and-one-half to three times per decade over this period. Expansion stalled during the Great Depression, but resumed in the 1940s with the number of pumps, plants, and wells rising to roughly 75,000 units by 1950. Individuals and partnerships dominated pumping, accounting for about 95 percent of total units and approximately 80 percent of capacity over the 1920–50 period.[41]

Since the 1950s, there has been a shift away from individuals and partnerships, as well as groundwater sources. By the 1970s, irrigation districts—public corporations run by local landowners and empowered to tax and issue bonds to purchase or construct, maintain, and operate irrigation works—had become the leading suppliers. The district organization rapidly rose in importance over two periods. In the first, lasting from 1910 to 1930, acreage supplied by irrigation districts increased from one-in-fifteen to approximately one-in-three. Much of this growth came at the expense of cooperative and commercial irrigation enterprises. Between 1930 and 1960, the district share changed little. During the 1960s, the district form experienced a second surge growth, which was due in part to the rising importance of large-scale federal and state projects, which distributed water through these organizations. By 1969, irrigation districts supplied more than 55 percent of all irrigated acreage.

LABOR

Few issues have invoked more controversy in California than recurrent problems associated with agricultural labor. Steinbeck's portrayal of the clash of cultures in *The Grapes of Wrath* represents the tip of a very large iceberg. The Chinese Exclusion Act, the Gentlemen's Agreement aimed at Japanese immigrants, the repatriation of Mexicans during the Great Depression, the Great Cotton Strikes of 1933, 1938, and 1939, the Bracero Program of the 1940s, '50s, and '60s, the UFW and Teamsters organizing campaigns and national boycotts, the state's Agricultural Relations Act, the legal controversy over the mechanization of the tomato harvest, and the current battles over illegal immigration are all part of a reoccurring pattern of turmoil deeply rooted in California's agricultural labor market. There are few if any parallels in other northern states; clearly, the history of agricultural labor in California is very different.

For all the controversy, however, the state's farms have remained a beacon attracting large voluntary movements of workers seeking opportunity. Chinese, Japanese, Sikhs, Filipinos, Southern Europeans, Mexicans, Okies, and then Mexicans again have all taken a turn in California's fields. Each group has its own story, but in the space allotted here we attempt to provide an aggregate perspective on some of the

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[41] Data on pump type are more limited. They show a rise of the turbine, which was used exclusively for well pumping, relative to the centrifugal, rotary, and plunger types. The turbine's share increased from 33 percent in 1930 to 62 percent in 1940. Associated with the 1910–30 expansion was a transition from steam and internal combustion engines to electric motors. In 1910, internal combustion engines comprised about 67 percent of pumping capacity, electric motors 17 percent, and steam engines 11 percent. Over the next twenty years, the relative roles shifted; in 1930, electric motors accounted for 84 percent, internal combustion engines 11 percent, and combinations of the electric and internal combustion methods an additional four percent. By 1950, electric motors made up 92 percent of the total capacity.

distinguishing characteristics of California's volatile agricultural labor market. The essential characteristics of today's labor market date back to the beginning of the American period.

Table 3 offers a view of the role of hired labor in California compared to the nation as a whole. Expenditures on hired labor relative to farm production and sales have generally been two to three times higher in California than for the U.S. Within California the trend shows some decline. Another important perspective is to assess the importance of agricultural employment in the economy's total labor force. Here the evidence is somewhat surprising. Both agriculture and agricultural labor play a relatively prominent role in most renderings of the state's history. But as Table 3 indicates, agricultural employment in California has generally been less important to the state than for the country. Clearly, it is the special nature of the state's labor institutions, not their overall importance in the economy, that warrants our attention.

Table 3. A Comparison of the Agricultural Labor Market in California and the United States.

	Farm Labor Force as a Share of the Total Labor Force		Hired Labor Expenditures as a Share of: Gross Value of Farm Production		Market Value of Farm Products Sold	
	Calif	*U.S.*	*Calif*	*U.S.*	*Calif*	*U.S.*
	percent					
1870	29.3	52.3	20.8	12.7	--	--
1880	28.6	49.4	--	--	--	--
1890	29.0	41.2	--	--	--	--
1900	25.0	37.6	19.6	7.6	--	--
1910	17.9	31.1	22.2	7.7	--	--
1920	17.3	27.0	16.4	6.3	--	--
1930	13.3	21.4	--	--	21.4	9.9
1940	11.0	18.9	--	--	25.3	11.7
1950	7.5	12.3	--	--	21.8	11.0
1960	4.7	6.7	--	--	17.7	8.5
1970	3.0	3.5	--	--	16.2	7.4
1980	2.9	3.0	--	--	14.7	6.4
1990	3.0	2.5	--	--	17.1	8.0

Sources:
Margaret Gordon, *Employment Expansion and Population Growth*, UC Press, Berkeley, 1954.
U.S. Bureau of the Census: *Compendium of the Ninth Census 1870*; *Twelfth Census 1900*, Agriculture; *Fourteenth Census 1920*, Agriculture, Vol. 5; *Census of Agriculture 1959*, California, Vol. 1, Part 48; *Census of Agriculture 1987*, California, Vol. 1, Part 5 and U.S. Summary and State Data, Part 51; *1980 Census Population*, Vol. 1.
U.S. Dept. of Commerce, *Regional Employment by Industry, 1940–1970.*

From the beginning of the American period, California farms have relied more extensively on hired labor than their counterparts in the East. At the same time

Californians never developed the institutions of slavery or widespread share-cropping as did their counterparts in the South. The parade of migrants who have toiled in California's fields have often been described as "cheap labor." But this appellation is something of a misnomer, because the daily wage rate in California was typically substantially higher than in other regions of the U.S., one of the world's highest wage countries.[42] In an important sense the "cheap labor" in California agriculture was among the dearest wage labor on the globe.[43] In addition, one of the remarkable features of California agriculture is that the so-called "development" or "sectoral-productivity" gap—the ratio of income per worker in agriculture to income per worker outside agriculture—has traditionally been relatively narrow.[44] This finding in part reflects the relatively high productivity of the state's agricultural sector. It also reflects demographic factors. Due to low rates of natural increase, California's farm sector never generated a large home-born surplus population putting downward pressure on rural living standards. Instead, the sector attracted migrants from the surplus populations of other regions. For these migrant groups, agricultural labor was an entry point into a generally robust and dynamic economy. To a significant extent, past cohorts or their descendants, through hard work and high savings rates, have managed to advance up the occupational ladder. Over the long run of California's history, agricultural labor has not been a dead-end pursuit creating a permanent class of peasant laborers.

Economic historians often explain the prevalence of the family farm in the northern United States by the working of the Domar model—if there is free land and a crop production technology offering little economies of scale and requiring little capital, then anyone can earn as much working for themselves as for anyone else. There will be no free hired labor, and if bound labor (slavery) is illegal, no farm will be above a family's scale. Like many simple abstract models, the implications of the Domar hypothesis are starker than the realities. But its fundamental logic is thought to explain many central features of the development of northern agriculture.

California's so-called "exceptionalism" also follows from the Domar model. In this state, production tended to involve larger scale and greater quantities of capital (for machinery, irrigation works, and orchards). In addition, due to the environment and the "initial" distribution of property rights, land (especially land with good access to water) was not free in California. Hence, the assumptions of the Domar model were violated. It proved possible for farmers to pay workers more than they could earn working for themselves and still earn a profit. From the mid-nineteenth century on, California was characterized by "factories in the fields" or "industrial agriculture" or, in more modern terms, "agribusiness." But it is important to note that agriculture based on profit-oriented commodity production employing a substantial amount of hired labor was a widespread phenomenon in the period, and by no means limited to California. This organizational form was common to the agriculture of many capitalist countries (i.e., Britain, Germany) in the late-nineteenth century, and it has arguably become increasingly common throughout the United States over the twentieth century. From a

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[42] The available statistics suggest that circa 1900–10, Asian workers in California were paid within 10–15 percent of the wage of white workers.

[43] Almost surely, if more migration of non-white population was permitted in the late nineteenth century, the state could have attracted more labor.

[44] The "development" gap is measured as (Yag/Lag)/(100-Yag/11-Lag) where Yag is the share of income generated in the agricultural sector and Lag is the share of the labor force employed there.

global historical perspective, the stereotypical midwestern commercially-oriented family farm employing little or no hired labor is probably a greater exception than what prevailed in California.

COOPERATIVES

California agriculture was uncommonly successful with collective action. By the 1930s, the state's farmers supported a powerful Farm Bureau, organized labor recruitment programs, numerous water cooperatives and irrigation districts, and a vast agricultural research establishment. Here we will focus on the state's experience with cooperatives designated to provide farmers with an element of control over the increasingly important marketing, middleman, and input supply functions. One of the most notable was the California Fruit Growers Exchange organized in 1905. By 1910 it marketed 60 percent of the citrus shipped from California and Arizona under its Sunkist label; in 1918 it marketed 76 percent of all shipments, and for most years between 1918 and 1960 Sunkist accounted for over 70 percent of citrus shipments.[45] The Exchange also entered the farm supply business through its subsidiary, the Fruit Growers Supply Company. In the late 1920s it was purchasing for its members $10,000,000 a year worth of nails, tissue wraps, fertilizer, orchard heaters, box labels, orchard stock and the like. The company also controlled 70,000 acres of California timber land and manufactured huge quantities of boxes.[46]

Other co-ops emerged catering to California's specialized producers. After more than 20 years of unsuccessful experiments, raisin growers banded together in the California Associated Raisin Company (CARC) in 1911. Between 1913 and 1922 the CARC handled between 87 percent and 92 percent of the California raisin crop, successfully driving up prices and members' incomes. But success brought Federal Trade Commission investigations and an anti-trust suit, which the CARC lost in 1922. In 1923 CARC was reorganized into Sun Maid Raisin Growers of California. Although that brand name still survives, the co-op was never again as successful as it was in its first decade.

Co-ops potentially offered their members several services. First, they could help counteract the local monopoly power of railroads, elevators, packers, banks, fertilizer companies and the like by collectively bargaining for their members; or as in the case of the California Fruit Growers Exchange, the co-op could enter into the production of key inputs and offer its own warehouses, elevators, and marketing services. Several co-ops representing various specialized crops have developed very successful marketing campaigns that have significantly increased consumer awareness and consumption.

While perhaps providing countervailing power, overcoming market imperfections on the output side, many co-ops strove to introduce their own imperfections by cartelizing the markets for agricultural goods. A leader in this movement was a dynamic lawyer, Aaron Sapiro, who had worked with several of California's co-ops in

[45] Kelsey B. Gardner and Irwin W. Rust, *Sunkist Growers, Inc.: A California Adventure in Agricultural Cooperation*, USDA, Farmer Cooperative Service, Circular 27, 1960.
[46] Cleland and Hardy, 1929; Elizabeth Hoffman and Gary D. Libecap, "Institutional Choice and the Development of U.S. Agricultural Policies in the 1920s," *Journal of Economic History*, Vol. 51, No. 2, June 1991.

the early twentieth century. His plan was to convince farmers to sign legally binding contracts to sell all of their output to the co-op for several (typically five) years. If a high percentage of producers in fact signed and abided by such contracts, then the co-op could act as a monopolist limiting supply and increasing prices. Since the demand for agricultural products is generally thought to be highly inelastic, farm income would rise. The surpluses withheld from the market would either be destroyed or dumped onto the world market. The co-op could also help increase demand by advertising and developing new markets.

The whole scheme depended on: (1) avoiding federal anti-trust actions like that which hit the raisin growers between 1919 and 1922; (2) preventing foreign producers from importing into the high priced American market; and (3) overcoming the free-rider problem. Even if these problems could be solved in the short-run, the longer-run problems of controlling supply in the face of technological change and increasing productivity in other countries would still exist.

The first two problems were fairly easily dealt with. The cooperative movement received federal encouragement in the form of highly favorable tax treatment and considerable exemption from anti-trust prosecution with the passage of the Capper-Volstead Act in 1922. Subsequently, the Cooperative Marketing Act of 1926 and the Agricultural Marketing Act of 1929 further assisted the cooperative movement by helping to gather market information (that was useful in limiting production and generating new market outlets), and by helping co-ops enforce production and marketing rules. In addition, the 1929 Act provided up to $500 million through the Federal Farm Board to loan to cooperatives so they could buy and store commodities to hold them off the market.

The federal government also provided a shot in the arm to the cooperative movement through a series of tariff acts that separated the domestic and foreign markets. The tariffs were in large part endogenous because co-op leaders and California legislators lobbied furiously for protection. But overcoming the "free rider" problem was a harder nut to crack. Every farmer benefited from the co-op's ability to cut output, and every farmer would maximize by selling more. There was thus a tremendous incentive to cheat on the cartel agreements or to not sign up in the first place. The early California fruit co-ops were successful in large part because they dealt with crops grown in a fairly small geo-climatic zone for which California was the major producer. Many growers were already members of cooperative irrigation districts and thus linked by a common bond. These factors made it much easier to organize and police the growers, and it reduced the chance that higher prices would immediately lead to new entrants who would, in a short time, drive the price level down. The fact that most output was exported out of the state via relatively few rail lines also made monitoring easier. If California raisin prices increased, it was not likely that Minnesota farmers would enter the grape market; but if Kansas wheat farmers banded together to limit their output, farmers in a dozen states would gladly pick up the slack. For these reasons the success of cooperatives in California was seldom matched elsewhere in the United States.

CONCLUSION

This essay has necessarily been cursory, neglecting many important crops and activities.[47] Nevertheless, it should provide a historical context for other chapters in this volume. Responding to market forces, the state has witnessed numerous transformations in cropping patterns, labor sources, and technologies. Among these changes, however, many fundamental characteristics have endured; many of the institutional and structural features found today have deep roots in the state's past.

In closing, we would like to comment on two issues of interest in the literature of agricultural development. First, the history of agricultural mechanization in California appears to conform nicely with the familiar predictions of the induced innovation model: mechanization represented a rational response by the state's farmers and mechanics to factor scarcities and the state's particular environmental conditions. But to fully capture the reality of the state's development, it is useful to supplement the induced innovation model with three additional insights: the importance of path dependency (whereby early investment decisions paved the way for subsequent developments); the importance of learning by doing; and the close, ongoing interactions between farmers and inventor-manufacturers.

Secondly, California's history does not conform to the standard paradigm that treats biological productivity changes as primarily a post-1930 phenomenon in American agriculture. The settlement process, the worldwide search for appropriate crops and cultural practices, the wholesale shift in crop mixes, and the massive investments in water control and irrigation, along with numerous other measures, are fundamentally stories of biological investment in a labor-scarce, land-abundant environment. These biological investments transformed the state's agriculture, vastly increasing productivity per acre.[48]

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[47] More so than most states, California's agricultural economy is really many economies. The grape and wine industries, the specialized citrus economy, the growers of vegetables, and many others have stories of their own that deserve detailed analysis. In a similar vein, our treatment of mechanization represents only a fraction of the more general category of science, technology, and productivity change.
[48] Alan L. Olmstead and Paul Rhode, "Induced Innovation in American Agriculture: A Reconsideration," *Journal of Political Economy*, Vol. 101, No. 1, 1993.

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Chapter 2

THE MEASURE OF CALIFORNIA AGRICULTURE: ITS SIGNIFICANCE IN THE STATE ECONOMY

Harold O. Carter and George Goldman

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California truly is unique among the world's major agricultural regions, notable for its high level of efficiency, innovativeness, size, and diversity. More than 250 crops are produced by its almost 78,000 farms, on almost 7.8 million acres of harvested cropland. Among the strengths of California's agriculture is its extremely high level of productivity. The state produces an abundance of products, including more than half the nation's output of fruits, nuts, and vegetables, on only 3 percent of U.S. farmland.

California's agriculture has been graced with a favorable climate, generally adequate water supplies, and fertile soils. To these natural resources farmers have added sophisticated technology and management systems, which allow them to produce and market superior agricultural products. Enormous agricultural advancements in this century have brought about the current strength, diversity, and depth of the food and fiber sector today.

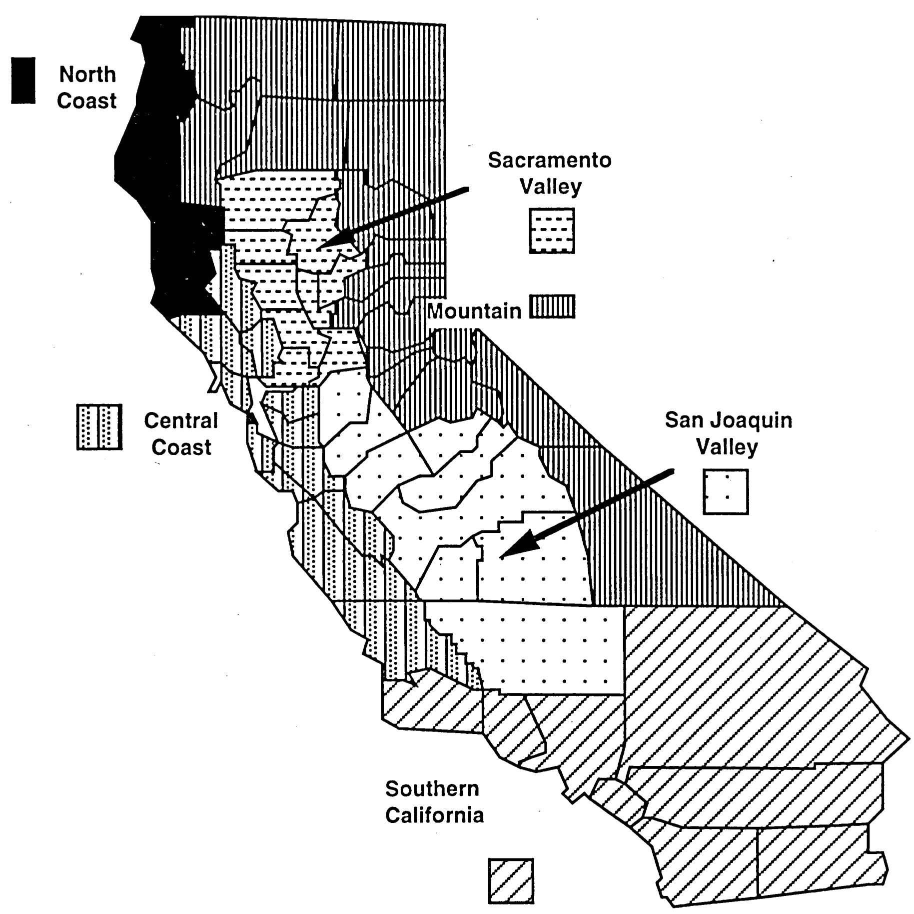
Despite the remarkable achievements of this advanced food, fiber and floriculture system, made possible by a combination of climate, resources, available capital, and dedicated agriculturists, California agriculture today faces great challenges. Maintaining productivity in the face of rapid population growth, mounting competition for global markets, and increasingly threatened natural resources all pose threats to the sustainability of agricultural production in the decades ahead.

FARMS AND FARMER CHARACTERISTICS

PRODUCTION REGIONS

California can be divided into six production regions. Southern California and the San Joaquin Valley, the two leading agricultural areas in the state and in the nation, produce an astonishing array of fruit, vegetable, livestock and dairy products plus most of California's cotton crop. Agriculture also plays a key role in the Central Coast and Sacramento Valley regions, known for high-value horticultural and vegetable crops, tree fruits, wine grapes, nuts, and rice. The North Coast and Mountain regions are home to California's vast rangeland resources.

Figure 1. Production Regions of California.



HOW THE LAND IS USED

Farms and ranches stretch across almost 29 million acres in California—29 percent of the entire state. Almost 16.2 million acres or about 56 percent of agricultural land is classified as pasture and rangeland, while cropland accounts for 10.47 million acres or 36.2 percent of total land in farms and ranches. The remaining acreage is about evenly shared by woodland (including woodland pasture) and other land (houses and barns, lots, ponds, roads, and wasteland).

Beyond its huge expanses of pasture and rangeland, California has millions of acres of highly productive cropland, much of it in the fertile Central Valley. In recent decades, however, land use has shifted in the state as illustrated in Table 1. Since 1982, farmland in pasture and range has dropped by over 2 million acres, cash grains have fallen by 920,000 acres, while vegetable, melon, fruit, and nut acreage has increased by more than 200,000 acres. The shift illustrates a long-term trend away from extensive agricultural crops, with more emphasis on intensive, high-value fruit, vegetable and nut crops.

Table 1. California Agricultural Land Use by Category, 1982–1992.

Category	----------------Acreage by Census Year----------------		
	1982	1987	1992
	------------------- *in thousands* ---------------------		
Harvested Cropland	8,765	7,676	7,761
Cash Grains	2,484	1,445	1,564
Vegetables and Melons	895	883	1,017
Fruit and Nuts	2,172	2,172	2,261
Horticultural Products	59	67	72
Other Field Crops*	3,298	3,470	3,449
Pasture and Range**	20,269	19,257	18,104
Other Land in Farms***	3,123	3,665	4,341

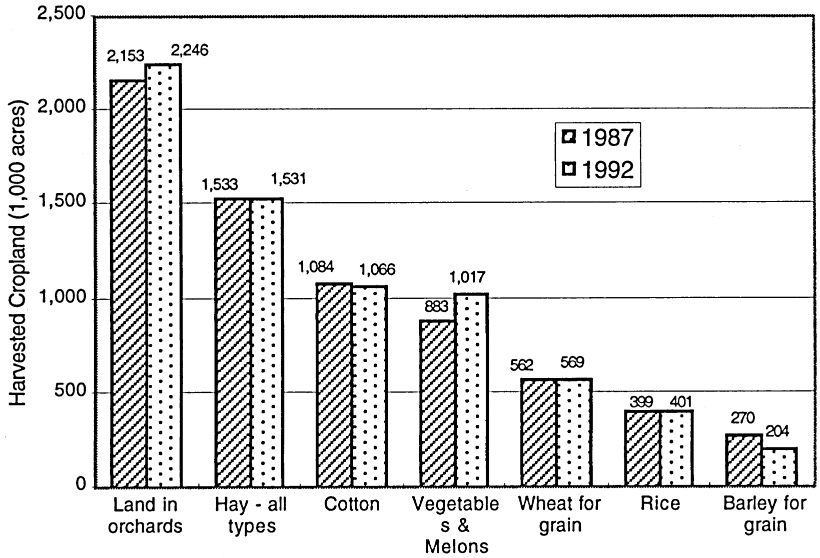
* Cotton, Dry Beans, Sugar Beets, Potatoes, Hay and Silage, Seed Crops, etc.

** Includes pasture and rangeland, cropland use only for pasture or grazing and woodland pastured. Pasture and rangeland acreage unavailable for 1969 and 1974, so proportionally estimated from cropland pastured/grazed and "other land."

*** Unharvested cropland, woodland not pastured, lots, roads, waste, etc. Categories may exceed total for "All land in farms" due to double cropping, etc.

Source: U.S. Department of Commerce. Bureau of the Census, Census of Agriculture for indicated years.

Figure 2. California Harvested Cropland by Category, 1987 and 1992.



Source: U.S. Bureau of the Census, Census of Agriculture, California, 1987 and 1992.

DIVERSITY

California agriculture stands out not just for its size and productivity but also because of its great diversity. Of a myriad of farm products, each makes a sizable individual economic contribution. In fact, in 1994 thirteen of California's top 20 commodities were also ranked No. 1 nationally for their production value. At the same time, no one crop dominates the state's farm economy; only one—milk and cream—exceeds 10 percent of total gross farm sales.

VALUE OF CROPS

Focus on High-Value

California agriculture is characterized by high-value cash crops that use advanced levels of technology, capital, and management. The nation's leader in production of many fruit and nut crops, California is also the exclusive supplier of many crops, including almonds, clingstone peaches, dates, figs, kiwifruit, olives, pistachios, pomegranates, prunes, raisins, and walnuts. The state earns the title of America's salad bowl as well: California harvested almost half (by value) of the nation's market and processing vegetables in 1993. Vegetable production has climbed by 75 percent since 1980 (1980–1993), helped along by increasing demand and trends in input costs that encourage producers to switch from grains to fruits and vegetables.

High per-acre yields partially explain California's consistently high cash receipts. The state exceeds the national average in yields per harvested acre for major crops like lettuce and rice, and more than doubles per-acre yields of cotton. Cotton brought California producers 1,340 pounds per harvested acre in 1993 compared to 601 pounds an acre in the U.S.; strawberries yielded 455 hundred weight (cwt) an acre in the Golden State while growers nationwide harvested 276 cwt an acre. California farmers have also dramatically increased their own yields for most crops over the last decade and a half.

Table 2. California's Vegetable Production for Selected Fresh and Processing Markets, 1993.

	Fresh	Processed
All Vegetables	9,151,150	9,090,550
Asparagus	n/a	n/a
Broccoli	391,230	57,000
Carrots	698,544	100,000
Cauliflowers	n/a	n/a
Tomatoes	459,270	8,951,580

Note: 1,000 CWT = 45.36 tons.

*1993 are preliminary figures.

Source: USDA, Agricultural Statistics, 1983, 1988, 1990, 1993, 1994.

Table 3. Yield per Harvested Acre, Representative Crops, U.S. and California, 1979, 1992 and 1993.

	--1979--		--1992--		--1993*--	
Crop/Units	U.S.	California	U.S.	California	U.S.	California
Corn for grain (bushels)	110	117	131	165	101	165
Cotton, upland (1,000 pounds)	547	1,000	694	1,359	601	1,340
Lettuce, summer (hundredweight)	249	278	329	346	326	360
Rice, medium grain (pounds)	5,397	6,600	6,778	8,540	6,575	8,320
Strawberries (hundredweight)	176	410	265	430	276	455
Sugar Beets (tons)	20	27	21	28	19	26
Tomatoes, processing (tons)	24	25	32	33	31	33
Wheat, winter (bushels)	37	70	38	72	40	77

*1993 are preliminary statistics from USDA Agricultural Statistics 1994.

Source: USDA, Agricultural Statistics, 1982, 1990, 1993 and 1994.

Growing Share of U.S. Cash Receipts

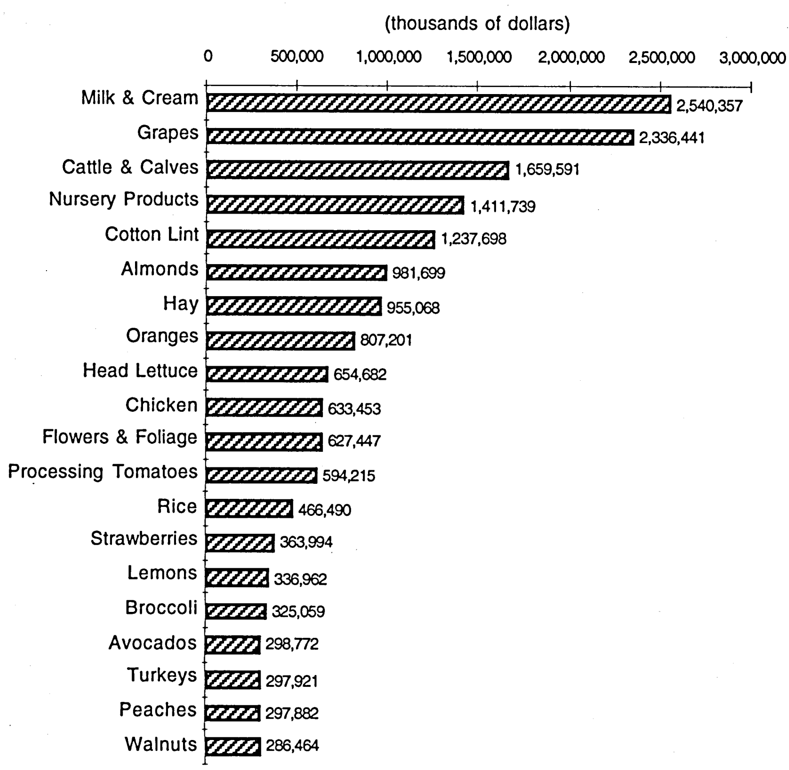
California's slice of U.S. cash receipts from farming has grown over the past three decades, from 9.3 percent of U.S. farm marketings in 1960 to 11.3 percent in 1994. The most recent numbers represent over $20 billion recorded by the state's farmers, an all-time high. California continues to out-produce other agricultural states by a wide margin. 1994 marked the 47th consecutive year the state's farmers led the nation in agricultural production.

Table 4. Cash Receipts from Farm Marketings, U.S. and California, Selected Years, 1960–1994.

Year	Cash receipts from farm marketings		Calif. as a percentage of U.S.	Government payments		Calif. cash receipts including government payments as percentage of U.S. receipts
	U.S.	California		U.S.	California	
	--million dollars--		*percent*	*--million dollars--*		*percent*
1960	34,014	3,165	9.3	693	22	9.2
1965	39,187	3,710	9.5	2,452	41	9.0
1970	49,231	4,456	9.1	3,717	132	8.7
1975	88,209	8,497	9.6	807	16	9.6
1980	136,431	13,539	9.9	1,286	14	9.8
1985	142,103	13,970	9.8	7,704	302	9.5
1989	159,173	17,515	11.0	10,887	372	10.5
1990	169,987	18,859	11.1	9,298	252	10.6
1991	168,795	17,806	10.5	8,214	261	10.2
1992	171,168	18,234	10.7	9,169	430	10.3
1993	175,052	19,850	11.3	13,402	522	10.8
1994	179,669	20,238	11.3	7,881	273	10.9

Source: USDA, Economic Research, Computer file.

Figure 3. Ranking and Value, 20 Leading Farm Products, California, 1994.

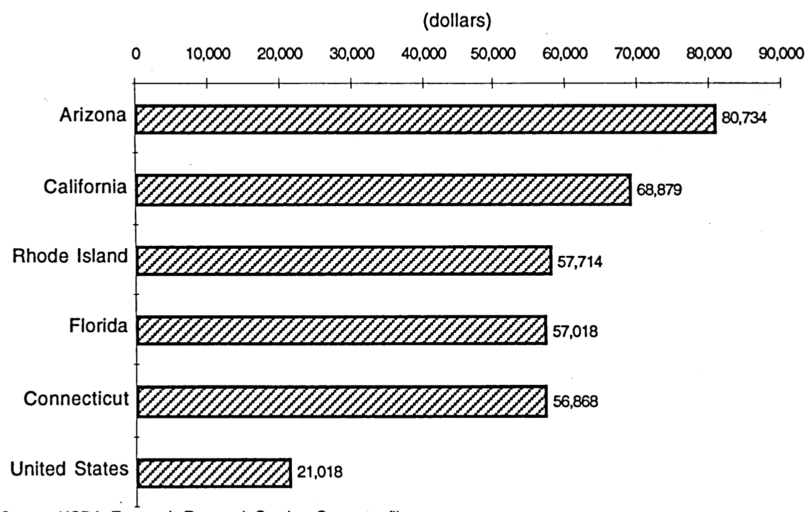


Source: CDFA, CASS, County Agricultural Commisioners' Reports, 1992, 1993 and 1994, in computer file.

Leading Commodities

California's top producers in gross sales value—dairy products, grapes, cattle and calves, and nursery products, and cotton—each exceed $1 billion. Lettuce was California's largest vegetable commodity in terms of value, representing 21 percent of 1994 total vegetable production, followed by processing tomatoes at 15 percent.

Figure 4. Average Net Farm Income per Operation, 1993.



Source: USDA, Economic Research Service, Computer file.

Table 5. Top Five State Rankings for Net Farm Income: Total and Per Farming Operation, 1993.

	Net Farm Income		Farm Income per Operation	
1993 Rank	State	Million Dollars	State	Dollars
1	California	5,235	Arizona	80,734
2	Texas	4,098	California	68,879
3	North Carolina	2,490	Rhode Island	57,714
4	Florida	2,224	Florida	57,018
5	Nebraska	2,092	Connecticut	56,868
	United States	43,401	United States	21,018

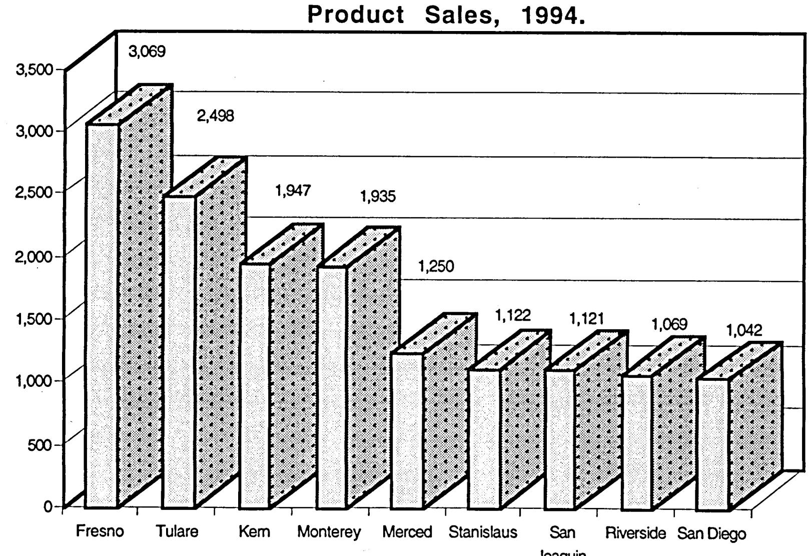
Source: USDA, Economic Research Service. Computer file.

Leading Agricultural Counties

Nine California counties report at least $1 billion in farm-product sales; six of these belong to the agriculturally rich San Joaquin Valley and two to Southern California. Agricultural muscle is not limited to these regions; 33 California counties have an agricultural output greater than $100 million.

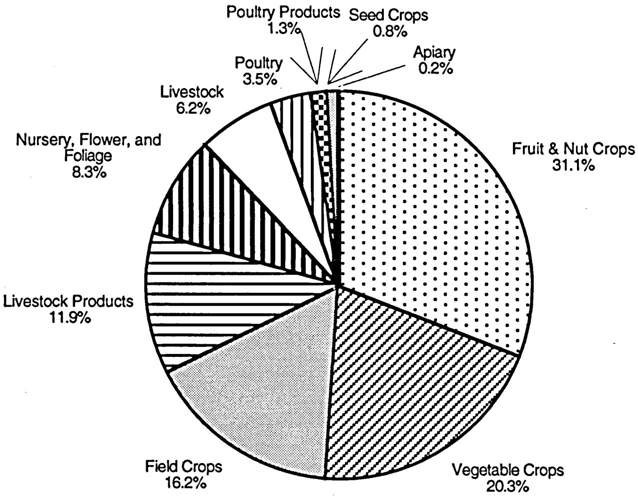
Fresno County—the state's agricultural leader with 12 percent of total value—produces a staggering number of commodities worth over $3 billion. Other regions have more specialized products, like Monterey County, where rich soils and a cool coastal climate nurture some of the world's finest vegetables and more than 28 percent of California's total vegetable crop.

Figure 5. The Billion Dollar Counties: California Counties Reporting at Least $1 Billion in Farm-Product Sales, 1994.



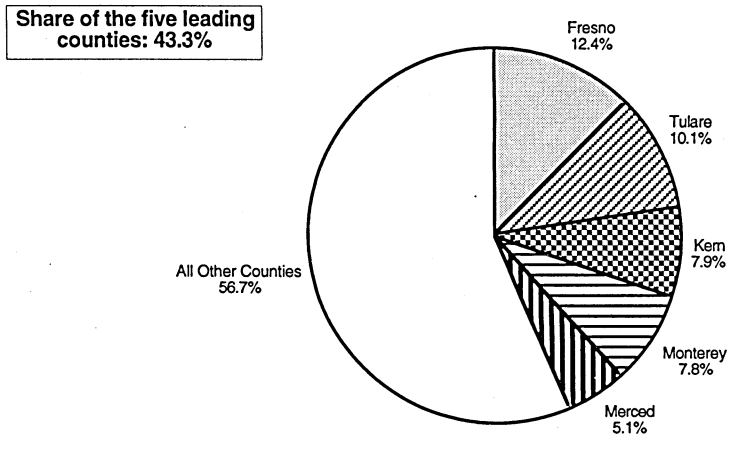
Source: CDFA, CASS, County Ag Commissioners' Reports, 1994.

Figure 6. Gross Value of Agricultural Production: Percent Contribution of Individual Commodities, 1994.



Source: CDFA, CASS, County Ag Commissioners' Reports, 1994.

Figure 7. Gross Value of Agricultural Production: Five Leading Counties, 1994.



Source: CDFA, CASS, County Ag Commissioners' Reports, 1994.

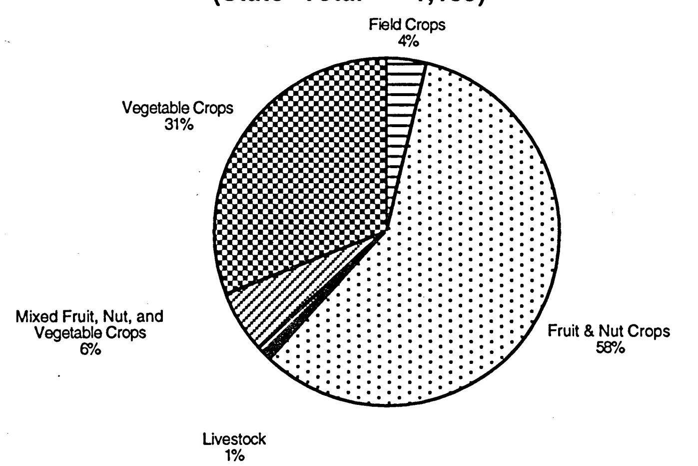
CALIFORNIA'S ORGANIC AGRICULTURE

Organic growers produce a wide and diverse variety of commodities. According to a recent survey for the California Department of Food and Agriculture, a total of 1,159 organic farmers sold over 70 individual commodities from 45,493 acres in 1992–93. The total of gross sales for all growers is estimated to be $75.4 million. Organic agriculture represented approximately one-half of one percent of the total farmed acres and total gross sales for all growers in the state in 1992. Handlers of organic products (registrants totaled 101) had total gross sales of $46.7 million.

The vast majority of organic growers produced fruit, nut and/or vegetable crops (Fig. 8). The largest contingent of organic growers was found in the South Coast region of the state (28 percent). The North Coast was second (21 percent), followed by the Central Coast (14 percent). Most organic growers (64 percent) are those whose gross returns are less than $10,000 per year. Less than one percent reported sales of over one million dollars for 1992–93.

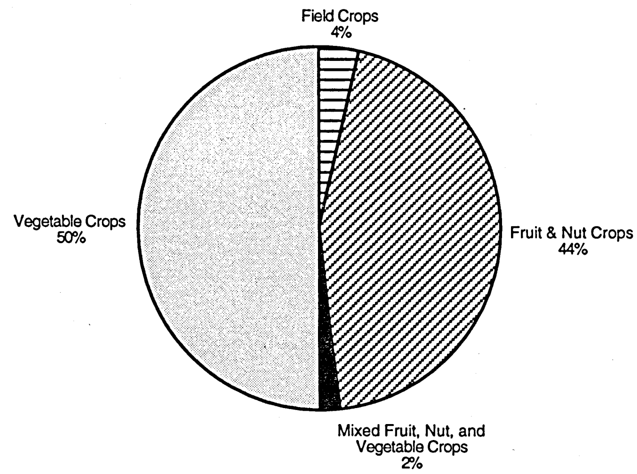
Vegetable crops were the highest value organic commodity group for the state, with $37.7 million, representing about 50 percent of the total gross sales (Figure 9). Fruit and nut crops were second highest with $33.5 million or 44 percent of the state's total gross sales.

Figure 8. Number of Organic Growers by Commodity Group in percent, 1993. (State Total = 1,159)



Source: Klonsky, K. and Tourte, L. Statistical Review of California's Organic Agriculture, 1992-93, UC Davis.

Figure 9. Organic Growers Gross Sales by Commodity Group
in percent, 1993.
(State Total = $75,436,817)



Source: Klonsky, K. and Tourte, L. Statistical Review of California's Organic Agriculture, 1992-93, UC Davis.

AGRICULTURAL EXPORTS

California's share of U.S. agricultural exports increased slightly in 1994, from about 17 percent in 1993 to about 18 percent. The state continues to be the leading agricultural exporter of the United States. Exports reached a record high value in 1994 of about $11.3 billion (estimated under the PIERS method), up by 9.5 percent from 1993 levels.

California's beef exports accounted for almost one quarter of all U.S. beef exports in 1994, significantly down from 1993 when the state's share was 38 percent. California is a dominant supplier of U.S. exports for numerous high value crops, including almonds, lettuce, walnuts, prunes, grapes, strawberries, broccoli, cauliflower, and celery. California's cotton lint exports accounted for about 40 percent of U.S. cotton lint exports in 1994, down slightly from 1993 when the share was about 44 percent.

In 1994 California supplied over 92 percent of the U.S. exports of the following commodities: lettuce (92.9 percent), walnuts (93.4 percent) and prunes (98.6 percent). The state also supplied 82.8 percent, 21.3 percent, and 65.9 percent of the U.S. exports of strawberries, dairy products, and onions, respectively.

Japan is the largest single market for California agricultural exports, accounting for almost a quarter of the total in 1994. Japanese purchases in that year were $2.6 billion. Of that amount, about 17 percent was meat, 15 percent fruits and nuts, 8 percent cotton, 6 percent vegetables, and the remainder other products.

Canada is the second largest single market for California agricultural exports, accounting for about 17 percent of the total in 1994, down from 23 percent in 1993. Canadian purchases in 1994 were about $1.9 billion. Of that amount, 27 percent was fruits and nuts, 21 percent vegetables, 8 percent meat, and the remainder other products.

Mexico received about 9 percent of California's total agricultural exports in 1994, valued at about $1 billion. This was an increase of 3 percent over the previous year, partly as a result of lower tariffs. Of the 1994 total, about 23 percent was meat, 14 percent fruits and nuts, and the remainder other products.

Exports to NAFTA members (Canada and Mexico) accounted for 26 percent of all California agricultural exports in 1994, down from 31 percent in 1993. However, NAFTA is still the major free trade market area for the state's agricultural exports. Exports to the European Union were 8 percent of the total in 1994, most of which were dried fruits, nuts, and fresh and processed vegetables. Hong Kong and South Korea accounted for 8 percent and 7 percent, respectively, of the market for California agricultural exports in 1994.

Table 6. California's Agricultural Export Profile, 1993 and 1994.

Commodities and Groups*	California Exports Valued at Port ($1,000)		Percent of California --Total Ag. Exports--		-----U.S. Exports----- Valued at Port ($1,000)		California as a Percentage of the U.S. Ag. Exports	
	1993	1994	1993	1994	1993	1994	1993	1994
1 Beef Products	1,046,272	988,857	10.1	8.7	2,727,001	4,161,933	38.4	23.8
2 Cotton Lint	679,928	978,983	6.6	8.6	1,537,506	2,434,617	44.2	40.2
3 Almonds	675,436	717,946	6.5	6.3	738,428	733,658	91.5	97.9
4 Grapes	587,068	589,907	5.7	5.2	718,153	691,720	81.7	85.3
5 Oranges	324,566	311,334	3.1	2.7	474,795	539,612	68.4	57.7
6 Dairy	161,125	185,511	1.6	1.6	619,599	871,375	26.0	21.3
7 Strawberries	163,633	151,630	1.6	1.3	171,584	183,193	95.4	82.8
8 Lettuce	176,879	136,815	1.7	1.2	181,855	147,259	97.3	92.9
9 Sudan/Alfalfa Hay	127,006	122,845	1.2	1.1	225,055	237,263	56.4	51.8
10 Walnuts	121,827	122,588	1.2	1.1	124,345	131,264	98.0	93.4
11 Prunes	99,156	120,265	1.0	1.1	99,337	122,026	99.8	98.6
12 Cherries	114,512	114,568	1.1	1.0	134,080	165,306	85.4	69.4
13 Onions	80,710	111,639	0.8	1.0	151,373	169,279	53.3	65.9
14 Wheat	229,906	102,076	2.2	0.9	7,774,023	4,559,629	3.0	2.2
15 Lemons	105,448	99,353	1.0	0.9	110,208	103,603	95.7	95.9
16 Rice	18,967	98,888	0.2	0.9	795,124	1,033,304	2.4	9.6
17 Grapefruit	79,276	95,970	0.8	0.8	203,427	215,935	39.0	44.4
18 Tomatoes	88,728	89,434	0.9	0.8	243,324	272,048	36.5	32.9
19 Chickens/Eggs	100,383	88,424	1.0	0.8	321,823	900,669	31.2	9.8
20 Broccoli	73,251	81,282	0.7	0.7	N/A	100,885	N/A	80.6
21 Vegetable Seeds	53,048	63,887	0.5	0.6	127,605	114,591	41.6	55.8
22 Cauliflower	55,662	61,807	0.5	0.5	86,248	73,732	64.5	83.8
23 Asparagus	52,331	60,867	0.5	0.5	64,414	76,862	81.2	79.2
24 Peaches/Nectarines	53,267	59,692	0.5	0.5	70,914	78,695	75.1	75.9
25 Melons	56,451	55,713	0.5	0.5	76,537	84,951	73.8	65.6
26 Pistachios	57,297	53,181	0.6	0.5	57,378	62,171	99.9	85.5
27 Plums	34,674	47,595	0.3	0.4	48,683	58,104	71.2	81.9
28 Celery	39,085	37,014	0.4	0.3	50,576	41,661	77.3	88.8
29 Flowers/Nursery	39,302	27,310	0.4	0.2	130,396	328,606	30.1	8.3
Total Agricultural Exports	10,366,620	11,355,161						

*Ranked in decreasing order by Export Value at Port of California Agricultural Exports.
**Excluding Timber and Fish/Crustaceans.
Note: Starting 1992, a new method for tabulating California Agricultural Exports (PIERS) was established. The new available figures are reported in this document and they should not be compared with previous figures specifically for 1992 and 1993 when the USDA Production Shares Method was used.

Sources: California Agricultural Exports. Annual Bulletin and Statistical Appendix, 1993 and 1994. Worldtariff, San Francisco, CA, June 1994 and 1995. U.S. Agricultural Export data for selected commodities were obtained from Worldtariff, Ltd. at Agricultural Issues Center's request, September 1995.

CROPLAND CHARACTERISTICS

California's six farming regions vary widely in terms of acreage and production. The San Joaquin Valley and Southern California have the smallest average farm sizes in the state, the most valuable real estate per acre, and the highest per-farm values for commodities sold. Both the Sacramento Valley and the Central Coast regions have somewhat larger average farm sizes, with lower per-acre real estate values and per-farm values for commodities sold. Farms in the North Coast and Mountain regions are dominated by rangeland and thus tend to be very large, with lower per-acre real estate and per-farm production values. The state's 77,669 farms cover almost 29 million acres in California and average 373 acres in size, about 100 acres less than the national average.

LAND IN FARMS

After hitting a plateau in the 1950s near 38 million acres, California farmland acreage has gradually declined by almost 9 million acres—about one-fourth of all agricultural land. Much of the loss has occurred in pasture and rangeland, partly from urbanization pressures. At the same time, the state's crop acreage has remained relatively constant. New measurement techniques adopted by the U.S. Census Bureau accounted for what appeared to be a significant decline in farmland in 1992. Previously, acreage in creeks and small rivers was included as farmland rather than waterways.

FARM SIZE AND NUMBER

California's average farm size of 373 acres (Table 7) is considerably less than its 1974 peak of 493 acres. Meanwhile, U.S. average farm size increased slightly during the same period, from 440 to 491 acres.

The number of farms in the state dropped rapidly from 1945 to 1964 and fluctuated moderately thereafter. In recent decades, fluctuations in the number of farms probably reflect changes in census definitions and more complete census surveys rather than significant structural changes in California farming.

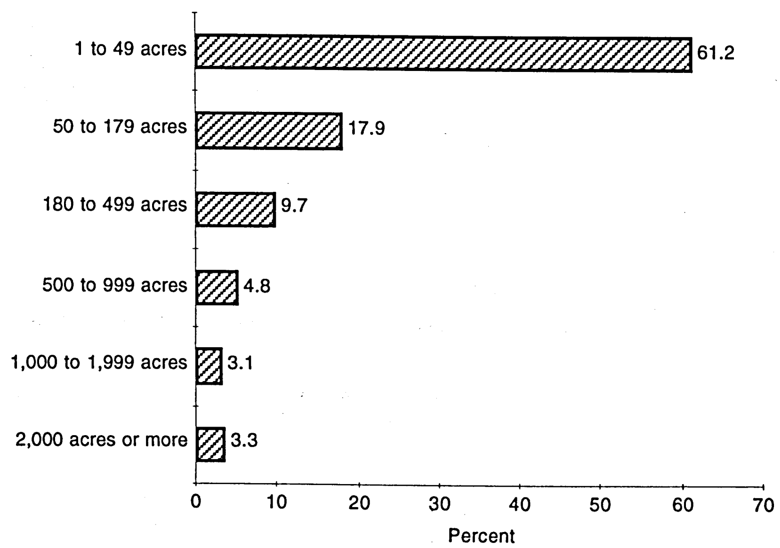
The size distribution of California farms shows almost 80 percent with less than 180 acres. While California agriculture is perceived as "large scale," actually only 6.4 percent of the state's farms have more than 1,000 acres.

Table 7. Farm Acreage, Number and Size, California.

Year	Number of Farms	Land in Farms	Average Size
		1,000 acres	*acres*
1940	132,658	30,524	230
1945	138,917	35,054	252
1950	137,168	36,613	267
1959	99,274	36,888	372
1964	80,852	37,011	458
1969	77,875	35,328	454
1974	67,674	33,386	493
1978	73,194	32,727	447
1982	82,463	32,157	390
1987	83,217	30,598	368
1992	77,669	28,979	373

Source: U.S. Bureau of the Census, Census of Agriculture, 1974, 1974, 1987 and 1992 Geographic Series B CD-ROM.

Figure 10. California Farms by Size, 1992.



Source: U.S. Bureau of the Census,
California Census of Agriculture, 1992.

VALUE OF LAND AND BUILDINGS

Investment values in agricultural land and buildings are high in California. On average, California farm, land, and buildings are worth about $820,063, more than twice the national average. About one-half of the farms have land and building assets in the $100,000–$499,999 range.

Over the last three decades, average per-acre values of land and buildings have increased about five times in California and in the nation. Value of farm real estate escalated sharply in the 1970s, only to be followed by a severe downturn in the '80s. Even in constant dollars, the per-acre land and building investment rebounded sharply in California from 1987 to 1992.

Table 8. Average Value Per Acre of Land and Buildings, U.S. and California.

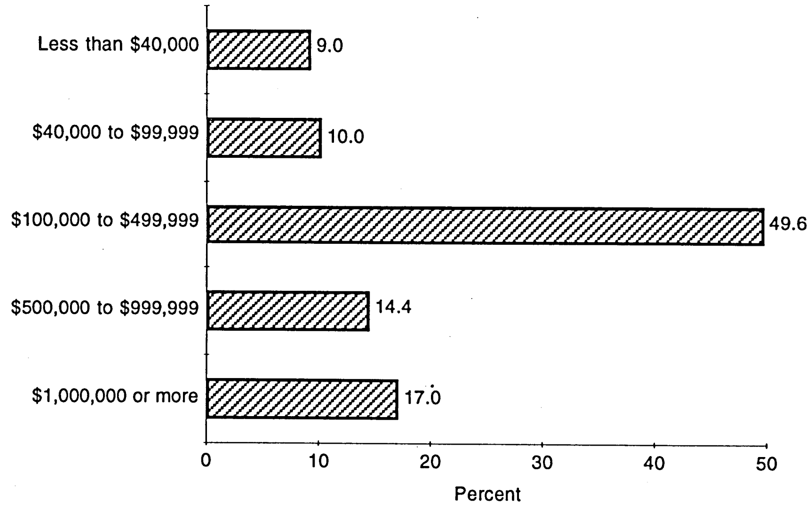
	-----United States*-----		-----California-----	
Year	Nominal	Deflated**	Nominal	Deflated**
1964	144	520	468	1,690
1969	194	581	479	1,434
1974	336	748	653	1,454
1978	619	1,027	1,161	1,925
1982	784	936	1,918	2,289
1987	627	627	1,575	1,575
1992	727	601	2,213	1,830

* 48 States--Excludes Hawaii and Alaska.

** Deflated by Gross Domestic Product implicit price deflator, 1987 = 100.

Source: U.S. Bureau of the Census for indicated years, United States and California; Economic Report of the President, February 1995.

Figure 11. California Farms by Value of Land and Buildings, 1992.



Source: U.S. Bureau of the Census, California Census of Agriculture, 1992.

ASSETS

Total farm business assets in California represent more than $66 billion, accounting for about 7 percent of all U.S. farm business assets. Farm real estate (land and buildings) is valued at $55.5 billion, about 8 percent of all U.S. farm real estate holdings. California non-real estate assets, including livestock and poultry, machinery, crops, and purchased inputs, are worth $8.2 billion. Farmers' other financial assets, including investments in California cooperatives, amount to some $2.7 billion.

Table 9. Value of Farm Business Assets (excluding households), California and U.S., December 31, 1993.

	California	United States
	$ millions	*$ millions*
Real Estate	55,534	656,300
Non-real Estate		
Livestock & Poultry	3,652	72,800
Machinery & Equipment	3,781	85,200
Crops	429	23,400
Purchased Inputs	335	4,200
Financial Assets		
Other Financial Assets*	2,761	46,155
Total Assets	66,491	888,055

* For 1993 Other Financial Assets also include Investments in Cooperatives.

Source: U.S. Department of Agriculture, Economic Research Service, Computer file.

PEOPLE ON FARMS

FARM TENURE AND POPULATION

Farm population, defined as all persons living on rural places with $1,000 or more of annual agricultural sales, has declined in the nation as well as the state. Persons living on farms represent less than 1 percent of California's 30 million residents. Nationwide, farmers make up about 1.8 percent of the population—a sharp drop from 23 percent in 1940. A declining farm population in California is accentuated by the fact that the state's total population has grown at a faster pace than the rest of the nation.

To many, California agriculture means corporate farming. Nevertheless, families or individuals own close to four-fifths of the state's farms—60,187 of the total 77,669 operations or 77 percent—a proportion that has remained relatively constant for nearly 15 years. Partnerships make up 15 percent of the state's farms, while just 7 percent or 5,067 are corporate farms. However, compared to U.S. averages, California proportionately has fewer family farms and more partnerships and corporations. Of the state's 77,669 farmers, 73 percent are full owners of their operations, while roughly 15 percent are part-owners, and 12 percent are tenants.

In 1992, 83 percent of the state's corporate farms were family held. Non-family held operations comprised 17 percent. The average-size corporate farm in California is 1,042 acres, compared to the 373-acre average for all California farms. Family-held corporate farms average 1,058 acres, while non-family corporate farms average 963 acres. While the average farm size in the state held steady, the size of the average corporate farm in California shrank between 1982 and 1992 by 443 acres.

Table 10. Type of Organization and Percentage of Total Land Operated by Each Type, All Farms, California, 1978, 1982, 1987 and 1992.

Year	Individual or Family	Partnership	Corporation	Other*	Total
		number of farms			
1978	57,916	10,815	3,871	592	73,194
1982	65,482	11,360	4,849	772	82,463
1987	64,928	12,127	5,367	795	83,217
1992	60,187	11,350	5,067	1,065	77,669
		percent of total			
1978	79.1	14.8	5.3	0.8	
1982	79.4	13.8	5.9	0.9	
1987	78.0	14.6	6.4	1.0	
1992	77.5	14.6	6.5	1.4	

*Includes farms operated by estates and trusts, cooperatives, colonies and institutions.

Source: U.S. Bureau of the Census, Census of Agriculture, 1987; Information Kit Geographic Area Series 1B CD-ROM 1992.

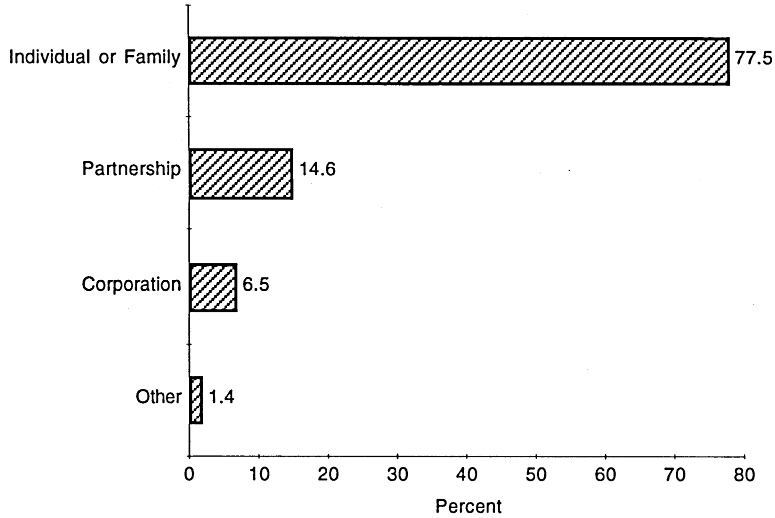
Table 11. Tenure of Farm Operators, California, Selected Census Years.

Year	All Farm Operators	Full Owners	Part Owners	Tenant*
		--------------------------*number of farms*	--------------------------	
1974	67,674	47,339	12,377	7,958
1978	73,194	51,729	12,702	8,763
1982	82,463	60,556	12,692	9,215
1987	83,217	60,639	12,218	10,360
1992	77,669	56,559	11,471	9,639
		--percentage distribution	*by tenure status--*	
1974		-70.0	18.3	11.7
1978		70.7	17.4	12.0
1982		73.4	15.4	11.2
1987		72.9	14.7	12.4
1992		72.8	14.8	12.4

* After the 1964 Census, managers were included in the tenant classification.

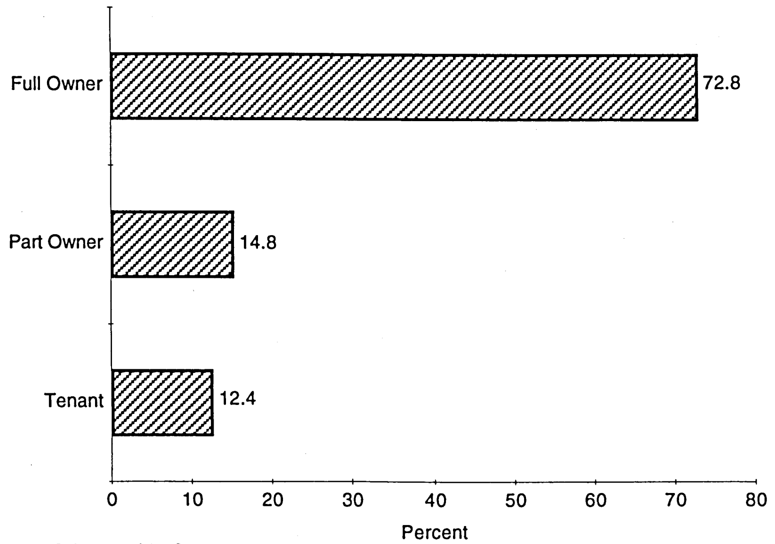
Sources: U.S. Bureau of the Census, Census of Agriculture, various years; Information Kit for Geographic Area Series 1B CD-ROM.

Figure 12. California Farms by Type of Organization, 1992.



Source: U.S. Bureau of the Census, California Census of Agriculture, 1992.

Figure 13. California Farms by Tenure, 1992.



Source: U.S. Bureau of the Census, California Census of Agriculture, 1992.

Farm Employment

Nationwide, farm employment has decreased gradually over the past 45 years. In 1995 the U.S. agricultural work force was only one-third of its 1950 level. Several factors influence this trend. Farmers produce food and fiber far more efficiently today than ever before, requiring fewer agricultural employees to maintain the same level of output. Today, each American farm worker provides food for more than 100 other people compared to just 13 other people in 1947. Labor needs on the nation's farms have also dropped, due to mechanization as well as farmers purchasing inputs that they formerly produced on the farm, such as feed, seed, and fertilizer. Another cause of shrinking farm employment numbers is a continually growing and diversifying U.S. economy, which draws resources (human and other) away from agriculture.

Trends in California

The same broad economic forces are also at work in the Golden State, yet farm employment in California presents a slightly different picture. Here, agriculture in the last few decades has shifted away from extensive operations (pasture and grain production) toward capital- and labor-intensive crops (fruits, vegetables, and horticulture), ensuring a constant and growing need for farm labor even with increased productivity brought about by new technology.

On most of the nation's farms, the bulk of agricultural labor is still performed by the farm operator and farm families. This is not true in California. Here, the total hired labor force in 1994 (231,100 workers) outnumbered farmers and unpaid family by seven to one. Nearly 35 percent of California's farm workers—82,900 men and women—are regular employees hired for more than 150 consecutive days; the remainder are seasonal workers hired for fewer than 150 consecutive days.

According to the National Agricultural Workers Survey (NAWS), three-fourths of all seasonal farm workers in crop agriculture are minorities, usually immigrants from Mexico who have been in the U.S. for less than 10 years. Some 90 percent of seasonal agricultural workers are employed on vegetable farms, by fruit and nut growers, and in nursery and horticultural specialty operations.

Table 13. Agricultural Employment by Type of Worker, California Farms.

Year	Farmers and Unpaid Family	Hired Regular - 150 consecutive days and over	Hired Seasonal - less than 150 consecutive days	Total Hired Labor Force
		------annual averages------		
1950	132,100	108,600	116,600	225,200
1955	115,400	100,900	150,500	251,400
1960	99,000	93,500	141,200	234,700
1965	90,600	90,300	121,700	212,000
1970	78,100	97,100	113,900	211,000
1975	69,800	99,200	116,900	216,100
1980	64,200	104,600	119,500	224,100
1985	60,700	93,900	120,600	214,500
1990	54,360	87,630	139,910	227,540
1991	52,030	88,780	130,520	219,300
1992	47,000	90,700	146,900	237,600
1993	39,100	96,700	147,900	244,600
1994	34,800	82,900	148,200	231,100

Source: California Employment Development Department, Agricultural Employment Estimates, Report 881-M.

AGRICULTURALLY-RELATED WORK FORCE

Employment on farms and in farm-related industries accounts for a smaller share of California's work force today than ever, in part because of the state's highly diversified economy. Still, agriculture remains critical to the economies of certain regions, most notably the fertile Central Valley. Agriculture's overall shrinking employment numbers also point to the state's more efficient food production system, in which relatively few producers provide abundant supplies of inexpensive food to the state and the nation.

On-farm production of crops and livestock provides more than half of all agricultural jobs, employing on the average 271,300 farm proprietors, unpaid family workers, and wage and salary workers in 1992. The figure includes, however, a number of seasonal workers hired for fewer than 150 consecutive days. Under this definition, agriculture represents 1.95 percent of the state's total employment.

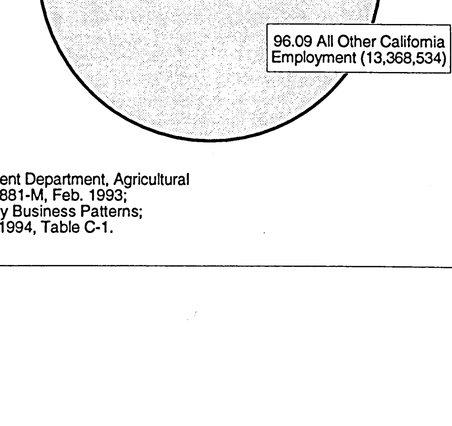
Employment indirectly related to farming represents nearly as many agricultural jobs in California. These 259,866 employees include producers of farm inputs like agricultural chemicals, feed, seed, and farm machinery; workers in agricultural services like packaging, transportation, storage and marketing; people in food packing and processing companies; jobs created by farm-related trade such as international brokers, shippers, and agricultural processors whose major markets are overseas; and employees in general but less directly linked agribusiness, including farm machinery repair, manufactures of containers, paper, and other products used in agriculture.

Agricultural Services

California's agricultural services sector covers packaging, transportation, storage and marketing of farm products, as well as other farm-related service industries. This key sector of agricultural employment continues to grow not only in overall numbers but in percent share of California jobs. Agricultural services provided 95,271 jobs to Californians in 1992, adding some 52,000 jobs and more than 5,500 firms in 15 years.

The state's largest farm-related employment sector is food manufacturing—some 2,700 California companies that pack or process all types of farm products, from cauliflower to kiwifruit. In 1992, a total of 2,755 food processing firms provided jobs to 162,711 employees. Although the state's food manufacturers have added 14,500 jobs since 1977, overall employment by agricultural processing represents a shrinking percentage of California's total jobs. The trend can be explained in two ways: other sectors of the state's economy are growing at a faster pace, and as productivity increases in food manufacturing, its share of production workers decreases.

Figure 14. Percent Agricultural Jobs, On-Farm and Farm-Related, Compared to Statewide Employment, 1992.



Source: California Employment Development Department, Agricultural Employment Estimates, Report 881-M, Feb. 1993;
U.S. Bureau of the Census, County Business Patterns;
California Statistical Abstract, 1994, Table C-1.

Table 14. California Farm-Related Employment, 1977, 1982, 1987, 1989, and 1992.

	1977	1982	1987	1989	1992
Agricultural Services					
Number of Employees	43,294	56,618	78,984	89,908	95,271
% of Total	0.65%	0.68%	0.78%	0.82%	0.89%
Payroll ($1,000)	426,176	734,529	1,163,744	1,439,199	1,623,555
Number of Firms	6,054	6,701	9,883	10,577	11,614
Food Manufacturers					
Number of Employees	148,200	159,494	153,535	161,300	162,711
% of Total	2.21%	1.91%	1.52%	1.47%	1.52%
Payroll ($1,000)	2,139,197	3,322,492	3,732,798	4,141,107	4,495,335
Number of Firms	2,370	2,359	2,574	2,571	2,755
Agricultural Chemicals					
Number of Employees	3,559	3,129	2,086	1,788	1,884
% of Total	0.05%	0.04%	0.02%	0.02%	0.02%
Payroll ($1,000)	53,882	66,537	58,496	54,957	67,466
Number of Firms	104	90	80	72	80
Total Farm-Related Employment					
Number of Employees	195,053	219,241	234,605	252,996	259,866
% of Total	2.91%	2.63%	2.33%	2.31%	2.42%
Payroll ($1,000)	2,619,255	4,123,558	4,955,038	5,635,263	6,186,356
Number of Firms	8,528	9,150	12,537	13,220	14,449
California Total*					
Number of Employees	6,696,345	8,330,004	10,086,198	10,959,450	10,729,697
Payroll ($1,000)	81,329,595	146,937,574	225,507,263	266,566,770	290,374,778
Number of Firms	465,944	526,168	703,258	733,755	746,789

* Excludes government employees, railroad employees, and self-employed persons.

Source: Department of Commerce, Bureau of the Census, County Business Patterns.

Agricultural Chemicals

Employment related to agricultural chemicals has slipped considerably in recent decades, with jobs in this sector reduced by half since 1977. The number of agrichemical firms is also down from its 1977 high of 104; in 1992 there were just 80 such companies in California. Part of the shift is due to market factors. Many of the smaller firms have not been able to meet the costs of keeping up with tough state regulations, while several of the largest chemical companies have relocated to other states. And, because the type of materials farmers are using for pest control has broadened to include beneficial insects and biological controls, changes in the definition of "chemical" may also account for part of the decrease in firms and jobs .

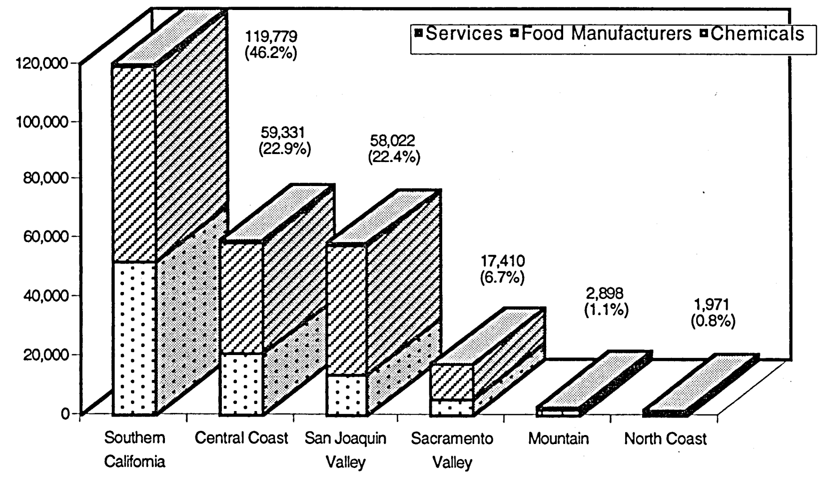
REGIONAL EMPLOYMENT TRENDS

When California's agricultural employment is split among its six diverse production regions, it is easy to see that a vast majority of jobs are in the southern and central parts of the state. Most employment is in food manufacturing and agricultural services, two areas that have enjoyed substantial growth in most agricultural counties. Even in the northern regions, where agricultural employment numbers seem small by comparison and relatively constant, farming continues to bolster local economies by creating a significant share of jobs and income.

Southern California has nearly twice the farm-related employment as other agricultural regions, for a variety of reasons. This area includes Riverside, Orange, Imperial and Los Angeles Counties, all densely populated areas that house a significant number of food processing firms. High employment numbers may also reflect the fact that Southern California is home to the headquarters of several of the state's largest agricultural employers.

Overall employment figures in the northern regions may seem surprisingly low compared to those farther south. In the north, however, agricultural industries support a higher percentage of total jobs. For example, farm-related industries employ 3.2 percent of the Sacramento Valley work force and 3.4 percent of all workers in the North Coast region, compared to 1.8 percent in Southern California.

Figure 15. Farm-Related Employment in Six Production Regions, 1992.



Source: County Business Patterns, U.S. Bureau of the Census.

DIRECT AND INDIRECT LINKAGES

Output, Employment, Personal Income, and Value Added

California's agriculture and agricultural processing sectors produce ripple effects in the state's economy. Each dollar earned within agriculture fuels a more vigorous economy by stimulating additional activity in the form of jobs, income, and output. In general, the greater the interdependence in the economy, the greater the additional activity, or multiplier effects.

The multiplier effects of California agriculture, calculated for 1994 using the IMPLAN system,[1] are presented in Tables 15 and 16, which display the aggregate economic effects of the agricultural sectors on the state of California and on the Central Valley specifically, and summarize agriculture's economic impact as a whole.

Four measures cited in the tables reflect the impact that agriculture has on the state. The first, **sales** impact, measures how agricultural purchases influence total private sector sales. Here, for example, we can measure sales linked to an initial purchase of equipment, packaging, even electricity—anything farm dollars buy.

A second indicator is the amount of state **personal income** produced directly and indirectly by the economic output of agriculture and agricultural processing.

The third measure calculates the total **value-added** impacts in the state linked to agriculture. "Value added" in this case is equal to the value of goods and services sold by a firm or sector of the economy, minus the cost of inputs and services (but not labor) required to produce those goods. For agriculture, "value added" would indicate value added to the economy from farm products, less processing costs, transportation, interest on loans, etc.

A final measure is the number of **jobs** in agriculture, agricultural processing, and other sectors of the California economy linked with agriculture, such as employment in retail trade or construction. This category measures agriculture's impact on overall employment figures, not just employment within farming.

Multiplier Effects: California

In Table 15 we see that fruits, nuts, and vegetables—California's high-value crops—have the greatest impact on sales, personal income, and employment in the state, producing almost $34.5 billion (value-added) and creating 601,343 jobs. Second in overall economic impact are the state's dairy and poultry industries, including processing. Value-added produced by agriculture is 7.9 percent of California's total Gross State Product of $827 billion, and agriculture creates, directly or indirectly, nearly one in twelve jobs in the state, with 8.7 percent of total employment.

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[1] The IMPLAN (IMpact analysis for PLANning) system was designed by the U.S. Forest Service/U.S. Department of Agriculture to estimate economic input-output models for any county or group of counties in the U.S. It does this with a huge data base and software and algorithms to estimate regional input-output models from secondary published data. An input-output model provides detailed economic multipliers for all sectors of the economy.

When viewed in the state aggregate, this relatively small number of agriculture-related jobs illustrates two important points: (1) California's diversified economy supports many industries unrelated to agriculture, and (2) agriculture in California becomes more efficient each year. As farmers adopt labor-saving technologies and agricultural processing is mechanized, fewer employees are required to maintain a high level of agricultural output. And while direct employment from agriculture might be falling off, jobs indirectly related to agriculture continue to be a strong source of employment for many Californians.

Multiplier Effects: The Central Valley

While agriculture is important to California as a whole, to the Central Valley it is absolutely critical. Farming and agricultural processing create (directly and indirectly) more than a fourth of all jobs in this region (see Table 16), produce 25.3 percent of value-added dollars, and generate about $1 of every $3.75 of personal income. Total sales from agriculture in the Central Valley are $55 billion, close to 42 percent of the state's total of $130.61 billion.

Tree and vine fruits, nuts, and vegetables—both fresh and processed—provide the most income and jobs to the Central Valley. Dominated by the state's profitable almond, table grape, raisin and wine crops, this segment contributes directly and indirectly more than $27 billion in sales, $14.9 billion in personal income, and 313,605 jobs. Overall value-added from tree and vine fruits, nuts, and vegetables is about $16.3 billion. A distant second and third are: (1) dairy, poultry producers/processors ($4.1 billion), and (2) food and feed grains ($3.4 billion).

Table 15. Economic Impacts of California's Food & Fiber Industry, 1994.

Major Commodity Groups	Food, Feed, and Fiber Production & Processing Sales, 1994	Impacts on California			
		Sales	Personal Income	Value-Added	Jobs*
	($1,000)	($1,000)	($1,000)	($1,000)	
Dairy, Poultry, and Dairy/ Poultry Processing	12,863,396	23,798,059	8,606,472	9,204,350	195,528
Livestock and Meat Processing	4,354,144	8,406,047	2,937,403	3,221,869	95,567
Cotton and Fabric/Yarn/Thread Mills	2,259,829	4,799,914	2,278,111	2,439,468	58,054
Food/Feed Grains, Hay and Flour/Grain Mill Products	10,968,520	18,497,178	8,473,764	9,028,258	160,059
Fruits, Nuts, Vegetables and Processed Fruits/Vegetables	34,700,849	61,670,100	31,348,778	34,497,485	601,343
Sugar/Misc. Crops and Sugar/ Confectionery Products	3,841,871	6,833,230	2,843,357	3,028,994	55,110
Greenhouse/Nursery Products	1,986,450	2,860,189	2,132,969	2,232,306	44,567
Other 1/	2,448,445	3,746,490	1,306,251	1,384,606	20,500
Total	73,423,503	130,611,207	59,927,104	65,037,395	1,230,728
California State Total			702,568,000	827,381,538	14,141,000
% of California Total			8.5%	7.9%	8.7%

* Adjusted for inflation to 1994.
1/ Includes vegetable oil mills, shortening/cooking oils, roasted coffee, and manufactured ice.

Note: California Gross State Product is an estimate.

Sources:
i) California State Personal Income, 1994: California Statistical Abstract, 1995.
ii) California Gross State Product, 1994: Estimated applying 1992 ratio of State Product to State Personal Income (California Statistical Abstract, 1995).
iii) California State Employment, 1994: Report 400C-MSA, Labor Market Information Division, EDD, Sacramento.

Table 16. Economic Impacts of Central Valley's Food and Fiber Industry, 1994*

Major Commodity Groups	Food, Feed, and Fiber Production & Processing Sales, 1994	Impacts on Central Valley			
		Sales	Personal Income	Value-Added	Jobs**
	($1,000)	($1,000)	($1,000)	($1,000)	
Dairy, Poultry, and Dairy/ Poultry Processing	6,571,172	11,074,323	3,831,777	4,131,405	104,271
Livestock and Meat Processing	1,486,531	2,857,923	990,430	1,107,861	40,614
Cotton and Fabric/Yarn/Thread Mills	1,461,028	3,403,322	1,647,450	1,779,912	48,365
Food/Feed Grains, Hay and Flour/Grain Mill Products	4,160,786	7,228,709	3,091,793	3,367,986	74,416
Fruits, Nuts, Vegetables and Processed Fruits/Vegetables	15,963,041	27,003,991	14,913,026	16,251,807	313,605
Sugar/Misc. Crops and Sugar/ Confectionery Products	1,898,862	2,770,488	1,066,459	1,147,138	23,393
Greenhouse/Nursery Products	274,336	436,770	336,775	350,272	8.022
Other 1/	128,627	241,327	86,641	93,686	2,189
Total	31,944,383	55,016,853	25,964,350	28,230,068	612,876
Central Valley Total			94,936,737	111,802,563	2,198,880
% of Central Valley Total			27.4%	25.3%	27.9%

** Adjusted for inflation to 1994.

1/ Includes vegetable oil mills, shortening/cooking oils, and manufactured ice.

* Central Valley includes the following 18 Counties in the San Joaquin and Sacramento Valleys: Butte, Colusa, Fresno, Glenn, Kern, Kings, Madera, Merced, Sacramento, San Joaquin, Shasta, Solano, Stanislaus, Sutter, Tehama, Tulare, Yolo, and Yuba.

Note: Central Valley Personal Income and Value Added is an estimate.

Sources:

i) Central Valley Personal Income, 1994: Revised data from California Dept. of Finance., Applying 1992-93 % increase to 1993 Personal Income.

ii) Central Valley Value Added, 1994: Estimated applying 1992 ratio of California State Product to State Personal Income (California Statistical Abstract, 1995).

iii) Central Valley Employment, 1994: Report 400C-MSA, Labor Market Information Division, EDD, Sacramento.

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Chapter 3

CROSS SECTIONS OF A DIVERSE AGRICULTURE: PROFILES OF CALIFORNIA'S PRODUCTION REGIONS AND PRINCIPAL COMMODITIES

Warren Johnston

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California agriculture defies simple, accurate generalizations. This short chapter gives the reader two of many possible cross-sectional views in an effort to portray the diversity and complexity which make simple descriptions impossible.

California's agriculture has always been sufficiently different from farming (or ranching) and other related activities found elsewhere in the United States, or in the world for that matter, to befuddle visitors and the uninformed. When discussing farming with visitors from the other 49 states, and places even more foreign, my father, a life-long Yolo County farmer, always proudly stated, "Anything that can grow anywhere, can grow somewhere in California!" He was right, of course. The state's agriculture developed in less than two centuries from a predominantly livestock grazing economy, which provided wealth to Alta California missions from the sale of hide and tallow products in the early 1800s, to today's agriculture which includes highly capitalized, intensively managed firms as well as smaller and part-time farms. Today's agricultural bounty consists of several hundred commercial agricultural commodities and products sold in every conceivable form at markets ranging from local roadside stands and farmers' markets to distant markets around the world.

The challenge to California farmers and ranchers has always been to match available, and often limited, physical, human, financial, and managerial resources to produce and market alternative outputs chosen from a long and constantly evolving set of potential agricultural commodities and value-added products. Investment and management decisions often involve the integration of production with other economic activities. The highest and best use of resources available to California's agricultural decision makers requires frequent reexamination of the criteria of the numerous possible uses that are legally permissible, physically possible, financially feasible, and maximally productive. In the dynamic setting of California agriculture, changes are frequent, and often dramatic, as producers and marketers recurrently assess alternatives and make decisions that change important features of the state's agricultural sector.

A half century ago, University of California Dean of Agriculture Claude B. Hutchison in his preface to the book *California Agriculture* noted the difficulty of measuring the diversity of agricultural production in California even then. He compared the existence of 118 distinct types of farming areas in California in 1946, to substantially lesser numbers in other important agricultural states—8 in Illinois, 12 in Kansas, 20 in the huge state of Texas, and 25 in Pennsylvania, the state with the next highest number of farming areas. He also noted that only 6 percent of California farms had been classified by the 1940 Census as being general field crop and livestock farms of the sort characteristic of the Midwest Corn or Dairy Belt. "The other 94 percent are distinctly specialized farms, farms devoted largely to the production of a single commodity....Such concentration of effort or specialization calls for outstanding technical and scientific knowledge as well as familiarity with good business methods and procedures" (Hutchison, p. vii).

The developments of the past half century have, if anything, accelerated greater diversity in types of farming and number of commercial commodities or products. California producers and marketers constantly pursue the highest and best uses of the resources available to them in a dynamic, and often volatile, economic setting.

This chapter portrays some of current dimensions of the state's diverse agricultural sector by first discussing the characteristics of the major agricultural production regions of California. Natural endowments and man-made infrastructures, in part, determine the nature of agricultural activity within each of the regions. Comparative advantage varies from region to region, and many crops are grown in several regions for reasons of temporal and geographical diversification. A second section discusses the changing composition of agricultural production from extensive to more intensive, higher investment, and higher valued crops. Finally, the third section, a discussion of the state's "Top Twenty" agricultural commodities gives better understanding of the nature of agricultural production in California. Nevertheless, the following pages, constrained by time and space considerations, are obviously nothing more than a brief introduction into several ways of examining the diversity of California agriculture.[1]

THE AGRICULTURAL PRODUCTION REGIONS OF CALIFORNIA[2]

Landforms, hydrography, and climate primarily comprise the physical resources available to farms, ranches, and agribusinesses. Augmented by inputs of production—capital, management, and labor—and by private and public investments in institutions and infrastructure, the physical resources importantly characterize the state's agricultural production regions.

California is a large state, the second largest in the conterminous United States. Within such a large geographical area, variations in physical resources are often extreme. For example, normal annual precipitation ranges from only 2.75 inches at Imperial in the southeastern corner of the state to over 100 inches of rain in the

[1] A much more comprehensive, though now somewhat dated, discussion of the many facets of California agriculture is found in Scheuring. Hartman may also contribute to the interested reader's understanding of the state and its agricultural sector.

[2] This section draws primarily from chapters from the edited work of Scheuring, especially the chapter by McCorkle and Nuckton; from Hartman and from Durrenberger; and from statistical information compiled from the 1992 Census of Agriculture and 1995 annual crop reports of California County Agricultural Commissioners.

northwest corner of the state and at higher elevations in the Sierra Nevada and Coast ranges.[3] The availability of natural rainfall and snowmelt fostered early irrigation development on the western slopes of the Sierras. The uneven seasonal and geographical distribution of surface water led to early private, and later governmental, investments in storage and conveyance systems. Both the highest and lowest elevations in the conterminous United States are found in California—within 75 aerial miles of each other.[4] Climatic regions range from hot desert to alpine tundra. While most of the state's population and much of its agricultural production occur in areas characterized by a Mediterranean climate, many of its agricultural areas in the San Joaquin Valley and along the southern coastline are located in steppe or desert climatic zones.[5] Growing seasons range from year-round frost-free areas along the coast to relatively short seasons in higher elevation mountain valleys. The more than 500 soil series in California also reflect vast variations in age, parent material, and natural vegetation, in addition to the influence of climate and topography. Residual and transported soils (valley, basin and terrace) vary greatly in soil depth, permeability, water-holding capacity, and nutrient-supplying capacity. For these and other reasons, the great variation in the physical resources available to agriculture across the state is more than sufficient to bear out the "any-crop, somewhere" maxim.

Figure 1 shows California agricultural production regions delineated along county boundaries.[6] For the most part, these regions are characterized by different resources and land uses, with the exception of valley versus mountain-type lands found along the boundary between the Central Valley (Sacramento and San Joaquin valleys) and the Mountain region.[7]

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[3] In general, precipitation decreases from north to south and west to east, except where mountains intervene; western slopes of mountains receive heavier precipitation, and eastern slopes are in the rain shadow of Pacific storms (Durrenberger).
[4] Mt. Whitney, 14,494 feet above sea level, and Death Valley, 282 feet below sea level.
[5] See, for example, either Durrenberger or Hartman.
[6] The Agricultural Production Regions are used by California Department of Food and Agriculture and related state and federal statistical agencies in various statistical reports and summaries.
[7] There are 58 counties in California. Central Valley types of agriculture are found in the western portions of "mountain" counties (Nevada southward to Mariposa), while eastern portions of Madera, Fresno, Tulare, and Kern Counties include substantial Sierra Nevada "mountain" type lands.

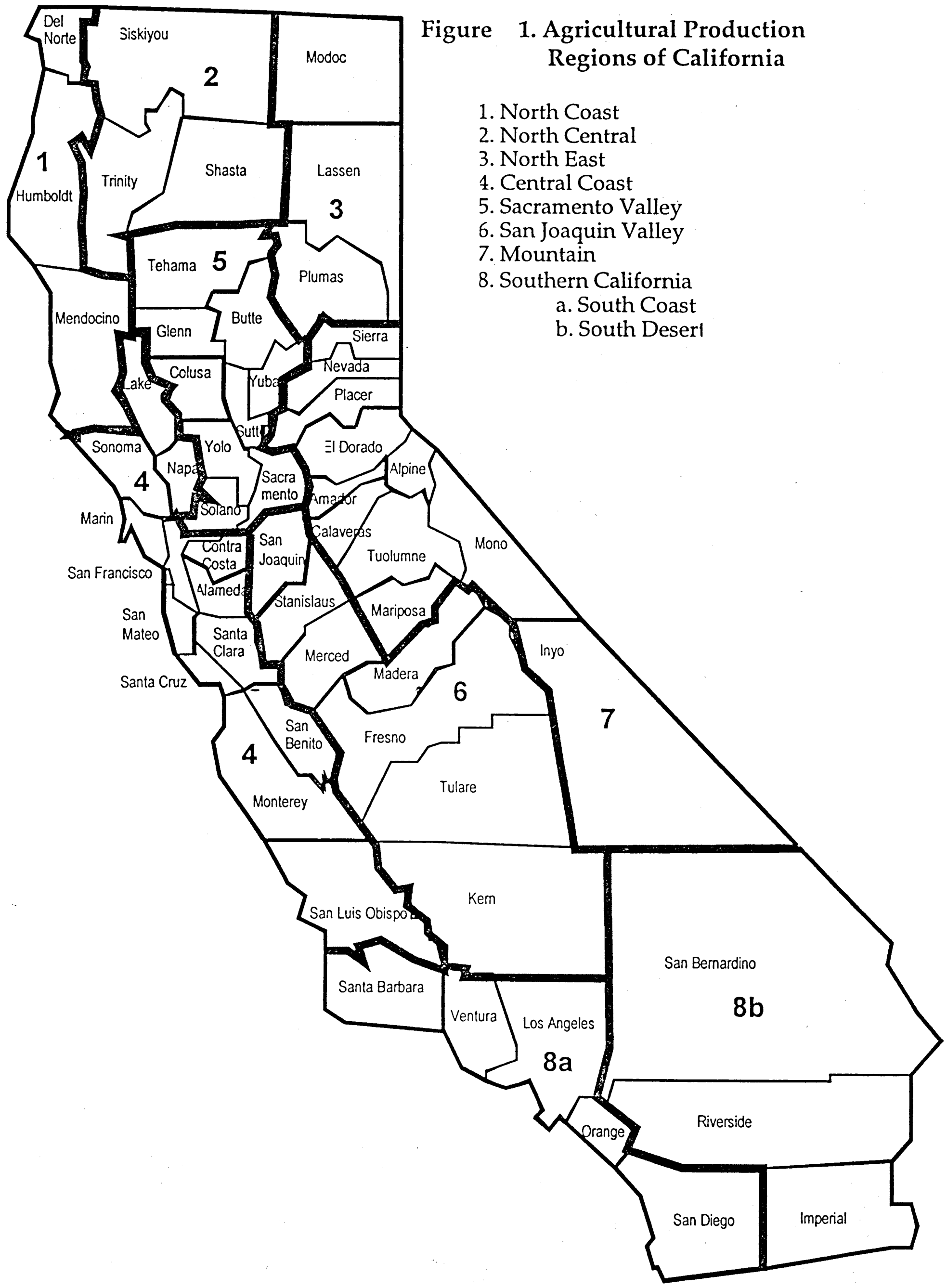

Figure 1. Agricultural Production Regions of California

1. North Coast
2. North Central
3. North East
4. Central Coast
5. Sacramento Valley
6. San Joaquin Valley
7. Mountain
8. Southern California
   a. South Coast
   b. South Desert

Forty-nine percent of California lands is in public ownership, most of it controlled by the federal government (Table 1).[8] Public land ownership is highest in the mountain and desert regions. Conversely, the most agriculturally important regions have the highest private ownership levels, ranging from 71 percent in the San Joaquin Valley to about 80 percent in the Central Coast and Sacramento Valley regions.

Statewide, 29 percent of the land area is in farms. Of the land in farms, 36 percent is cropland; and of the land in cropland, 72 percent is irrigated. The 1992 Census tallied 77,669 farms, which averaged 373 acres in size and sold an average of $219,546 of farm products per farm. The size and value-of-sales statistics, however, include both small, part-time and larger full-time farm units.[9] Among regions, the highest average per acre sales were reported for the more intensive South Coast and South Desert subregions of the Southern California production region and the San Joaquin Valley region.

Brief descriptions of California's agricultural production regions refer to Table 1. Regional value of agricultural production inserts are based on 1995 crop reports prepared by County Agricultural Commissioners. Regional production is distributed among seven categories: (1) field crops, (2) vegetable crops, (3) fruit and nut crops, (4) nursery products, (5) foliage and cut flowers, (6) livestock and poultry, and (7) livestock, poultry, and apiary products.

[8] The federal government owns 45 million of the nearly 49 million acres in public ownership (County Supervisors Association of California).

[9] The census definition of "farm" includes a substantial number of small-sized part-time farming units. Only 41,278 operators considered farming to be their principal occupation, while 26,581 operators reported that they worked at least 200 days off farm. Only 17,817 farms reported sales of $100,000 or more.

Table 1. Farming Characteristics of the Agricultural Production Regions of California.

	Total for for California	North	Central Coast	Sacramento Valley	San Joaquin Valley	Mountain	South Coast	South Desert
1. Land Area								
1,000 acres	100,207	20,860	10,148	7,166	17,525	15,529	8,758	20,219
2. Public Owned Lands								
1000 acres	48,960	10,870	2,002	1,349	5,132	10,718	3,622	14,466
Percent of land area privately owned	51	48	80	81	71	31	59	28
3. Land in Farms								
1,000 acres	28,979	3,780	5,285	4,185	10,016	1,549	1,920	2,244
Percent of total land in farms	29	18	52	59	57	10	22	11
4. Cropland								
1,000 acres	10,479	689	1,185	1,979	5,169	170	452	777
Percent of land in farms that is cropland	36	18	22	47	52	11	24	35
5. Irrigated Land								
1,000 acres	7,571	411	479	1,381	4,258	127	280	635
Percent of cropland that is irrigated	72	60	40	70	82	75	62	82
6. Number of Farms	77,669	4,597	12,068	10,618	28,616	3,749	12,198	5,821
Average farm size acres	373	822	438	394	350	413	157	385
7. Average Value of Farm Products Sold								
\$ per acre	588	88	480	358	843	74	1,012	966
\$ per farm	219,546	72,7484	210,343	151,258	295,167	30,632	159,221	372,392

Sources: Lines 1-2: County Supervisors Association of California, *California County Fact Book '88-'89*. Lines 3-7: U.S. Bureau of the Census, *Census of Agriculture, 1992.*

The North

Consisting of the nine counties in the three northernmost production regions, the North region is in the main a relatively unimportant agricultural area of the state, even though it contains about a fifth of the state's land area. More than half of the land area is in public ownership, and private forestry is a significant land use. Relatively small proportions of land are in farms (18 percent), and of that land only 18 percent is cropland.

Cattle and sheep operations, the most important component of the region's overall agricultural economy, utilize a combination of owned land, a portion of which is typically devoted to hay or irrigated pasture production, and leased public rangelands. Some dairying is still found in coastal areas. Field crop production, which includes rangeland and pasture for livestock, contributed 34 percent of the value of production in 1995, and livestock production itself amounted to another 28 percent. Some highly productive farming areas include the North Coast grape growing region in Mendocino County and the Tulelake district and mountain valley areas of the northeast, where potatoes, alfalfa hay, malting barley, durum wheat, and sugar beets are regionally important cash crops.

The Central Coast

This production region consists of a number of highly productive areas with coastal climate and fertile soils devoted to high-valued vegetable, fruit, and nursery production, as well as less productive dryland farming areas, all of which occur in relatively close proximity to the north-south Coast Range of mountains. Since early settlement, the Central Coast has been a very important agricultural region of the state. However, significant acreage has been lost to urban development as California's population has grown. For example, farm land in the once highly productive Santa Clara Valley has been almost totally displaced by urbanization; having lost its historic reputation for tree fruit and nut production, the region is now widely known as the "Silicon Valley," a center of the computer industry. Because of agreeable climate and other amenities, pressures for urban development continue in many coastal locales.

Despite the inclusion of the important Napa and Sonoma County wine grape growing areas north of San Francisco, and the important vegetable and wine grape production areas of the Salinas Valley and Santa Maria and other coastal areas of the south, only 22 percent of the Central Coast land area is in crop land. About 60 percent of the cropland is irrigated. High valued vegetable production, mainly in Monterey, Santa Cruz, San Benito, and San Luis Obispo Counties, contributed 53 percent of the value of production from the Central Coast production region in 1995; fruit and nut crops contributed 23 percent. Major vegetable crops include almost all of the vegetables from A (artichokes) to Z (zucchini squash).[10] Wine grapes, strawberries, and raspberries are the major fruit crops. Expansion of high valued production has exacerbated surface and groundwater supply concerns. Producers in this region are highly specialized and often use very sophisticated technologies in production and post-harvest activities. Nursery

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[10] Central Coast region counties lead in the production of artichokes, asparagus, broccoli, Brussels sprouts, cabbage, carrots, cauliflower, celery, garlic, herbs, lettuce, mushrooms, peppers, and spinach, plus a number of more minor vegetables.

products (plants, ornamentals, and transplants) are important in several of the counties. Dryland farming and livestock activities on the more extensive farming operations contribute only a minor portion of the region's value of production.

The Central Valley

The Sacramento and the San Joaquin Valleys lying north and south of the Delta, together form the Central Valley. Containing almost half of the state's farm land, about 60 percent of the cropland, and 75 percent of the irrigated land, this is California's agricultural heartland.[11] The Central Valley is generally regarded as the richest agricultural valley in the world. It has also recently been identified as the most endangered agricultural region in the United States because of the potential loss of substantial acreages of farmland to urbanization.

The Sacramento Valley

The northernmost part and the smaller component of the Great Central Valley, the Sacramento Valley has the highest proportion of land in private ownership (81 percent) of any production region of the state. While urbanization pressures are substantial in the southern portion of the Sacramento Valley, most of the region continues to be heavily dependent on agriculture. Nearly 70 percent of Sacramento Valley cropland is irrigated. Irrigation water sources include private and cooperatively developed surface water supplies along the western slope of the Sierras, riparian sources along the major rivers, e.g., the Sacramento, Feather, Yuba, Bear and others, and more recent additions of federally developed water supplying the western valley via the Tehama-Colusa Canal. The Sacramento River and its tributaries are the initial components of the conveyance system for federal and state water systems which, from the Delta southwards, delivers surface water via pumping plants and canals to the San Joaquin Valley and Southern California for agricultural, municipal, and industrial uses. Groundwater sources are also significant.

Cooler winters, higher rainfall, and less productive soils than the San Joaquin underlie the continued importance of field crops (38 percent of the 1995 value of production) in the Sacramento Valley. Rice is grown in areas with more impervious basin soils; wheat remains important in western foothill dryland farming areas; both wheat and corn are included in irrigated crop rotations; and alfalfa, sugar beets, dry beans, sunflowers, safflower, and vineseeds are among other important field and seed crops. Field corn is grown extensively in the Delta.

A variety of fruit and nut crops—mainly almonds, peaches, pears, prunes and walnuts—are grown on the deeper, better-drained and more fertile soils of the region. Fruits and nuts amount to 33 percent of the region's value of production. In 1995, vegetable crops, mostly processing tomatoes, contributed 16 percent, and livestock and livestock products, an additional 11 percent, of the regional production total.

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[11] The recent 1993 University of California Press book, *The Great Central Valley: California's Heartland* (Johnson, Haslam and Dawson), is an excellent photographic and narrative history of the region.

The San Joaquin Valley

About a third of California's farmland and 56 percent of its irrigated lands lie in the San Joaquin Valley. More than 80 percent of valley cropland is irrigated. The eight counties of the San Joaquin Valley accounted for $12.75 billion (58 percent) of the $22.1 billion total value of California agricultural production reported for 1995 (California Department of Food and Agriculture, 1996b). Unlike the Sacramento Valley, the San Joaquin does not have a single river system that runs through the entire valley. The southern portion of the valley was two lake basins, which historically were fed by seasonal runoff from the Sierra Nevada Mountains to the east. Early farming depended on private and cooperative development of water supplies from Sierra rivers to irrigate alluvial lands on the east side of the valley, and on the reclamation of the Tulare and Buena Vista Lake Basins in the south valley which brought more acreage into agricultural production. In the post-World War II period, federal and state surface water development brought further water supplies to the most southern area and to the entire western San Joaquin Valley, which had formerly depended on limited and often poor quality groundwater.

Because much of the valley is either of a desert or steppe climatic type, irrigation is the major factor that has made the San Joaquin the most extensive and productive of the agricultural regions of California. The west side of the San Joaquin Valley was the region most affected by the recent (1987–93) drought; consequently, this area is among the most innovative in implementing market transfer initiatives and adopting water-conserving irrigation technologies. Clearly the economic fate of this region, and the others, is closely tied to long run supplies of irrigation water and to current initiatives that seek to reallocate surface water supplies among competing agricultural, municipal and industrial, and nonconsumptive environmental uses.

With the majority of the state's agricultural production located in "The Valley," most kinds of production can be found somewhere within its confines. What is surprising is the diversity in types of farming enterprises, ranging from older, smaller, more intensively cultivated farms in the east to the larger, more extensive farms on the west. Fruit and nut crops, including grapes and citrus, are important to the region, contributing 39 percent of the total value of production in 1995. While the majority of permanent plantings (citrus, grapes of all sorts, almonds, walnuts, peaches, plums, nectarines, and other deciduous fruits) lies on the east side of the valley, recent plantings of nuts (almonds, pistachios) and some deciduous fruits have been made on the west side. Livestock (cattle and calves, poultry) and livestock products (milk, chickens, turkeys, eggs, and apiary products and services) are located throughout the valley and contribute an additional 28 percent of the region's agricultural production. Field crops (19 percent) are concentrated in the more recently developed areas of the region. Cotton is the most important field crop. Recent introductions of pima varieties have augmented traditional upland cotton production. The region is an important producer of most field crops (e.g., barley, dry beans, corn, hay, potatoes, sugar beets, wheat and oil crops). Irrigation and a long growing season have also led over time to increased vegetable production (12 percent). Summer melon production (cantaloupe, honeydew, watermelon) is important, as is seasonal production for many of the major vegetables (asparagus, beans, carrots, corn, garlic, lettuce, peppers, tomatoes). Some seasonal production is timed to fill marketing niches as the fresh produce industry moves in the spring from desert to coastal areas and in the fall back toward the desert. Of the major categories, nursery products and cut flowers appear relatively insignificant in comparison with the total value of agricultural commodities (2 percent). [12]

The Mountain Region

This region of the state is very similar to that of the North, being largely dominated by livestock and livestock related economic activity on private and leased public lands. The Mountain region covers about 15 percent of the state's land area, and land is mostly in public ownership; only 10 percent of the total land area is in farms. Together, livestock (39 percent), livestock products (6 percent), and field crops—mainly rangeland and pastureland production (31 percent), appear to amount to about three-quarters of the value of the region's agricultural activity in 1995. In truth, the dominance of these commodities in the region's agricultural economy is larger, due to the geographic location of fruit and nut production (mostly wine grapes), and nursery products in west slope foothill "valley" portions of several mountain counties.[13]

The South Coast Region

This region is still a base for significant agricultural production despite its progressive development as a largely urban population center. Los Angeles County was once the most important agricultural county in the United States, measured by the value of its agricultural production. Despite urbanization, 22 percent of the region's land area remains in farms, with often intense and complex interactions between agriculture and urban constituencies. The average size of farm is the smallest among state agricultural production regions, while the average value of farm products sold per acre is highest. With 62 percent of cropland irrigated, production is mostly high-valued nursery products, fruits, and vegetables.

High-valued crops grown in the South Coast area are those suitable to its moderate climate and usually frost-free growing seasons. High values are needed to rationalize the application of some of the highest-cost irrigation water in California. Nursery products, foliage and flowers are the most important economically of all product categories, making up 35 percent of the regional value of 1995 production. San Diego County alone produced $585 million of nursery products, foliage and flowers in 1995; indoor decoratives, ornamental trees and shrubs, and bedding plants and turf are the top three county production commodity classes reported. Avocados and citrus (lemons, grapefruit, oranges), strawberries, and wine grapes are the main fruit crops (33 percent). Vegetable production, some of which is seasonal before and after the winter desert production season, includes broccoli, celery, lettuce, and bell peppers. Egg production and dairying are the two major intensive livestock product enterprises.

[12] With such a rich agricultural industry it is easy to be deceived when dealing with relative magnitudes. While appearing to be relatively insignificant when compared to other agricultural products within the San Joaquin Valley, nursery products (mainly rootstock for trees, vines, and perennials) still amounted to about $50 million in the 1995 crop year.

[13] For example, the wine grape and fruit growing areas of El Dorado, Amador, and other mountain counties are really located in valley foothill areas on the Sierra west slope.

The South Desert

Including the eastern areas of the Los Angeles area (western San Bernardino and southwestern Riverside Counties), this region also extends across the more remote desert valleys—the Coachella, Palo Verde, and Imperial Valleys—irrigated by early diversion rights to Colorado River water. Only 28 percent of the land area is in private ownership, and only 11 percent of the land area is in farms. Because of the severe climatic conditions, a high proportion of cropland is irrigated—82 percent. The western San Bernardino and Riverside areas include remnants of the once-dominant citrus and drylot dairying industries, which are gradually being displaced by urban expansion.

Livestock and livestock product activities contribute the greatest proportion of the value of production in the South Coast region (42 percent) by capitalizing on the region's proximity to markets (poultry, eggs, dairying) and a long tradition of cattle feeding in the Imperial Valley and other desert valley areas. Vegetable production (26 percent of total value), predominantly in the irrigated desert valleys, includes important winter and early season production of asparagus, carrots, lettuce, melons, and sweet corn. Highly productive desert lands with irrigation benefit from nearly frost-free growing seasons and temperate winters to produce a variety of high-valued fruit and vegetable crops that are in supply in the off- and early seasons of the major production regions. Fruit production is mainly in the western areas and in the Coachella Valley (citrus, dates, table grapes, and deciduous fruits). Field crop production includes alfalfa hay production for the region's livestock activities, cotton, sugar beets, and wheat, including durum.

The Intensification of Agricultural Production

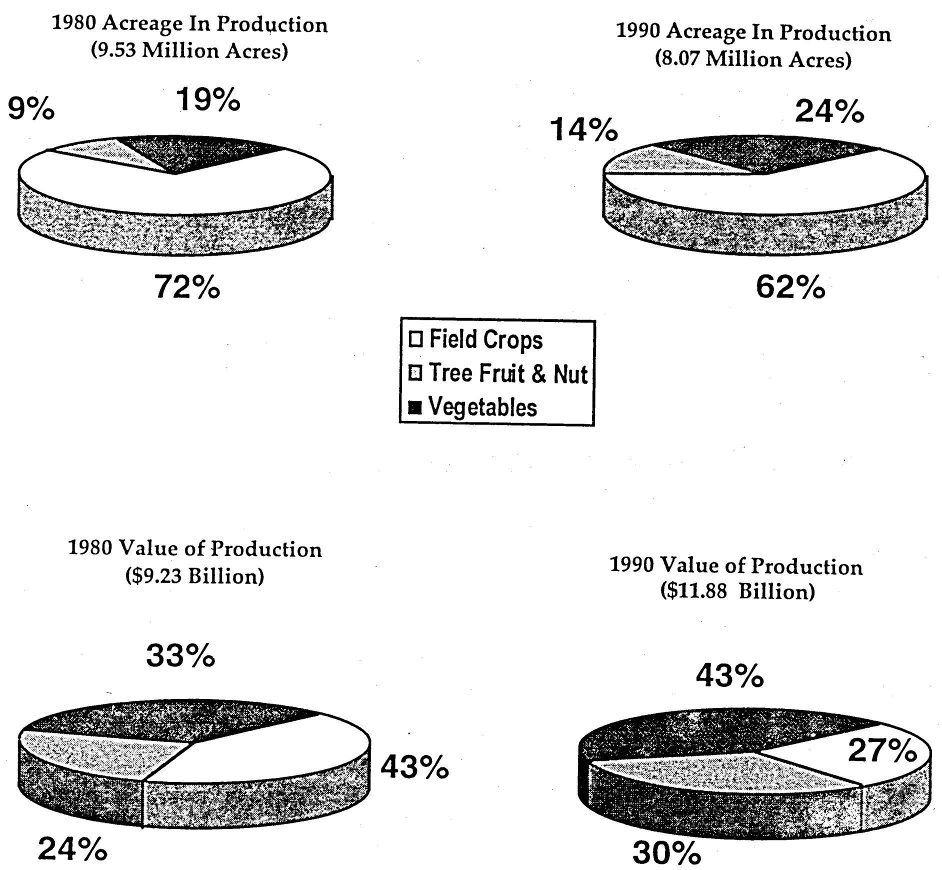
California agriculture continues to expand production of higher valued crops and products. The production environment is one of intense competition for land and water resources, ongoing needs for large amounts of capital for development, infrastructure, technology and production investments, and high levels of business and management skills. Capital flows into agriculture come not only from individual entrepreneurs but from institutions and outside investors who demand economic returns commensurate with evaluated levels of risk.

Risk is substantially greater in the production and marketing of perishable fruits and vegetables than in more stable commodities.[14] Investments in permanent plantings are large and must be paid back over the period of economic production. Figure 2 shows the pronounced change in the distribution of field crop, tree fruit and nut, and vegetable acreages and value of production over the decade of the 1980s. In 1980, production of fruit, nuts, and vegetables contributed over half of the value of production (57.7 percent), but only used 27.9 percent of the acreage in production. In 1990, these more intensive, higher-valued, higher-risk crops amounted to 73 percent of the value of production, while using 38.7 percent of acreage. The residual nature of field crops is evident as farmers and ranchers seek more intensive production enterprises. Shifts toward increased acreages of vegetables and permanent plantings continued through

[14] See Blank et al. for a discussion of the increased risk.

the decade of the 1990s, most noticeably with substantial increased acreages of nut crops (almonds, walnuts, pistachios), deciduous tree fruits (prunes, peaches), and wine grapes.

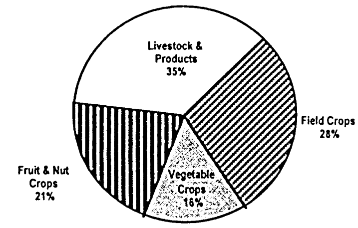
Figure 2. Harvested Acreage and Value of Production, California Field Crops, Fruit and Nut Crops, and Vegetable Crops, 1980 and 1990.



The composition of California agricultural production is compared for the years 1955, 1975 and 1995 in Figure 3. Change between 1955 and 1975 was not as dramatically different as that which has occurred over the last period, 1975–95, partly due to an overall increase in irrigated acreage through most of the first time period.[15] By 1995, high-valued fruit and nut, vegetable, and nursery and greenhouse products contributed 60 percent of the aggregate value of production for the state. Field crop and livestock/livestock product categories were reduced by about one-half and one-third, respectively, in terms of their relative contribution to the value of California agricultural production.

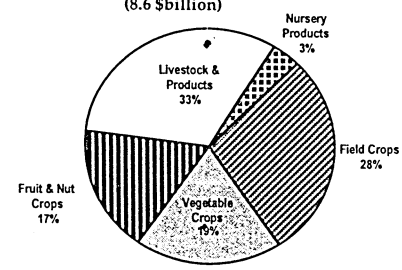
Figure 3. The Composition of California Agricultural Production, 1955, 1975 and 1995.

California Cash Receipts from Farm Marketing, 1955
(2.6 $billion)



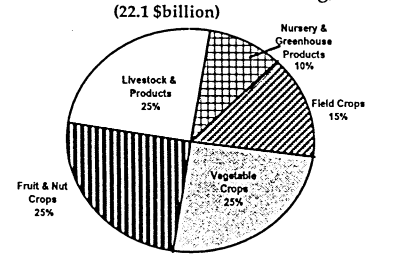
Source: California Crops and Livestock Reporting Service, 1957

California Value of Production from Marketing, 1975
(8.6 $billion)



Source: California Crops and Livestock Reporting Service, 1976

California Cash Income from Marketing, 1995
(22.1 $billion)



Source: California Department of Food and Agriculture, 1996 b.

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[15] For example, the State Water Project began agricultural water deliveries to the west side of the San Joaquin Valley and to Kern County in the south in the late 1960s.

CALIFORNIA'S "TOP TWENTY" CROP AND LIVESTOCK COMMODITIES

The shifting composition of agricultural production is also reflected in changes in the state's "Top Twenty" agricultural commodities over time. Table 2 shows the "Top Twenty" commodities ranked by gross farm income for the 1995 crop year, with comparisons for 1975 and 1961. Comparison of the 1961 and 1995 lists show that whereas there were a total of 12 livestock, livestock products, and field crops identified in 1961, only 7 were on the 1995 list. In sharp contrast, there are now 11 fruit, nut, and vegetable crops on the 1995 list, compared to only 8 on the 1961 list. Nursery products and foliage and cut flowers have been added as well.

Milk and cream have risen to the top (so to speak) as California agriculture's highest gross income product. Grapes, the highest income fruit, and nursery products rank second and third; cattle and calves rank fourth. Cotton (#5) is the highest gross income field crop. Lettuce (#6) and almonds (#7) are the highest grossing vegetable crop and nut crop, respectively.

In the following sections, a selective description is given for each of California's "Top Twenty" agricultural crop and livestock commodities. For many commodities, the state's production is a significant and often dominant component of total U.S. production. Each section features a small map, which gives quick recognition to major areas of production. The stylized heading for each section is based on California Agricultural Statistics Service (CDFA 1996b) and California County Agricultural Commissioners' (1995) data. Narrative information draws heavily on sources that include Cook et al. (1994), Johnston (1985, 1994), and Scheuring (1983).

Table 2. California's "Top Twenty" Crop and Livestock Commodities: 1995, 1975, and 1961.

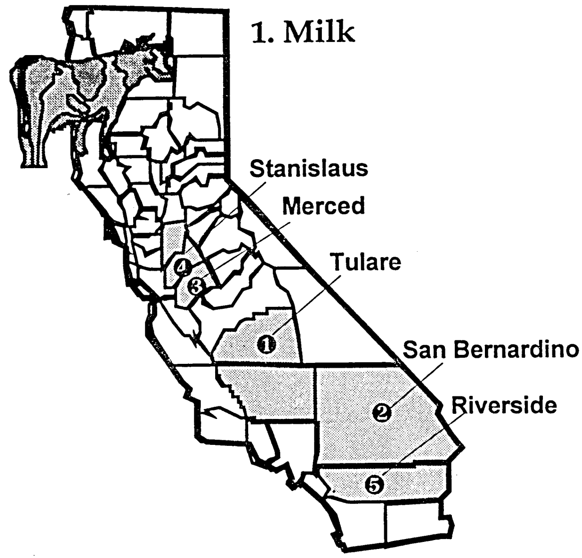
Agricultural Product	Commodity Ranking 1995	1975	1961
Milk and Cream	1	2	2
Grapes	2	4	6
Nursery Products	3	8	
Cattle and Calves	4	1	1
Cotton Lint	5	3[a]	3[a]
Lettuce, Head	6	10	10
Almonds	7	18	19
Hay	8	5	5
Tomatoes, Processing	9	6	7[b]
Flowers and Foliage	10	14	
Strawberries	11	19	18
Oranges	12	13	8
Chickens	13		20
Rice	14	9	12
Broccoli	15		
Walnuts	16		
Eggs, Chicken	17	7	4
Carrots	18		
Celery	19		
Cantaloupe	20		
Sugarbeets		11	15
Wheat		12	
Barley		15	9
Peaches		16	14
Potatoes		17	13
Tomatoes, fresh market		20	
Turkeys			11
Prunes			16
Beans, dry			17

[a]Cotton lint and seed.
[b]Processing and fresh market tomatoes.

Source: California Crop and Livestock Reporting Service, 1962 and 1976. California Department of Food and Agriculture, 1996.

1. Milk and Cream

- 16 percent of U.S. milk production;
- 1995 gross farm income: $3,078 million;
- Top five counties—65% of value of production: Tulare, San Bernardino, Merced, Stanislaus, Riverside;
- Other counties with >2.5% of state production: Kern, Kings, San Joaquin.



California is now the number one milk producer in the United States. California's dairies and the dairy processing sector are part of a dynamic system that has progressively become more efficient, larger, and more specialized over its history. Herd sizes are, on the average, 10 times larger than the national average, and cows are, on the average, significantly more productive. Dairy processing capacity has at least doubled during the 1990s.

The state's dairy industry has evolved from "local dairies" that originally provided fluid milk to the state's growing population centers in the San Francisco and the Los Angeles area milksheds. The San Joaquin Valley milkshed was first a center for lower-valued manufacturing milk used mainly for butter and cheese. With improved transportation systems and reduced land available for dairies in or near the main population centers, the San Joaquin Valley is now the major source of fluid milk serving both the Bay Area and the Los Angeles Basin, and processing continues to be concentrated there. Continuing urbanization and waste disposal challenges have caused more dairies to move into the San Joaquin Valley and into San Bernardino, Riverside and Imperial Counties.

California's dairies are highly specialized. As the number of dairies decreased, their size has become significantly larger, requiring more capital-intensive specialized systems based on genetics, herd health, nutrition, and high levels of management. Urban expansion in the Los Angeles area led to the development of the drylot, feedlot-style dairy using concentrates and feedstuffs often grown in other areas. Modern dairies often milk 2,000 or more cows daily and use waste effluents and solids on silage and forage crops on adjacent cropland.

California operates three separate state marketing orders for pricing and pooling purposes. A multiple milk component pricing system is used in establishing prices paid to producers for Class I fluid milk.

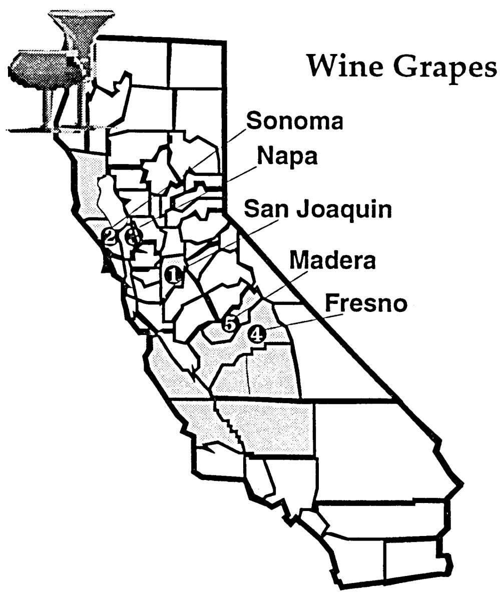
2. Grapes

- 88 percent of U. S. production;
- 1995 gross farm income: $1,839 million.

Grapes are produced throughout most of California for one of three end uses—the wine crush, the fresh table grape market, or dried raisin production. Each requires a production system specifically designed to maximize the economic potential of the vineyard for the chosen market. Grape varieties have limited ability to fit more than one market use, although the Thompson seedless variety is able to be used for both table grapes and raisins, and sometimes crush, depending on market conditions. California grape production is important to domestic and foreign consumers. Among California agricultural exports, ranked by export value, wine is #6, table grapes #7, and raisins #9.

Wine Grapes

- 95 percent of U.S. production of grapes crushed for wine;
- 1995 value of production: $1,206 million;
- Top five counties—62% of 1995 value of production: San Joaquin, Sonoma, Napa, Fresno, Madera;
- Other counties with >2.5% of state production: Kern, Mendocino, Merced, Monterey, Sacramento, San Luis Obispo, Stanislaus, Tulare, Yolo.

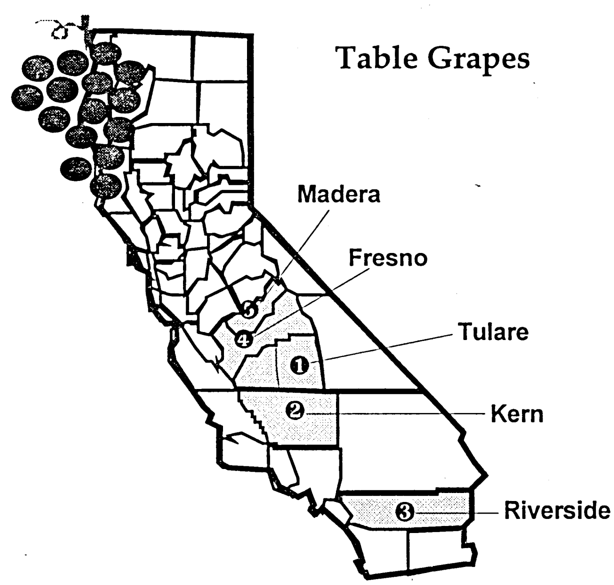


Wine grape production occurs throughout the state. California's premium wines come from grapes grown predominantly in cooler, coastal valleys, most notably in the Napa Valley, but also in other North Coast areas (Sonoma and Mendocino Counties) as well as in some Central Coast areas. Higher yielding vineyards in the San Joaquin Valley produce standard and mid-quality table wines often marketed in larger-sized bottles and containers.

The California wine-grape vineyard and wine-production industries have grown sporadically over the last half century. Following World War II, about 80 percent of the wine produced was in the fortified appetizer or dessert wine category with production chiefly in the San Joaquin Valley. Americans did not then know much about quality wines, but gradually, as tastes changed, the industries also changed toward the production of both standard table and world-class premium quality wines. Bearing acreage increased from about 120,000 acres in the early 1960s to over 300,000 acres by the mid-1990s. Rapid expansion occurred in the 1970s. The current expectation is that another 100,000 acres may be brought into production within the next five years, including many replanted acres replacing diseased or economically obsolete vineyards in the premium areas. The specter of oversupply is of concern, as the new and potentially higher yielding vineyards incorporating disease-resistant rootstocks and up-to-date trellising, irrigation, and management systems come into production. Much of the new acreage is in the premium varieties currently in favor: Merlot, Chardonnay, Cabernet Sauvignon, and Zinfandel.

Table Grapes

- 98 percent of U.S. production of fresh grapes;
- 1995 value of production: $936 million;
- Top five counties—99% of 1995 value of production: Tulare, Kern, Riverside, Fresno, Madera.

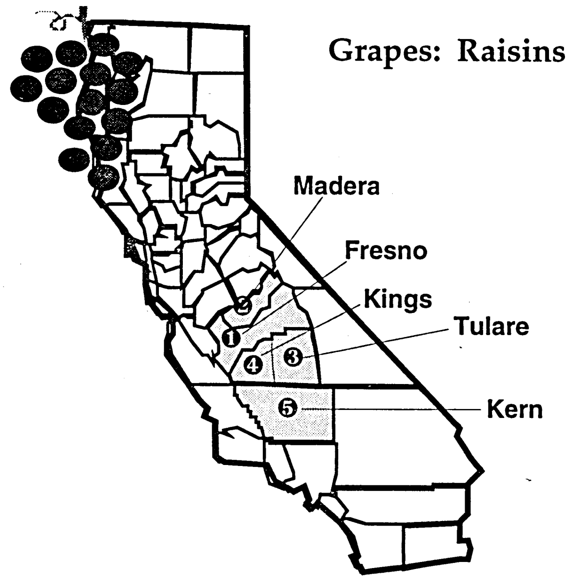


Some grape varieties are better for fresh use because of certain combinations of characteristics: attractive appearance, large berries, good eating quality, and resistance to injury when handled, shipped, and stored. Fresh grapes are among the nation's most popular fruits in terms of quantity consumed, and they are second, following bananas, in sales value.

California table grapes are harvested from late May through late fall. Harvest begins in the desert regions, primarily in the Coachella Valley in Riverside County, and continues in the San Joaquin Valley, beginning first in Kern County and moving northward through the summer and fall. With careful treatment, California grapes may be enjoyed through March of the year following harvest. Many grower-shippers are involved in production and packing throughout the California season, and some are also involved in operations in the Southern Hemisphere, assuring the marketing of products under their labels in the U.S. on a year-round basis.

Raisin Grapes

- 99+ percent of U.S. production of dried grapes;
- 1995 value of production: $364 million;
- Top five counties—99% of 1995 value of production: Fresno, Madera, Tulare, Kern, Kings.



A substantial portion of the world's raisin supply comes from the San Joaquin Valley. The Thompson Seedless grape is the major raisin grape variety. Besides making excellent raisins, Thompsons are very important on the fresh market and were once important for wine blending. Most of California's raisins are grown within a 75-mile radius of the city of Fresno, where climatic conditions are usually ideal for raisin-drying, with over 200 hot, dry days a year. Most of California's raisins are still dried by the traditional method of laying them out in the sun. Much hand labor is required. The acreage and production of raisin varieties has not changed significantly over the past several decades.

3. Nursery Products

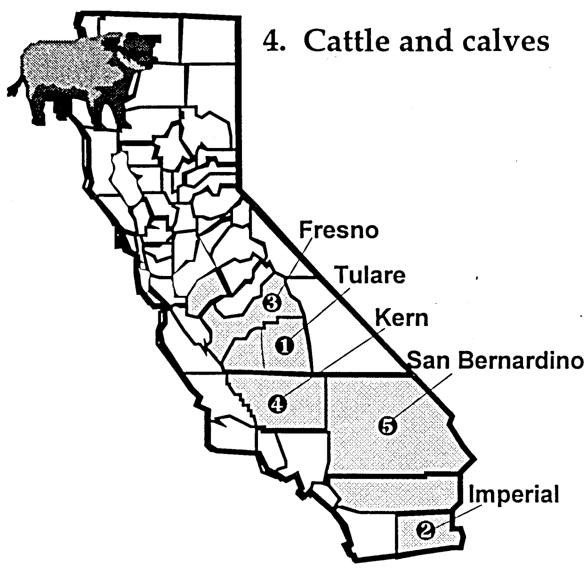
- 25 percent of U.S. production;
- 1995 gross farm income: $1,500 million;
- Top five counties—27% of value of production: San Diego, San Mateo, Kern, Ventura, Riverside;
- Other counties with >2.5% of state production: Los Angeles, Monterey.

Nursery production includes products for both urban and agricultural uses, bedding plants and transplants, seeds, bulbs, potted plants, propagative materials, rootstock, trees, vines, turf, and woody ornamentals. The category "deciduous and evergreen trees, shrubs, and vines" is the largest valued component. Because about 10 percent of the U.S. population calls California its home and the population continues to increase, part of the demand for nursery products arises from residential and urban development and the growth of the state's economy. Much of the nursery industry is located in areas accessible to large urban markets.

California's agriculture is also a source of demand for both annual and perennial plants and trees, e.g., vegetable transplants, strawberry plants, seeds of all kinds, rootstock for trees, and young nursery stock for new plantings and replacements of vines, tree fruits, and nuts. The types of firms producing nursery products vary widely, including extensive field operations, outdoor nurseries, and intensive greenhouse operations.

4. Cattle and Calves

- 5 percent of U.S. production;
- 1995 gross farm income: $1,290 million;
- Top five counties—52% of value of production: Tulare, Imperial, Fresno, Kern, San Bernardino
- Other counties with >2.5% of state production: Riverside, Kings, Merced.



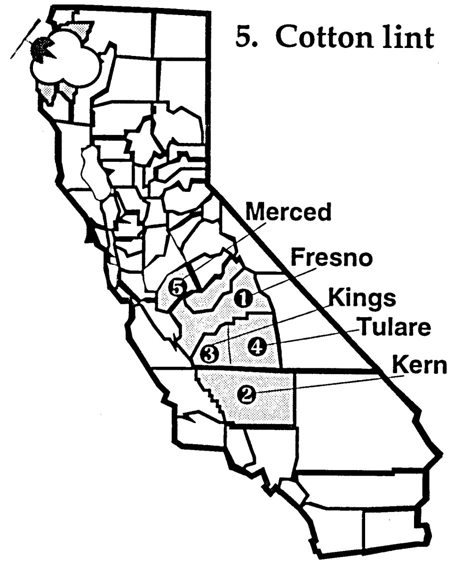
Cattle and calves were California's #1 agricultural commodity until 1980, when the number one position was taken by milk. Later, grapes and nursery products moved ahead of cattle and calves as well. Almost all breeds of beef cattle are raised in California. The dairy sector contributes a significant quantity of steers, culled cows, and bulls as animals marketed for beef.

More than two-thirds of the state's land area is essentially nontillable because of steep slopes or poor soils. These areas are typically used as rangeland for cattle. In addition, cattle are raised on irrigated pasture lands in the foothill areas and on marginal agricultural lands in the Central Valley. The cattle feeding industry is located primarily in the Imperial and San Joaquin Valleys.

Climate, topography, and overall conditions vary widely within the state, as do the sizes and types of cattle operations. Some are purely cow-calf operations, while others buy and sell animals as stockers, replacements, or feeders to fit the carrying capacity of owned and leased lands. All areas present separate and distinct challenges to cattle production in terms of rainfall, temperature patterns, topography, breeding and calving conditions, transportation, marketing, urban development, and cattle rustling and vandalism.

5. Cotton Lint

- 14 percent of U.S. production;
- 1995 gross farm income: $1,064 million;
- Top five counties—95% of value of production: Fresno, Kern, Kings, Tulare, Merced;
- Other counties with >2.5% of state production: Madera.



Cotton is the most important field crop grown in California. The state produces both upland and pima cotton, with American upland the predominant type grown on about 1.1 million acres. It has a worldwide reputation as the premium medium staple cotton, with consistently high fiber strength useful in many apparel fabric applications. American pima is an extra-long staple (ELS) cotton, the acreage of which has been expanding following its recent introduction into the San Joaquin Valley. Plantings are currently about 150,000 acres. Export markets are important, attracting as much as 80 percent of California's annual cotton production in some years and making cotton California's #2 export crop.

Cotton is well suited to the San Joaquin Valley's long-growing seasons and warm temperatures, which are conducive to high yields. Key concerns of growers are the availability and cost of irrigation water, disease outbreaks, and pest infestations. Elimination of commodity programs now offers producers planting flexibility which, along with the presence of more reliable water supplies, has drawn attention to the western Sacramento Valley as a potential new production area.

6. Lettuce

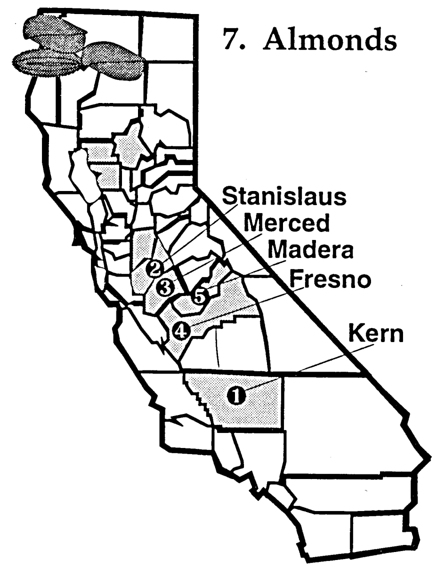
- 69 percent of U.S. head lettuce production;
- 82 percent of U.S. leaf lettuce production;
- 1995 gross farm income: $987 million;
- Top five counties—76% of value of production: Monterey, Imperial, Fresno, Santa Barbara, San Luis Obispo;
- Other counties with >2.5% of state production: Kern, Santa Cruz, Ventura.

California produces lettuce in approximately equal quantities each month in different areas of the state. Consumer demand for lettuce is relatively inelastic, and prices vary widely for this perishable commodity depending on acreage and weather-dependent supply conditions. Large grower-shippers operate in the several production areas in California and Arizona, moving with the seasons. The nation's "salad bowl" is the Salinas Valley in Monterey County, where lettuce is harvested from April through early November. Other coastal areas produce during the same period. The Imperial Valley and other desert areas ship from early December until mid-March. Production on the west side of the San Joaquin Valley fills the market niches between the two major production areas.

Field packing, vacuum cooling, and refrigerated transportation are key components requiring coordination for moving lettuce from the field to the consumer with minimal post-harvest loss in quality. Development of value-added pre-package salad greens has reduced shipments of "Iceberg" head lettuce and effectively increased the demand for other greens, including leaf lettuce. Lettuce is California's #10 export crop, mainly to Canada.

7. Almonds

- 99+ percent of U.S. production;
- 1995 gross farm income: $858 million;
- Top five counties—69% of value of production: Kern, Stanislaus, Merced, Fresno, Madera;
- Other counties with >2.5% of state production: Butte, Colusa, Glenn, San Joaquin.

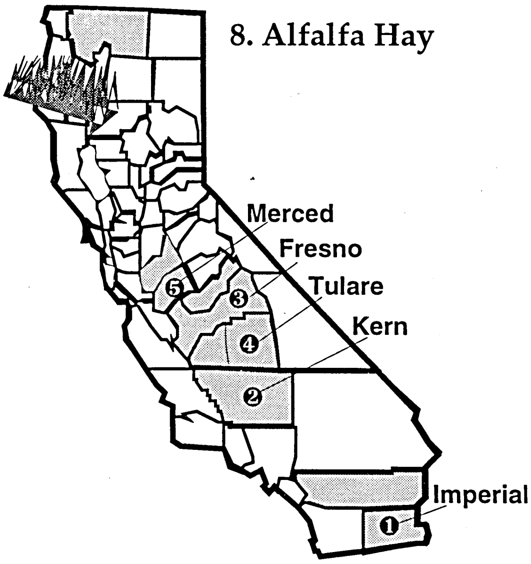


California's almond trees were once typically planted on non-irrigated foothill lands, but today's producing orchards are located on irrigated lands in the Central Valley. Changes in rootstock and improved management were required for the shift to irrigated production. New varieties have been developed to meet rising consumer demands for almonds worldwide. It is California's #3 export crop.

While many factors contribute to the growth of any commodity, two are important in understanding the quadrupling of almond acreage from 100,000 acres in the 1960s to 400,000 bearing acres by 1985. One was product development and marketing with innovative value-added products, such as small tins of flavored almonds easily used as snack food attractive to consumer tastes, that led to expanded markets of "new" almond products. The second factor was the beginning of irrigation deliveries from the California Water Project to areas in the San Joaquin Valley, beginning in the late 1960s. By 1970, the major areas of almond production had moved from the Sacramento to the San Joaquin Valley, and most of the expansion since then has been primarily in the San Joaquin, where new plantings have higher yields because of better soils, climate (less rainfall and warmer temperatures at bloom), irrigation, and improved management and cultural systems.

8. Hay

- 6% of U.S. production;
- 1995 gross farm income, all hay: $847 million;
- Top five counties, alfalfa hay—52% of value of production: Imperial, Kern, Fresno, Tulare, Merced;
- Other counties with >2.5% of state production: Kings, Madera, Riverside, Siskiyou, Stanislaus.



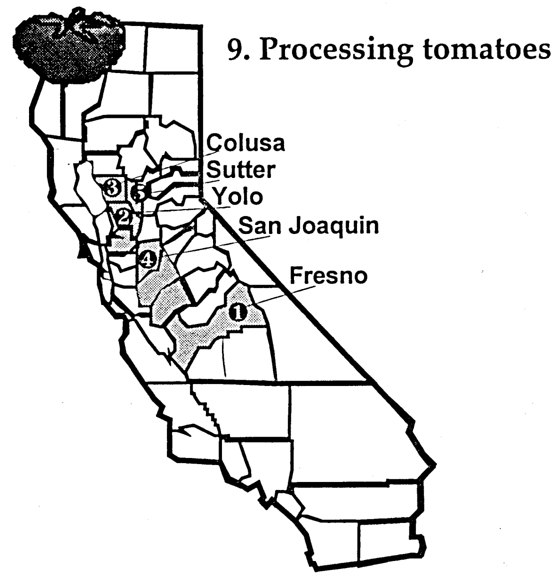
Hay as a commodity category includes alfalfa hay, grain hay, green chop, sudan hay, and wild hay, but alfalfa is by far the most important component, contributing about 85 percent of the value of all hay production. Alfalfa hay acreage in California has averaged about a million acres, but is influenced by profitability of alternative annual crops (e.g., cotton, tomatoes), trees, and vines. The demand for alfalfa hay is determined to a large part by the size of the state's dairy herd, which consumes about 70 percent of the supply. Horses consume about 20 percent.

Alfalfa hay is grown in every climatic zone of the state. Climate determines the number of cuttings of hay. In the low desert there are as many as 8 to 10 cuttings per year; in the cool northern intermountain region, farmers harvest only 2 to 4 cuttings a year. Most of the crop is not used on the farm where it is produced, but is usually baled and shipped to end users. Pellets and cubes are other forms for equines and export markets.

Alfalfa, a perennial crop with a three- to five-year economic life, does best when planted on well drained, deep, medium-textured soils. Because it is a highly water-intensive crop, its production cost will be directly affected by higher water prices and pumping costs, reducing the long-term profitability of the crop in the state's crop mix. However, its importance in crop rotations will remain because of its beneficial effects on the soil.

9. Tomatoes, Processing

- 93 percent of U.S. production;
- 1995 gross farm income: $672 million;
- Top five counties—78% of value of production: Fresno, Yolo, Colusa, San Joaquin, Sutter;
- Other counties with >2.5% of state production: Solano, Stanislaus, Merced.



In 1950, California production of 2 million tons of processing tomatoes accounted for only 36 percent of U.S. production. The combination of favorable climate, good soils, ample water, an excellent highway system, applied technology, and research and development has allowed the industry in California to grow to produce 10.6 million tons in 1995.

Tomato production is specialized and capital-intensive. Growers contract with processors for tonnage to be delivered to meet the processor's schedule. Processors specify delivery dates and varieties with desirable components, such as low pH, high soluble solids, high vitamin A and C content, and good color, flavor, and peelability. Processing has changed from consumer products produced at multi-product plants to single product (paste) production at specialized "industrial plants" where tomato paste product is packaged in aseptic plastic containers in boxes and drums and shipped throughout the year to end users. Paste is simply a commodity bought and further processed into final consumer products—catsup, sauces, soups, etc.

Processing tomatoes are produced from the Mexican border to the northern Sacramento Valley. Harvest begins in the desert valleys in mid-June and continues northward in the Central Valley through September. A late harvest ends in the southern coastal counties in November. All processing tomatoes are harvested mechanically.

10. Flowers and Foliage

- 21 percent of U.S. production;
- 1995 gross farm income: $672 million;
- Top five counties— 72% of value of production: San Diego, San Mateo, Santa Barbara, Monterey, Santa Cruz;
- Other counties with >2.5% of state production: Orange, San Luis Obispo.

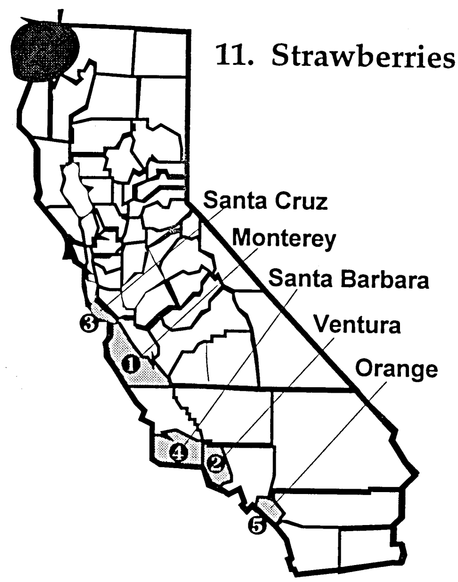
Flowers and greens are sold in cut and in potted forms. The major areas of production are the coastal counties where the typical mild climate permits outdoor production and lower-cost greenhouse operations. The major production areas of cut flowers are in the counties surrounding San Francisco Bay and extending to Salinas, and in the coastal regions of San Diego and Santa Barbara Counties.

The marketing of cut flowers in California is extremely intricate and complex. Although air shipments are used for transcontinental deliveries, most cut flowers are now precooled and shipped by refrigerated trucks. Increased imports, particularly from Columbia and Mexico, are a concern to California greenhouse growers of the three main cut flowers—roses, chrysanthemums, and carnations. The three have historically accounted for as much as two-thirds of the annual income from cut flowers and cut greens.

Potted plants, including the seasonal items—poinsettias, lilies and hydrangeas—are favored as consumers bring flowers and greenery into residences and offices. There are now more than 250 species and varieties of foliage plants being offered for sale in the trade.

11. Strawberries

- 77 percent of U.S. fresh market production;
- 86 percent of U.S. processing production;
- 1995 gross farm income: $552 million;
- Top five counties—93% of value of production: Monterey, Ventura, Santa Cruz, Santa Barbara, Orange.

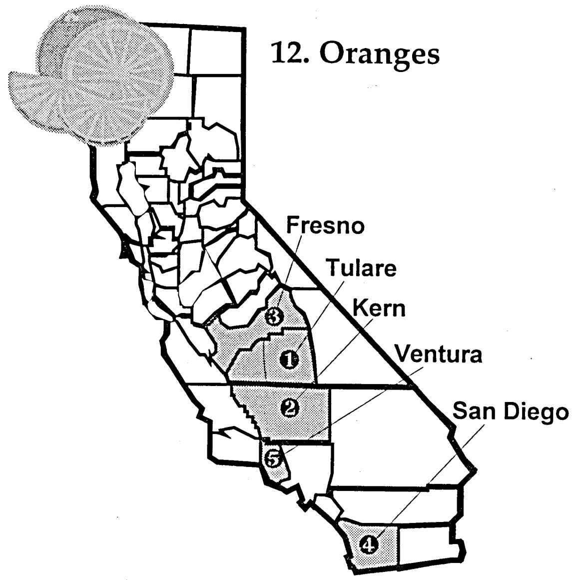


About 70 percent of the California strawberry crop is sold fresh; the remainder is sold for processing. Production of California strawberries runs from mid-February through mid-November and occurs in several growing areas along the southern and central coast. Even though strawberry plants are perennials, growers replant annually to obtain maximum yields and the best quality of fruit. Development of new varieties from an industry-supported fruit breeding program at the University of California has been important to the growth of the California strawberry industry.

Strawberries are one of the most capital- and labor-intensive crops. Perishability and vulnerability to disease, weather, and market conditions make it a very risky crop to grow and sell. Labor issues and the loss of methyl bromide fumigation are current concerns of California growers.

12. Oranges

- 19 percent of U.S. production;
- 1995 gross farm income: $458 million;
- Top five counties—82% of value of production: Tulare, Kern, Fresno, San Diego, Ventura.

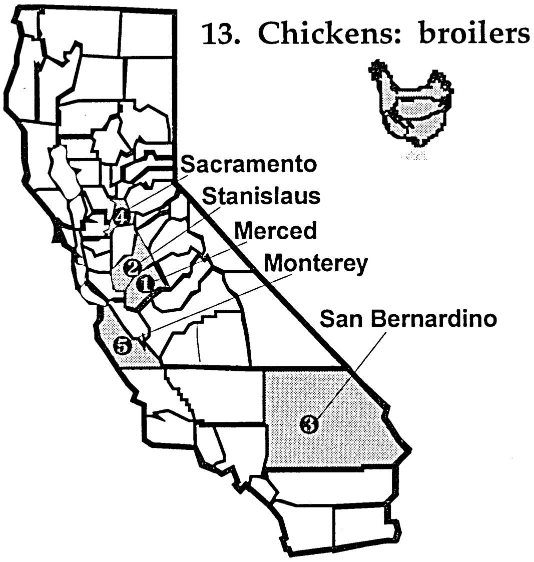


California oranges are produced primarily for fresh consumption and not for juice. The two varieties that are grown, the Washington navel and the Valencia, provide for a year-round harvest of oranges. Valencias are primarily a summer fruit, navels a winter fruit, though the navel and Valencia fresh marketing seasons do overlap some in the spring.

Following World War II, Valencia production in Southern California, primarily in Los Angeles and Orange Counties, was reduced by the combination of urbanization, industrialization, and virus disease. To fill the need for greater production, citrus plantings were expanded on the east side of the central and southern San Joaquin Valley. Most of those plantings were navel oranges. The San Joaquin Valley now is the larger of the two production areas, and navels are the dominant variety. Although a major freeze in December 1990 did much damage to citrus trees (some groves had to be replanted), most groves quickly returned to production. New plantings have occurred in the 1990s.

13. Chickens

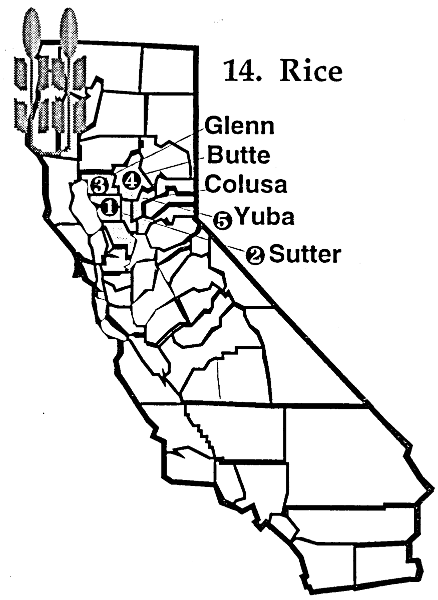
- 3 percent of U.S. broiler production;
- 1995 gross farm income: $384 million;
- Top five counties—99% of value of production: Merced, Stanislaus, San Bernardino, Sacramento Monterey.



Consumer demand for chicken, the most economical meat available, has risen markedly over the past decade. California broiler production is concentrated in the upper San Joaquin Valley; Merced and Stanislaus alone accounted for nearly half of the statewide value of production in 1995. The industry is highly concentrated, with several firms accounting for a large majority of broilers processed from either company-owned or contract ranches. Processors are fully integrated from placement of chicks at grow-out facilities to the marketing of branded products at retail stores. Most of the broilers produced in California are sold fresh-dressed and command a premium price compared with frozen fryers imported from other U.S. production areas.

14. Rice

- 20 percent of U.S. production;
- 1995 gross farm income: $318 million;
- Top five counties—87% of value of production: Colusa, Sutter, Glenn, Butte, Yuba;
- Other counties with >2.5% of state production: Placer, Yolo.

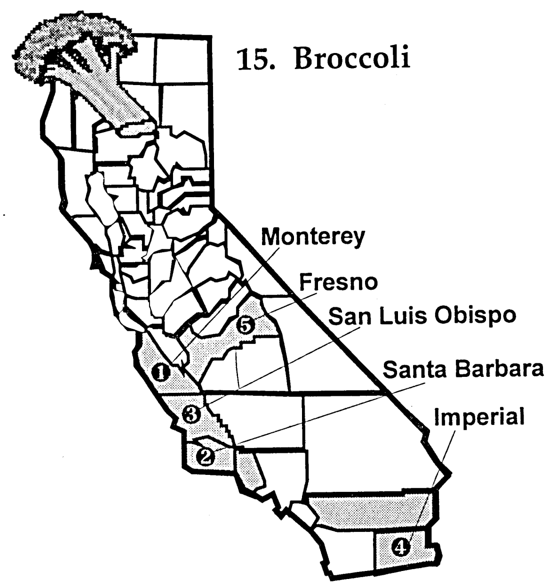


Two market classes of rice are produced in California: pearl or short grain, and medium grain rice. Most of the state's rice production is on heavy, clay basin soils requiring large tractors and heavy-duty implements. Seeding, fertilization, and insect and weed control are commonly done by air While some rice land is suitable to other crops, rice is usually grown year after year on the heavier soils, primarily because these soils are not well-suited to other crops.

High quality irrigation water, good drainage, and hot summers favor rice production in the Sacramento Valley. Clay soils require relatively less water for continuous flooding. Although commonly regarded as a water-intensive crop, rice actually requires no more water than several other summer crops when grown on heavy soils, in laser-leveled basins, and with good water management practices. Water availability, environmental concerns, and changes in public policy are key concerns of the industry. Recent environmental regulations that minimize the burning of rice straw have resulted in the increased winter flooding of fields, which has brought about increased wildlife habitat, mainly for migrating waterfowl.

15. Broccoli

- 88 percent of U.S. production;
- 1995 gross farm income: $318 million;
- Top five counties—89% of value of production: Monterey, Santa Barbara, San Luis Obispo, Imperial, Fresno;
- Other counties with >2.5% of state production: Riverside, Ventura.

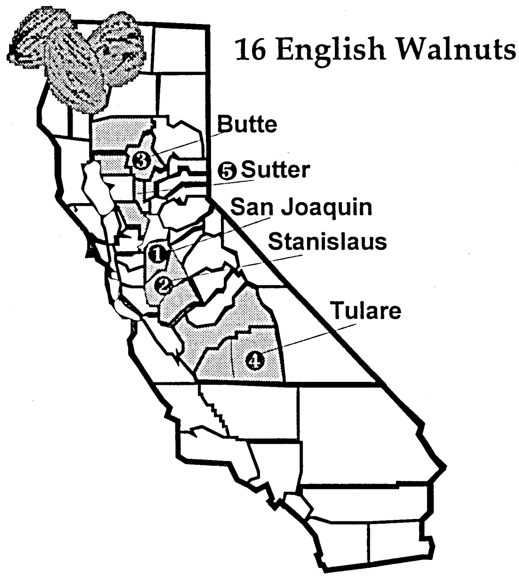


U.S. per capita consumption of broccoli has increased faster than any other vegetable over the last two decades. Fresh consumption increased almost sevenfold between 1970 and 1990, while processed use (mostly frozen) more than doubled. In 1970, disposition of the California crop grown on about 30,000 acres was about two-thirds to processed use, one-third to fresh marketings. By 1987 acreage increased to 108,000 acres, with three-fourths of the crop going to fresh use. Acreage has since fallen to about 90,000 acres because of the loss of processing capacity to Mexico. The processing market is now regarded as a residual outlet for the crop whenever fresh prices are less favorable. Fresh use now constitutes over 90 percent of California production, with shipments made to both domestic and export markets.

California growers have a climatic and marketing advantage over other regions by being able to ship fresh broccoli year-round. New varieties have spread production of this cool season crop to other areas. The Salinas Valley and the Santa Maria area in Santa Barbara County ship fresh broccoli all year, while seasonal production occurs in the desert valleys and on the west side of the San Joaquin Valley. New broccoli-like varieties, e.g., broccoli-cauliflower crosses, are finding growing consumer acceptance.

16. Walnuts

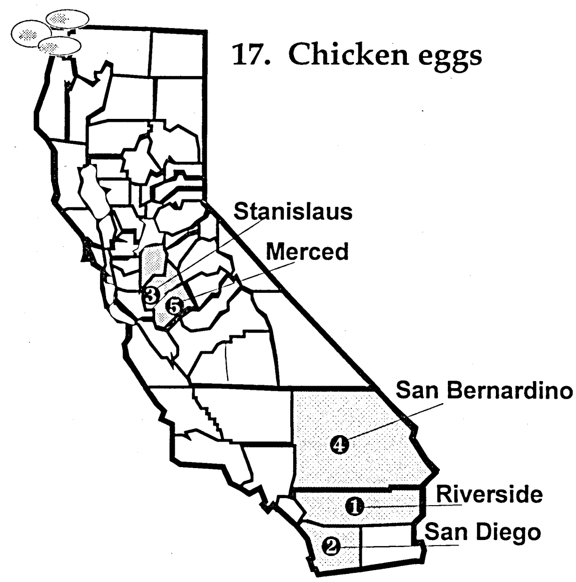
- 99+ percent of U.S. production;
- 1995 gross farm income: $314 million;
- Top five counties—62% of value of production: San Joaquin, Stanislaus, Butte, Tulare, Sutter.
- Other counties with >2.5% of state production: Fresno, Glenn, Kings, Merced, Tehama, Yolo, Yuba.



English (or Persian) walnuts were once grown mainly in Southern California, but acreage has now almost disappeared because of higher production costs, increased competition from alternative crops, pest infestations, and rapid urbanization. Central Valley walnut acreage now dominates production because of relative freedom from urban pressure, less costly land and water, and fewer diseases. Once considered a seasonal "holiday" item, walnuts are now in wide demand for usage by bakers, confectioners, ice cream manufacturers, and households. Marketing efforts for both shelled and in-shell products have successfully encouraged year-round walnut consumption. Most of the crop is now sold in shelled form. About 30 percent of the crop is exported.

17. Eggs, Chicken

- 9 percent of U.S. production;
- 1995 gross farm income: $288 million;
- Top five counties—65% of value of production: Riverside, San Diego, Stanislaus, San Bernardino, Merced;
- Other counties with >2.5% of state production: San Joaquin.



Egg production is concentrated in interior areas of Southern California. Production in the northern San Joaquin Valley is closer to San Francisco Bay Area markets. The concentration of production on fewer and larger farms has been encouraged by advancements in nutrition, breeding, mechanized feed handling, improved disease control, and the development of closely controlled housing environments. These advancements, combined with the breeding of hens for continuous laying, have resulted in consistent egg production all year. Eggs that are not sold in shell are broken for use in the baking or food industry.

18. Carrots

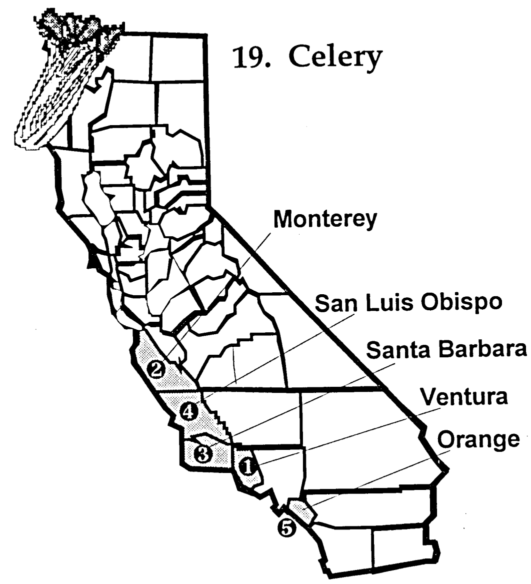
- 55 percent of U.S. production;
- 1995 gross farm income: $287 million;
- Top five counties—93% of value of production: Imperial, Kern, Monterey, Riverside, San Luis Obispo.

Carrots are another cool season crop that has seen an increase in demand, mainly for fresh use. Unlike some fresh vegetables, carrots are easy to grow, can be mechanically harvested, and are grown in other areas of the U.S. Carrots are produced in California year-round, with seasonal production moving from the desert valleys in the winter to the southern San Joaquin Valley and coastal areas for the longer part of the year. Carrots grow best on well-drained, sandy soils, which facilitate the growth of a premium product and the mechanical harvesting of the crop. In some areas there is intense competition among growers for suitable land.

California's share of U.S. carrots for fresh use was reported to be 71 percent in 1991. California acreage has doubled within the past two decades, partly in response to a new product, the "baby" carrot which has found recent rapid consumer acceptance, even as a snack food item. Two large, vertically integrated firms located in Kern County dominate the baby carrot industry from the production to the marketing of the ultimate product.

19. Celery

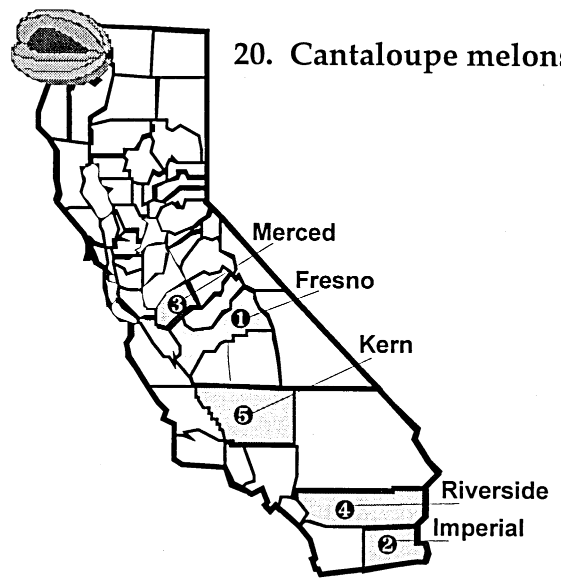
- 90 percent of U.S. production;
- 1995 gross farm income: $246 million;
- Top five counties—96% of value of production: Ventura, Monterey, Santa Barbara, San Luis Obispo, Orange.



While normally a biennial plant, celery is produced as an annual crop in today's agriculture. It is a year-round crop in California and is mostly marketed fresh. This is another vegetable crop where geographical and temporal diversification of production is the practice, assuring delivery of green celery throughout the year by many of the same grower-shipper firms. Harvest begins in early November in Ventura, Orange, and San Diego Counties, where it lasts until mid-July. San Luis Obispo and Santa Barbara Counties start in May, and the Salinas Valley begins in mid-June; harvests last until January. Within a given production region, growers stagger their harvests by planting a small amount of celery each week.

20. Cantaloupe Melons

- 65 percent of U.S. production;
- 1995 gross farm income: $237 million;
- Top five counties—96% of value of production: Fresno, Imperial, Merced, Riverside, Kern.



The cantaloupe is the most important muskmelon grown in California. Other muskmelons grown in the state include honeydew, casaba, Santa Claus, crenshaw and Persian melons, grown on smaller acreages. Cantaloupes are harvested from mid-May through November. Mexico is the dominant foreign source of cantaloupes, with peak shipments between December and April, when U.S. supplies are not available. About a quarter of the California cantaloupe crop comes from spring and fall production in the desert valleys of Imperial and Riverside Counties. That production has been threatened in recent years by white fly infestations. Summer melons, the bulk of California production, are grown in the San Joaquin Valley and harvested from late June through early October.

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Chapter 4

SCIENCE AND TECHNOLOGY IN CALIFORNIA AGRICULTURE

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California agriculture today is known around the world for its diverse product mix, remarkable productivity, and technological sophistication. It is also known for its large-scale farm firms, vertical coordination in food marketing and processing, and, less happily, its environmental problems and farm-labor concerns. The development and adoption of improved technology has been a central element in all of the changes during the twentieth century that have led to the marvel that is today's California agriculture, and the problems that it faces entering the twenty-first century. Technology is likely to be the solution to many of these new problems as well.

In this chapter we review the role of new technology in the development of California agriculture emphasizing the period since World War II. First, we document the changes in the inputs and outputs over the 1949–91 period showing the general trend to save land and labor, to increase the use of capital and purchased inputs, and to increase the output of all categories, but especially vegetables, and nursery and greenhouse marketings. Along with the growth in measured productivity, there have been some important changes in the structure of agriculture as well as in the nature of farms and farming, with a trend to fewer and larger, more specialized farms being an important element of the structural change.

The second part of this chapter focuses on the evolution and adoption of various technologies in California agriculture. California is a part of the United States, and its agriculture has shared in many general developments such as the mechanical innovations that displaced the horse over the first half of this century, and other nationwide chemical and biological advances; still, California agriculture remains unlike farming in most of the rest of the country in many ways. We describe major changes in the elements of technology that have facilitated California agricultural development, using examples of mechanical harvesters, pest-control strategies, and irrigation technology. We also discuss some examples of integrated systems involving multiple elements of production technology and marketing—such as the development of tomato varieties that could withstand mechanical harvesting, and the development of new strawberry varieties along with pest-control and production technology to match market requirements.

In the last part of the chapter we consider the sources of new agricultural technology and the role of government in providing resources for research and development, as well as institutional structures to facilitate private-sector activity.

TECHNOLOGICAL CHANGE AND CALIFORNIA AGRICULTURE

California agriculture today is very different from what it was in the gold rush years and through the early part of the twentieth century. In the early years, even in this century, there were few people to feed within California, and transportation costs and technology were such that perishable commodities were not economic to produce for shipment over long distances to the population centers in the East. The main focus of the state's agriculture was on producing grain under dryland conditions, either for human consumption or for livestock feed. Feeding horses was a primary role of California agriculture up through the 1920s. The development of irrigation, transportation infrastructure and technology, postharvest storage and handling technology and facilities, food preservation technology, and the growth of the state's population, along with the replacement of the horse by motorized vehicles, changed all that.

The seeds for the radical transformation of California agriculture during the twentieth century were sown in the last decades of the nineteenth century. In the first chapter of this volume, Olmstead and Rhode provide an overview of the history of California agriculture; they emphasize the role of technology.[1] We build on the foundation laid in that chapter. The key elements of technical change have included mechanization (including tillage technology, mechanical harvesters, bulk-handling, and transportation equipment), irrigation, agricultural chemicals (including fertilizers, pesticides, and hormones), improved varieties and other biological improvements, and improved management and information systems. These changes in technology have been made in conjunction with changes in the output and input mix, for related reasons.

Important elements of change in California agriculture have included:

1. increases in demand for specialty products in eastern urban markets;
2. improved transportation, especially the transcontinental railroad; and
3. California's participation, along with the rest of the world, in the adoption of widely applicable mechanical technology.

To these we can add the effects of more local factors, including:

4. the spread of irrigation;

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[1] More detail on the role of different elements of new technology in the development of California agriculture in the late 1800s and early 1900s is provided in other publications. The process of mechanization, introducing labor-saving machinery, has been going on since the 1870s (e.g., as described by Olmstead and Rhode (1988) in relation to the grain industry). Other technologies affected the balance of products produced more than the input mix. For instance, Rhode (1990) emphasizes the role of capital accumulation and biological learning. Musoke and Olmstead (1982) explain California's relatively rapid, early, and extensive adoption of the mechanical cotton harvester in terms of the environmental conditions prevailing in California.

5. the increased availability of "cheap" labor;
6. the importation of technology from other countries with similar climates through immigration, with immigrants bringing their human capital, knowledge, and favored plant varieties; and
7. the accumulation of knowledge about California's environment and suitable agricultural production practices.

The ingredients and sources of change in the post-World War II period, which is the focus of the present chapter, can be seen to a great extent as a continuation of the process that began fifty to one hundred years earlier.

Inputs, Outputs, and Productivity Patterns, 1949-1991[2]

Indexes of output in California agriculture in the post-World War II era are shown in Table 1. In terms of total agricultural output, California farmers produced over three times as much in 1991 as in 1949 (the index went from 100 to 318). Different components of agriculture grew at different rates at different times. For instance, greenhouse and nursery products grew almost tenfold (the index went from 100 to 917), while output of field crops (including wheat, rice, cotton, and corn) grew much more slowly (the index went from 100 to 282). There was considerable variation within individual categories, with some individual products growing very rapidly and others shrinking to negligible amounts. Thus the composition of California production changed markedly over the post-war period. Higher-valued products such as vegetables, greenhouse and nursery products, as well as fruits and nuts, account for a larger share of the value of agricultural output in the 1990s than they did in the immediate post-war period; the shares of livestock and field crops are smaller, accordingly, even though all sectors of California agriculture grew significantly over the period.

The use of inputs in California agriculture has also changed markedly over the post-war period, as seen in Table 2. California agriculture's use of purchased inputs (e.g., electricity, feed, fertilizer, fuels and oil, and seed) more than trebled from 1949 to 1991 (the index increased from 100 to 334). The use of capital services—including physical inputs such as automobiles, tractors, trucks and combines, as well as biological inputs such as dairy cows, ewes, and breeder pigs—grew by a little over 50 percent from 1949 to 1991 (an increase from 100 to 156). However, quality-adjusted land and labor use in agriculture actually declined over the same period. Land use fell by 8 percent (the index went from 100 to 92), while labor use decreased by 10 percent (the index went from 100 to 90). Across all input categories, the index of input use increased from 100 to 158 percent.

[2] Craig and Pardey (1996) have developed improved measures of indexes of agricultural outputs, inputs, and productivity based on the USDA's state-level data series. The figures in the text are derived from the Craig and Pardey data. The measures of inputs and outputs are quantity indexes (and therefore *real* rather than monetary measures) and are adjusted for changes in the composition and quality of their components.

Table 1. California Agricultural Output, 1949–91. (Indexes, 1949 = 100)

Year	Total Output	Field Crops	Fruits & Nuts	Livestock	Vegetables	Greenhouse & Nursery
1949	100.00	100.00	100.00	100.00	100.00	100.00
1950	101.82	94.54	99.90	106.48	105.57	105.94
1955	127.08	121.47	113.18	137.05	128.84	140.62
1960	144.79	159.01	107.14	161.21	140.52	195.64
1965	163.80	160.18	133.23	188.67	142.61	244.65
1970	177.08	168.61	132.78	209.05	169.98	277.54
1975	220.05	271.41	181.12	216.11	187.23	408.87
1980	260.42	314.77	232.80	245.27	202.70	606.96
1985	279.43	298.78	247.65	273.70	221.40	726.46
1990	315.10	293.81	248.04	337.71	270.95	962.04
1991	318.23	281.59	266.73	339.93	248.66	977.38
Growth Rate	---------- *percent per annum* ----------					
1949–60	3.36	4.22	0.63	4.34	3.09	6.10
1961–70	2.01	0.59	2.15	2.60	1.90	3.50
1971–80	3.86	6.24	5.62	1.60	1.76	7.83
1981–91	1.82	–1.01	1.24	2.97	1.86	4.33
1949–91	2.76	2.46	2.34	2.91	2.17	5.43

Source: Compiled by Alston and Zilberman using data provided by Craig and Pardey, 1996.

That the 218 percent increase in agricultural output was achieved with only a 58 percent increase in agricultural inputs is a reflection of the changing productivity of those inputs. Expressing *aggregate* output per unit of *aggregate* input provides a measure of productivity, as shown in Table 3. Productivity (the index of output divided by the index of inputs) in California agriculture doubled between 1949 and 1991 (from 100 to 201). This means that, if input use had been held constant at the 1949 quantities, using 1991 technology would have resulted in twice as much output as using 1949 technology.[3] Alternatively, to produce the output in 1991 using 1949 technology would require using twice as many inputs as were actually used. In other words, half of today's agricultural output is directly attributable to improved technology; the other half is attributable to conventional inputs.

[3] Although productivity growth is largely attributable to changes in technology, there may also have been other unaccounted for changes, such as infrastructure improvements, that contributed to the measured change in productivity.

Table 2. Input Use in California Agriculture, 1949–91. (Indexes, 1949 = 100)

Year	Input	Land	Labor	Capital	Purchased Inputs
1949	100.00	100.00	100.00	100.00	100.00
1950	101.58	100.20	100.91	105.63	101.57
1955	108.02	100.00	87.51	130.44	128.74
1960	122.71	98.60	88.12	146.32	178.42
1965	128.28	96.70	76.92	197.08	199.93
1970	119.90	93.01	68.39	124.74	221.56
1975	125.77	95.80	83.47	107.29	218.36
1980	136.23	99.90	76.16	133.73	266.11
1985	133.60	94.01	71.21	162.42	257.48
1990	155.19	92.11	87.05	158.73	325.64
1991	158.18	92.11	90.18	156.13	333.64
Growth Rates	---------------------------- *percent per annum* ----------------------------				
1949–60	1.86	–0.13	–1.15	3.46	5.26
1961–70	–0.23	–0.58	–2.53	–1.60	2.17
1971–80	1.28	0.71	1.08	0.70	1.83
1981–91	1.36	–0.74	1.54	1.41	2.06
1949–91	1.09	–0.20	–0.25	1.06	2.87

Source: Compiled by Alston and Zilberman using data provided by Craig and Pardey, 1996.

Growth rates of output, input use, and productivity have varied widely from decade to decade. The period of greatest productivity growth was during the 1970s when global commodity markets boomed. The 1980s was a decade of relatively slow growth in output and productivity. Based on similar data ending in 1985, Alston, Pardey, and Carter (1994) estimated that the rate of return to public-sector agricultural R&D in California, to which much of that productivity growth could be attributed, was around 20 percent per annum in real (inflation-adjusted) terms.[4]

[4] This estimate is lower than the estimates obtained in most studies of rates of return to agricultural research, which typically range from 40 to 60 percent per annum in real terms. Partly that is because Alston, Pardey, and Carter (1994) used conservative assumptions, which tended to result in lower estimates. They also showed that their estimate was relatively robust in that a similar rate of return was obtained regardless of the treatment of extension expenditures or allowances for private R&D roles.

Table 3. Productivity Patterns in California Agriculture, 1949-91.
(Indexes, 1949 =100)

Year	California Output	California Input	California Productivity	U.S. Productivity
1949	100.00	100.00	100.00	100.00
1950	101.82	101.58	100.24	97.90
1955	127.08	108.02	117.65	111.86
1960	144.79	122.71	117.99	121.23
1965	163.80	128.28	127.69	127.96
1970	177.08	119.90	147.69	143.07
1975	220.05	125.77	174.96	169.43
1980	260.42	136.23	191.16	180.26
1985	279.43	133.60	209.15	214.53
1990	315.10	155.19	203.05	218.26
1991	318.23	158.18	201.18	220.45

Source: Compiled by Alston and Zilberman using data provided by Craig and Pardey, 1996.

In the early part of the twentieth century, farms and farming were very different from what they are today. Clearly, new technology has been a major driver in the development of California agriculture—and not just agricultural technology. Important changes off the farm have included improvements in methods of food preservation, storage, transport, and handling, along with general improvements in the transportation infrastructure. A host of other technological changes have been applied on the farm. Many of these have been shared with agriculture in other places, and beyond agriculture. In what follows we emphasize those developments that have been specific to California and important here, focusing for the most part on technology applicable at the farm level.

EVOLUTION AND ADOPTION OF AGRICULTURAL TECHNOLOGIES IN CALIFORNIA

The process of technological innovation in California has much in common with the process of technological innovation in the United States more generally. Nonetheless, there are some unique features. Like other regions in the United States in the early part of the twentieth century, changes in technology in California emphasized the adoption of mechanical technology—improved plows, various kinds of harvesting machines that were initially powered by animal power or steam engines, tractors, and so on. All of these innovations reduced costs, especially labor per acre.[5] Such mechanical inventions enabled the establishment of land-intensive agriculture and, together with the Homestead Act of 1862, were crucial elements in the settlement of California.

As in the rest of the United States, California agricultural production in the twentieth century has grown primarily through increases in yield per acre. California farmers were early in their adoption of chemical inputs such as fertilizers and pesticides, and swiftly took up more advanced agronomic and biological management practices. Recently, California has become the leader in introducing biotechnology and computerized systems into agriculture. Unlike other states, however, the growth of agriculture in California required diversion of water. From the nineteenth century on, California agriculture emphasized the introduction and adoption of institutions and technology to facilitate irrigated agriculture. The institutions ranged from local collective arrangements for diverting the water (water districts) to massive state water projects. Technology emphasized physical innovations in delivering water to improve control and efficiency.

In California, as in other western states, much emphasis was given to improved irrigation technologies. California farmers used modern irrigation methods, such as sprinkler and drip, to introduce advances in the use of chemical fertilizers. More recently, computerization has contributed to the more precise management of irrigation.

While the emphasis on irrigation is one distinctive feature in California agriculture, perhaps an even more important feature that distinguishes this state is the selection of crops. California agriculture is the leading producer of fruits, nuts, vegetables, and flowers in the nation—and, for many fruit and nut crops, in the world. The land share of these crops has grown steadily over time. The nature of these crops, which are less important in much of the heartland of the United States, means that a great deal of the technological development in California has more in common with Florida, parts of the southern hemisphere, and regions of the Middle East (as well as with Italy, France, Israel, and even Holland), than with Illinois and Iowa.

The evolution of agricultural technology in California was strongly influenced by technological innovations and other events that originated in nonagricultural sectors of the economy. During the late nineteenth and early twentieth centuries, much of the Central Valley consisted predominantly of grain-producing areas. Grains were essential for feeding the local population and their draft animals, which provided the main source of energy for transportation and farming. Early California exported grain mostly by boat, but the introduction of the railroad provided a cheaper alternative. Dried or preserved fruits and vegetables were also shipped, since logistical constraints prevented the export of products with a relatively short shelf life. During the second half of the twentieth century, with the introduction of the federal highway system and great improvements in truck transportation, California began shifting toward the export of fresh fruits and vegetables. The past 10 or 15 years have seen increased airplane transportation to export high value-added, tree-ripened fruits from California to markets in Pacific Rim countries as well as along the East Coast—another step in the continuing process of supply response to improved transportation technology

[5] See Cochrane (1993); Hayami and Ruttan (1970); Olmstead and Rhode (1993).

that began a century earlier (Rhode, 1990).

International Technology Spillovers

Subtropical crops and vegetables produced in California have had extensive technological exchange with other regions where weather and crops are similar. In the nineteenth century and early twentieth century, a significant transfer of technology came from southern Europe and Asia to California, embodied in the immigrants from Italy, Germany, France, Armenia, and Odessa near the Black Sea who settled in the San Joaquin Valley, near the Russian River, and in other areas of California. These immigrants brought crop varieties and cultivation practices from their original countries and established the foundation for many fruit and vegetable industries in California.

Traffic in ideas and technology has been on a two-way street, however. Early on, for example, the wine industry in California was essentially an importer of knowledge from France and Italy. However, as the University of California developed its significant research capacities, the state evolved from being an importer to an equal trader and even exporter of agricultural knowledge. California developed its own varieties of wine grapes, stone fruits, nuts, and citrus, and some California grape varieties were even sent to France to cope with a plethora of problems in the wine industry there.

While traditionally in many Mediterranean countries almond and other nut trees were grown mostly as single trees, without much cultivation, California researchers in the Experiment Station made a strong effort to adapt many nut varieties to California conditions and to increase their intensity of production. California has become the leading state worldwide for varieties as well as production methods in almonds, walnuts, and pistachios. Additionally, realizing the relatively small markets for many fruits and vegetables, California farmers have continually sought to produce new specialty crops and develop markets for them.

Transfers of technologies between California and regions with similar crops and growing conditions have continued. Drip irrigation and the production system developed around it came from Israel. Some South African entrepreneurs and Australian companies have played a major role in technology transfer.[6] California has been a major beneficiary of the Bi-National Agricultural Research and Development (BARD) program with Israel. This research program, with an endowment of about $200 million, has allocated a large share of its U.S. funds to California research institutes. Much of the expected economic benefit from this program (estimated in 1987 to be around $500 or $600 million) has accrued to growers in the form of improved irrigation and drainage practices, the user of computerized systems in cotton production, introduction of solarization for pest control, and so on.

California growers constantly benefit from varieties being developed in other countries, including high-value flower and vegetable crops from the Netherlands and,

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[6] Tom Riddering, from South Africa, was crucial in the establishment of a large-scale drip irrigation company in California, Agrifim, and he has been a dominant force in California's irrigation industry. Hardy, an Australian company, became a major player in California irrigation. Much earlier, the Chaffey brothers from California pioneered the development of irrigation in the Murray Valley, leading to the development of the grape and citrus industries in the Sunraysia region of Australia.

especially, the range of fruits and vegetables from Asia. The international spillovers of genetic material are not confined to exotic species, however; a recent study by Pardey, Alston, Christian, and Fan (1996) showed that California has been a major beneficiary of new wheat and rice varieties developed by the International Agricultural Research Centers of the Consultative Group on International Agricultural Research (CGIAR). The new higher-yielding wheat varieties developed by the International Maize and Wheat Improvement Center (CIMMYT) in Mexico, incorporating semi-dwarfing genes and rust resistance, were designed for developing countries but turned out to be especially suitable for use either directly, or as parental lines, in California and Australia. Similarly, the improved rice varieties from the International Rice Research Institute (IRRI) in the Philippines have been relatively well suited for adaptation and adoption in California. Essentially all of California's rice has some IRRI ancestors.

Asian-Americans have played a dominant role in California's high-value crops, especially along the coast. While California has been a significant importer of crops and varieties, exports of crops and genetic material from California have outweighed the imports significantly. In the future, we may expect much more emphasis on the development of crops and varieties to meet Pacific Rim demands. California has by far the world's strongest research establishment in subtropical agriculture, exporting knowledge that was crucial in the development of cotton and subtropical farming in Australia, Israel, and other countries.[7]

In recent years a significant transfer of agricultural technology has taken place, including processing as well as production technologies, from Northern California to Latin America, especially Chile and Mexico. NAFTA may well encourage a gradual integration of farming in California and certain regions in Mexico that produce high-value crops. Finally, there has been a steady technology exchange between California and Florida, which are unique in the nation for their subtropical crops such as citrus.

Irrigation Technology

Without irrigation, much of California would be a dry and nonproductive land. With irrigation, however, the Central Valley has become the most agriculturally productive valley in the world. Combined with the soils, climate, and a long growing season, water availability has brought high yields per acre for a multitude of crops.

Traditional irrigation in California was based on gravity and consisted of either flooding the fields or using furrow delivery. These methods were often technically inefficient, since a significant portion of applied water was not consumed by the crop but ended up as deep percolation, runoff, or evaporated water. Modern technology has increased irrigation efficiency significantly. Sprinkler and drip irrigation can increase yields and save water, especially in areas with sandy soils where deep percolation is

[7] Cotton was introduced in Israel by a California farmer, Sam Hamburg, and the largest cotton grower in California, Boswell, was at one time probably the largest operation in Australia as well. Conversely, the Tatura trellis, developed in Tatura in Australia, has been adopted and adapted for use much more extensively in the fruit industries elsewhere in the world, especially South Africa, Israel, and California, than in Australia. These spillovers arise as a matter of course, since most mechanical, chemical, and biological technologies know no geopolitical boundaries and can be applied in many places with similar agroecologies.

significant, and with uneven soil topography where problems of runoff are severe. The problem with percolation is especially serious in some areas of the Central Valley where there is an impenetrable soil layer close to the surface, which results in water-logging problems. In these cases, adoption of modern irrigation methods can avoid or slow these problems.

While modern irrigation tends to increase revenue by increasing productivity, it can entail higher capital costs. Producers must balance gains against costs. Studies suggest that adoption of the new methods is most appropriate in areas with high-value crops, high prices of water, and farming conditions (sandy soils, deep hills) that make them attractive. Modern technologies are not appropriate for every location, as for example in areas with low-value crops (field crops such as wheat and barley) and heavy or poorly drained soils. At present, only 25 percent of California farm land is irrigated by sprinkler, and the share of drip is 10 percent or less. Table 4 presents information about adoption of irrigation technology over time in California.

Table 4: Adoption of Irrigation Technology in California, 1969-1994.

Year[a]	--Sprinkler--		--Gravity--[b]		--Drip or Trickle--[c]		--Subirrigation--	
	Farms	*Acres*	*Farms*	*Acres*	*Farms*	*Acres*	*Farms*	*Acres*
1969	12,708	1,261,494	34,322	5,970,451	-----	-----	525	91,153
1974	12,872	1,407,098	31,796	6,221,203	-----	-----	518	129,940
1978	25,056	2,135,959	35,056	6,351,354	3,922	191,549	145	30,765
1988	16,698	1,747,231	27,306	5,594,321	8,759	359,843	616	75,515
1994	20,366	1,848,697	24,046	5,185,677	14,019	933,696	85	55,896

[a] These are census years.
[b] Gravity in 1969 and 1974 is the sum of flood and ditch-and-furrow irrigation.
[c] Data not available for 1969 and 1974.

Source: Census of Agriculture, U.S. Department of Commerce.

Flood Irrigation. While sprinklers and drip delivery systems can cope with uneven terrain, much of California's irrigated agriculture is irrigated by flood or ditch-and-furrow methods fed by gravity, especially field crops (over 5 million acres, and still two-thirds of the irrigated area in 1994, as shown in Table 4). An important element in the development of irrigation technology for these crops, and improvement in the control of water, has been the use of improved grading techniques, especially *laser levelling* technology. Much Central Valley farm land has been leveled over the years, making flood and ditch-and-furrow irrigation efficient and cost-effective.

Irrigated agriculture in California benefited from developments outside agriculture and from the importation of technologies from outside the United States. The ability to drill deep wells and convey water under high pressure, activities important to the use of sprinkler systems, came in large part from knowledge acquired in the oil industry; learning how to pump and transfer liquid in the oil business led to developments later found to be profitable when applied to water.[8]

Sprinkler Irrigation. While sprinkler irrigation was introduced prior to World War II, the sprinkler manufacturing industry went through a period of rapid expansion after the war. The early sprinkler systems consisted of iron pipes that connected sprinklers to the main water line. The early post-war years also saw an excess U.S. production capacity for aluminum; since then, there has been a rapid increase in the share of irrigation systems that use lighter aluminum pipes, which have enabled the introduction of movable sprinkler systems at lower cost, an attractive alternative for some field crops, including cotton.

Sprinkler systems were largely promoted by manufacturers and dealers from which farmers rented equipment in early years. As they became more knowledgeable about sprinkler irrigation, farmers rented equipment less frequently and began to purchase it outright.

Sprinkler irrigation has been adopted for a wide variety of crops. Since different crops have different requirements, and the profitability of investment in equipment may be different, various types of sprinkler systems have evolved; this evolution also reflects new opportunities with respect to materials and equipment. Many field crops still use the removable sprinkler system. In these cases, farms do not spend much money on equipment; the pipes are simply moved from field to field, which restricts the frequency of irrigation. Higher value crops use permanent sprinkler systems, which allow quicker response to changes in weather and also permit longer irrigation cycles with lower volumes, which increases water use efficiency. In some cases, sprinkler systems are also used for frost protection. With the introduction of plastic, there has been a demand for sprinkler systems relying on plastic pipes and meters, which may be less expensive in terms of cost and easier to move, but may require more frequent replacement.

Center Pivot. The most significant adaptation of the sprinkler system was the introduction of center pivot irrigation in the 1970s. This system revolutionized agriculture in the Midwest and increased the irrigated acres in the United States by several million acres, but it has not had a significant impact on California agriculture. Center pivot irrigation is most appropriate for crops such as corn, and is most efficient when the same machinery is used for both pumping of groundwater and irrigation. This system also requires production in continuous plots of quarter sections (160 acres). While center pivot might have been appropriate for crops such as alfalfa and cotton in California, reliance on groundwater for these crops is not very common, so a combination of pumping and irrigation is not likely.

Drip Irrigation. Drip irrigation is another form of modern irrigation that has had significant impact on California agriculture. Introduced into California in the late 1960s, drip was initially exported from Israel. This system requires a high up-front investment; therefore, it is primarily adopted for high-value crops in situations of water scarcity, and in locations where it is especially favorable. The first significant adoption of drip was in the avocado orchards of the San Diego area, where it enabled expansion to steeper hills in both San Diego and Ventura Counties. Similarly, the use

[8] This observation is credited to the late Yair Guron.

of drip enabled expansion of grape production to the hills of Monterey County and throughout the Central Valley.

Drip systems can be very complex. During the early 1980s, the adoption of drip expanded, and local dealers and personnel developed the skills to design and improve the systems. Currently, much of the design is done at the dealer level, and dealerships often have sales engineers who can design sophisticated drip systems. Some large farms are able to design their own systems with the help of professional designers. Advantages associated with the introduction of drip in high-value crops in California are reduction of chemical use and replacement of unskilled laborers with a smaller number of more highly skilled employees.

Continuous processes of adaptation and improvement of the technology reduced the fixed cost of drip systems, and the effectiveness of use increased because of "learning-by-using" by farmers. Some farmers combine drip with computer technology to allow irrigation activities to respond to environmental conditions. This version of precision agriculture has been found in some areas to increase yield and reduce water use significantly (Parker et al., 1996). In future, the combination of drip and sprinkler irrigation with automated computerized systems that use weather and other data to adjust timing and flow will almost certainly become more popular.

Information Technology. Public investment in provision of weather information in the form of the California Irrigation Management Information System (CIMIS) has given impetus to the development of computerized and automated irrigation systems. About 100 weather stations have been established throughout the state to provide detailed weather information via telephone, e-mail, and other modes of communication. Water districts, irrigation consultants, and growers have gradually joined the CIMIS system (Parker et al., 1996), and the annual benefits are estimated at about 20 times its cost. The introduction of this public weather system has reduced the cost of information to farmers and resulted in a proliferation of consultants who use the data, develop software, and provide farmers with irrigation advice. These consultants have gradually changed the way California agriculture operates. CIMIS has also provided a means to increase productivity and incomes; in the future the use of consultants, computers, weather stations, and more precise irrigation is likely to expand beyond the regions and the crops in which they are currently used.

Water Markets. The California experience suggests that immense benefits are associated with the provision of knowledge that enables the introduction and improvement of technologies. Public policies that support provision of infrastructure (such as CIMIS) and favorable economic conditions are crucial for technological development. However, policies involving the transfer of water in the past were not particularly conducive to increased irrigation efficiency. Water markets (i.e., trading in water) may offer an opportunity to transfer water away from agriculture; on the other hand, they may also provide a significant impetus for improving water use efficiency. As water markets develop in response to water scarcity, we may expect to see an increase in adoption of modern irrigation practices and more rapid development of new, improved practices.

Harvest Technologies

In many cases in the past, the expansion of crop acreage was slowed by labor availability and costs associated with harvesting. The complexity of fruit and vegetable crop harvesting, partly related to the fragility of the produce, has combined with relatively small markets for equipment to make the introduction of harvesting equipment slower for these crops than for some major field crops. For many fruit and vegetable crops, mechanical harvesters were not introduced or significantly adopted until the 1960s or 1970s, and a range of significant commodities (e.g., grapes for raisins and most fresh fruits and vegetables) continue to be harvested by hand because mechanical harvesting technology remains unavailable or costly.

Available data on the introduction and adoption of mechanical harvesters is sketchy and incomplete. [9] Relatively good information is available on the cotton harvester (e.g., Musoke and Olmstead, 1982) and the tomato harvester, which received particular attention from economists because it was controversial. University research has played a major role in developing harvesting technology for tomatoes, wine grapes, and lettuce. Economic considerations often delayed the introduction of such technologies once they were available, but also helped promote their adoption later.

Tomatoes. The processing tomato industry, in particular, was dependent on the Bracero Program, which was terminated in 1965. Introduced in the post-World War II period, the program contributed to the expansion of labor-intensive crops in California and to the transfer of production of major vegetable crops, especially tomatoes, from other states to California. That same year a mechanical tomato picker was introduced which coincided with the introduction of a new variety suited for mechanical harvesting. The design for the tomato harvester was devised by a private company (Blackwelder), based on a design developed at the University of California at Davis. The machines worked better with new varieties of processing tomatoes bred especially for mechanical handling, which were also developed by the University. Following the cancellation of the Bracero Program, adoption of the tomato harvester (and suitable new tomato varieties) was remarkably swift; by 1968, 95 percent of California's processing tomatoes were mechanically harvested (Zahara and Johnson, 1979). Not only was the technology beneficial to growers—reducing labor uncertainty and decreasing costs—it also improved the lot of consumers by reducing the cost of tomato products.

Critics charged, however, that the introduction of the tomato harvester negatively affected farm workers (Schmitz and Seckler, 1970). The case is not altogether clear. California's processing tomato industry today employs many more workers than it did when the tomato harvester was first introduced. If the harvester were banned, the California processing tomato industry would be so adversely affected that the effects on workers would be clearly negative. Such longer-term consequences of the introduction of so-called labor-saving technology has not always been fully appreciated. The total impact on farm workers of harvest mechanization depends on both the effect on labor intensity (which is negative), and the effect on the scale of

[9] Zahara and Johnson (1979) reported figures for the United States as a whole: at that time, for processing uses, 38 percent of fruits and 58 percent of vegetables were machine harvested; for the fresh market, over 90 percent of the nuts, 26 percent of the vegetables, and less than 1 percent of the fruits were mechanically harvested. Their article provides detail on some specific California crops.

production (which is positive).[10]

Lettuce. The introduction of the mechanical lettuce harvester seemed also to be a response to labor-supply problems. With the advent of the lettuce harvester, however, labor demand in both harvesting and postharvest activities declined. On the other hand, productivity increased significantly. Because owners needed more commitment and responsibility from workers, they began contracting with unions, and contracts brought workers higher pay and longer employment, although in many fewer jobs.

In the year following the Bracero Program, illegal immigration of farm workers to California increased. The transaction costs associated with recruitment of seasonal labor during the Bracero Program and especially afterwards stimulated the use of farm labor contractors (FLC), who take responsibility for the recruitment of laborers. The adoption of FLCs was further stimulated by the introduction of the Immigration Reform and Control Act of 1986 (IRCA), which was intended to reduce the flow of illegal immigrants and has changed the risk to farmers of employing potential illegals directly.[11] Although the literature raises doubts about the effectiveness of the changing regulations in controlling the flow of immigrants, the rules have affected the nature and reliability of the agricultural labor force as well as the costs of labor. Such factors are likely to continue to be an incentive for farmers to seek labor-saving alternatives.

Cotton. Harvesting technology has played a major role in the California cotton industry, as documented by Musoke and Olmstead (1982). California's cotton industry expanded rapidly in the immediate post-World War II years, with the adoption of mechanical harvesting being a major reason. California cotton growers adopted mechanical harvesters more rapidly and more completely than farmers in other states. Musoke and Olmstead attribute this rapid adoption to factors such as the relatively large size of California farms and dry weather during the harvest season, factors that may also have contributed to California's relatively rapid adoption of other mechanical technologies. By 1960, over 90 percent of California's cotton was mechanically harvested; by 1965, virtually 100 percent.

Fruits, Nuts, and Vegetables. Mechanical harvesting and bulk handling equipment have been important innovations in California's horticultural industries. In many fruit and vegetable industries, especially those where products were destined for processing, harvesting innovations came in the 1960s or earlier and became standard technology by the 1970s. For instance, Zahara and Johnson (1979) reported 100 percent mechanical harvesting in 1978 for a variety of processing vegetables, including snap beans, carrots, sweet corn, onions, green peas, and potatoes. However, none of the fresh or processing fruits used significant mechanical harvesting except prunes and dates (100 percent mechanically harvested) and tart cherries (75 percent). In fresh vegetables, mechanical harvesting was important only for carrots and potatoes. Mechanical harvesters for wine grapes were introduced in California in the late 1960s, and by 1974 between 5 and 10 percent of the crush was being mechanically harvested (Johnson 1977); by 1978, 20 percent (Zahara and Johnson 1979). Currently, perhaps half of the crush is

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[10] Martin and Olmstead (1985) provide an excellent discussion of the tomato harvester issue and the agricultural mechanization controversy more generally, including a discussion of the implications of mechanization for consumers, food quality, rural life and rural communities, as well as for employment.

[11] Much has been written about this topic, including articles by Taylor and Thilmany (1992, 1993), Thilmany (1996), Thilmany and Blank (1996), and Thilmany and Martin (1995).

mechanically harvested.[12] On the other hand, by 1975 virtually all almonds, pecans, filberts, and walnuts were mechanically harvested, and most of this production was in California.

Genetic Improvement

Genetic improvement has led to higher-yielding varieties, with improved pest resistance, as well as varieties that have other advantages such as improved quality, suitability for particular growing areas, or different seasons.

Wheat and Rice. As discussed above, California has benefited from the adoption and adaptation of new wheat and rice varieties developed in the CGIAR. California's role has been to develop varieties with local adaptation from the parental material developed by the international centers. California's wheat and rice yields have improved substantially as a result of this synergistic, multinational effort.

Almonds. Other examples of genetic improvement have been entirely the result of local efforts. California's almond yields per acre roughly tripled between 1950 and 1990, as a result of a combination of improved varieties that allow higher planting densities, and other improvements in technology.[13] Other cost-saving improvements, such as improved irrigation methods and mechanical harvesting, and overall quality enhancement have helped spur the growth of the almond industry in California to the point where it now dominates the world market. Similar developments in technology and management have been an important impetus in many of California's other "Cinderella" industries, including other nuts, fruits, and vegetables.

Grapes. Yield improvement is not the only form of varietal improvement. In several industries, varietal improvement has brought improvements in quality, though sometimes at the expense of yield, or an increase in the number of varieties available, which offers more choice for consumers or an extension of the season for short-season fruits. Table grapes are a good example. In 1953 there were only three important table grape varieties (Thompson Seedless being the most important for fresh as well as drying use, and perhaps white wine). By 1993, eight specific table-grape varieties were planted on over 2,000 acres each; several of these are superior quality seedless varieties. The extension of the season and the range of varieties are thought to have provided an important stimulus to demand for fresh grapes.[14]

Strawberries. A similar story holds with California strawberries. In this case the variety improvements extended a short season to almost year-round availability of high quality fruit, at the same time bringing huge yield gains. Genetic improvements were only a part of the strawberry miracle, which combined advances in pest control with better general management.[15]

Lettuce. Another example of multifaceted varietal improvement is provided by the California lettuce industry. At one time, lettuce meant only iceberg lettuce. Today California grows many distinct types and varieties of lettuce, so that the U.S. salad

[12] Personal communication, Pete Christensen.
[13] See Alston, Carman, Christian, Dorfman, Murua, and Sexton (1995) for details.
[14] See Alston, Chalfant, Christian, Meng, and Piggott (1997).
[15] See Alston, Pardey, and Carter (1994) for an extended discussion.

bar can be stocked year-round with a range of fresh lettuce. Again, the combination of improved genetic material with other mechanical, chemical, biological, and postharvest technologies, along with a better understanding of the market, have resulted in a commercial success story.

Regulation of Cotton Varieties. Technological regulation is likely to become more important over time, as elements of society become more concerned not only about the consequences of today's production methods for issues such as food safety, environmental contamination, and animal welfare. Technological regulation attempts to exercise control over production methods so as to safeguard product quality, worker safety, animal welfare, and the environment.

Technological regulation may also allow one group of producers to profit at the expense of others—and perhaps at expense to society as a whole. An important example of this has been the regulation of variety choices in the California cotton industry under a law introduced in 1925, which restricted production to a single variety of Acala cotton, supposedly to promote demand. Constantine, Alston, and Smith (1994) showed that the evidence of an important stimulus to demand is lacking, yet the one-variety law had a depressing effect on yield in some parts of the San Joaquin Valley while growers in other parts of the Valley benefited both from having suitable planting material for their conditions and a higher price for their cotton. Overall, the beneficiaries outnumbered the losers, and the law remained in force for over 50 years, until a 1978 amendment opened the industry to private breeders—although the restriction to Acala cotton remains in force.

Pesticides

To a large extent, the ability of California farmers to grow more than 200 different crops stems from their ability to develop and apply technologies enabling plants to resist a multitude of diseases and pests that prevent them from being grown elsewhere. The relatively dry weather of the Central Valley reduces the severity of some pest problems that have plagued other, more humid regions growing similar crops. Nevertheless, without the extensive research, extension, and pest control application activities carried on throughout the state to combat plant diseases and pests, California's agriculture would not be nearly as diversified or successful as it is today.

The unique composition and diversity of California agriculture have challenged its agricultural research system. Farmers must find solutions to many pest and plant disease problems, and do not benefit much from spillover of research done elsewhere. The California Agricultural Experiment Station and Extension Service have developed major research programs in Entomology and Plant Pathology, and the Center for Disease Control has also played a major role. Furthermore, some private chemical companies have developed large research and experimentation facilities in California to address pest problems, especially in high-value crops. There has been significant collaboration between the public sector and private companies in working on pest control. Chemical companies have provided universities with various compounds to address emerging pest problems and relied on university facilities to test new materials and develop appropriate procedures for their use. A major challenge in pest control has been the development of effective procedures for the use of chemicals, and this has been an area of close collaboration between private and public sectors.

Chemical pesticides have been essential in controlling severe outbreaks of pests. The Experiment Station and the Extension Service have played important roles in identifying and disseminating chemical solutions to pest problems. For example, the identification and development of procedures for using methyl bromide to control fusarium and other soil-borne diseases in strawberries and other high-value crops was a major research accomplishment of the California Agricultural Experiment Station.

Zilberman, Siebert, and Schmitz (1990) document that chemical pest controls have had a wide range of impacts—increasing crop yields, reducing production costs, improving product quality, expanding shelf life of commodities, and reducing inventory losses. On the other hand, the productivity gains from use of pesticides have external costs. The high intensity of pesticide use in the high-value crops of California, and the high intensity of labor use, bring significant worker safety risks. Some chemicals, such as the DBCPs, which have significant productivity effects, have been discovered to be carcinogenic; there are worker safety and groundwater contamination problems. Because the highly valuable methyl bromide is linked to the depletion of atmospheric ozone, it is doubtful that this chemical will be available for application in the long run.

Because of the side effects of chemical use and the high costs of dealing with the risks, California agriculture has developed a wide array of nonchemical methods to address pest problems. One approach is biological control. This area, while holding much promise, needs increased research emphasis, particularly in understanding the role of plant systems in a total ecological system.

Integrated Pest Management (IPM) has been an important development in pest management philosophy that integrates several tools to address pest problems. Researchers in the University of California have been experimenting and promoting these techniques since the 1950s, and since the early 1970s IPM practices have become viable. Currently, IPM is practiced in one form or another by more than 50 percent of the state's growers. The University of California has a large IPM program, with a budget of $2 million to promote and expand IPM use.

The key components of IPM are the monitoring of pest populations and treatments of pest problems according to natural conditions. The technology combines a wide variety of tools: biological control, agricultural practices, the use of pheromones, and, when needed, the use of chemical pesticides.

The introduction of IPM has led to several institutional innovations in California agriculture. First, two new professions have emerged: agricultural scouts who monitor pest populations, and pest control consultants who recommend pesticide use. Large growers may employ their own in-house scouts and consultants, but scouts and consultants are also employed by dealers, and there are also independent consultants. Recently, the State imposed certification requirements on pesticide consultants.

Agriculturists in California and worldwide are recognizing that reliance on chemical pesticides will decline over time, and greater attention is being given to research on alternative technologies. Biotechnology has provided some widely used alternatives to chemical pesticides in California and is likely to provide many more options in the future. For example, the bacteria *Bacillus thuringiensis* has been introduced to combat pests in several crops, including cotton, corn, and tomatoes. California growers have been among the first to adopt certain new genetically engineered pest-resistant or herbicide-resistant crop varieties. Since some leading agricultural biotechnology companies, including Calgene, originated and are based in California, some growers in collaboration with these companies have experimented with new genetically engineered pest-control products.

Computers

Much of the computer revolution in the past 30 years originated in California; the Silicon Valley itself previously contained flourishing fruit farms. Nevertheless, California farmers have adopted computer technology only gradually in their enterprises, and the potential for computerization in many California agricultural industries has not been fully realized.

In general, farmers initially use computers for bookkeeping and accounting functions, with production management activities coming later. Currently, only a small percentage of farmers use computers intensively for production management.

One exception is the dairy industry, where the use of computerized herd improvement programs is widespread. Dairy farmers had intensive manual bookkeeping systems and herd improvement activities before the introduction of the computer; thus computerization simplified existing operations. (In other management applications, computerization may significantly alter production processes and decision making.) Another reason for the popularity of computerized herd improvement programs is that the software, to a large extent, was provided by the public sector and promoted heavily by the Extension Service. That is not the case with other production management applications.

Private-sector innovations are often embodied in capital goods, public-sector innovations less so. Computer software falls in between. Programs can be easily copied, and they are not very well protected by patent laws. Public universities have not put much effort into developing computer software for farm management; to a large extent, the perception is that such activity should be left to the private sector. (Indeed, in the UC system there is not much emphasis on the general area of farm management either in research or extension.) Most agricultural software companies, in most cases, develop production management software in response to clients' specific needs. Several past attempts to develop more general production management software were unsuccessful, perhaps because of limited computer literacy among farmers.

The largest farms have been the leaders in the use of computers for both business and production management activities; some employ programmers and/or software experts. Smaller operations frequently rely on consultants, and a significant number of small agricultural software and consulting businesses have sprung up throughout the state. The future of computer use in California agriculture appears quite promising, especially since serious experimentation with precision agriculture is taking place.

Livestock Production Technology

To a great extent livestock production technology is not as location-specific as cropping technology. California's livestock industries have evolved in much the same ways as throughout the United States. Technological change has been especially important in the most intensive livestock industries—broilers and hogs, in particular. But the effects in California have been uneven. Between 1949 and 1991, California's broiler industry grew more than seventeen-fold (the index went from 100 to 1,734), much faster than turkeys (from 100 to 443), and eggs (from 100 to 249); meanwhile, the hog industry contracted markedly (from an index of 100 to 47), along with sheep and wool.

The one area of livestock production in which California has developed and improved its technology more rapidly than the rest of the U.S. has been the dairy industry. Milk production has grown relatively rapidly (from an index of 100 in 1949 to 372 in 1991). California is now the largest and lowest-cost dairying state in the nation. Technology in dairy feed production, milk harvesting and milk handling, has improved in a number of ways. California leads the nation in large-scale, intensive dairy production. Family-owned dairy operations may milk up to several thousand cows, in some cases three times a day, with computerized recording of the production by each individual cow used to determine individual rations fed (in the bale) during milking. The typical Midwestern dairy milking farm, by contrast, still operates with fewer than 100 cows in a grazing system.

SCIENCE POLICY

The technologies that have played such an integral role in the development of California agriculture have been developed through synergism between public-sector institutions and private-sector investments. Government has played a role by creating appropriate incentives for private firms to conduct their own research and development (R&D) and develop products and technologies for which they can be rewarded by the market, as well as by financing and conducting public research in areas where the private sector cannot or will not invest. Science policy encompasses public-sector R&D plus decision making relating to private R&D, intellectual property rights, and technological regulation. Because agriculture and agricultural markets are evolving along with society, social attitudes, and science itself, science policy must evolve as well.

Research Institutions

Many crops grown in California are special to it; thus California has developed its own unique institutional arrangements for research. The California Agricultural Experiment Station (CAES), spread over the campuses of UC Berkeley, UC Davis, and UC Riverside, is the state's main institution for public agricultural R&D. CAES research and Cooperative Extension are supported through a combination of federal, state, and private funding, but the State provides the lion's share. The University of California is the largest public university in the world, and CAES is the largest public agricultural research enterprise based on the U.S. land grant system model.[16]

Public institutions perform some research that is essentially of a private nature (e.g., under contract), while some public R&D is funded from the private sector. One mechanism for such funding is through commodity groups, using marketing orders. Commodity groups can play a large role in R&D activities relating to their commodities and have been important supporters of university research. Commodity marketing order funds collected as check-offs on each unit sold have been used much more extensively for commodity promotion than for research (see Lee, Alston, Carman and Sutton, 1996), but in several industries are a primary resource for applied commodity-specific research. [Check-off funding is much more highly developed and heavily used for financing agricultural R&D in Australia (Alston and Pardey, 1996).]

In the U.S. generally, private spending on agricultural R&D has been growing faster than public spending, especially during recent years which have witnessed a rolling back of support for public R&D. Data on private research investments are spotty, but private expenditures have exceeded public expenditures on agricultural R&D for most of the past 20 years (Alston and Pardey, 1996; Fuglie et al., 1996). Data on private agricultural R&D in California are not available, but it is probably safe to assume that California mirrors the nation as a whole.

In recent years, some large distributors of high-value crops have developed their own research and are trying to establish their own fruit and vegetable varieties. Some of these producers have even signed technology transfer agreements with the University, hoping to establish proprietary rights. There is a growing effort in the University to encourage commodity groups and cooperatives to invest in private R&D.

California is the leading state for research in biotechnology. The first genetic manipulation of crops to gain much attention was the research in strawberries conducted by the University of California. The first agricultural genetic engineering company formed was Calgene. However, as in the medical biotechnology area, the most successful agricultural biotechnology companies established in California were later purchased by large multinationals (e.g., Monsanto recently purchased Calgene).[17]

Research Investment Patterns

From 1961 to 1991, the California Agricultural Experiment Station (CAES) research expenditures grew at an annual average rate of 6.9 percent, or just one percent per annum when measured in real terms. This 6.9 percent rate of growth is significantly slower than the 8.5 percent per annum growth in the national commitment to Experiment Station research (Pardey, Craig and Deininger, 1992). Part of the reason for this slower rate of growth is the dramatic 7.9 percent drop in state appropriations to CAES research in 1992, compared with the amount appropriated in the previous year. Because state funds account for nearly two-thirds of total CAES expenditures, a

[16] A detailed history of the development of agricultural research in California is provided by Scheuring (1995). A more general picture of the U.S. land grant system is provided by the Board on Agriculture (1996, 1997). Data on research investments are summarized by Alston, Pardey and Carter (1994).
[17] For more details on technology transfer and the evolution of biotechnology, see Postlewait, Parker, and Zilberman (1993) and also Parker, Zilberman, and Castillo (1997).

significant contraction in state funding has a proportionately large effect on the total funds spent on public-sector agricultural research in California.

In 1992, the total research investment by the CAES was over $142 million. The sources of funds for CAES research have varied over time. Funds from federal sources now account for about one quarter of total CAES expenditures, and just over a third of these federal funds are administered by the USDA. The biggest single source of funds is provided through the state legislature, accounting for about two-thirds of the total funds going to CAES in recent years. The areas of most rapid growth in non-federal funds are from the sale of products (such as royalties from plant variety patents) and from industry grants and agreements, including check-off funds (marketing orders for a number of California specialty crops raise funds for both research and promotion). Industry-sourced funds now account for over 10 percent of the total CAES research budget.

Public- and Private-Sector Partnerships and Technology Transfer

The rise of genetic engineering has encouraged closer collaboration between public and private enterprises in research and product development, at least partly because of the profit motive. Technology transfer activities, which are already significant in medical biotechnology, are starting to take place in the agricultural sector. For example, university researchers who discover the specific properties of a gene or develop a new product apply for a patent. The UC Office of Technology Transfer then can sell the rights to use the products, and to take advantage of the patents, to private companies. The University of California has engaged in several such arrangements, and the University receives significant royalties, for example, from rights to use its strawberry varieties.

Much more radical and exciting biotechnologies are now being developed, as for instance new pest-control alternatives. Some organizations that are considering biotechnology transfer agreements with the University include chemical and seed companies. Some large food and vegetable marketers have bought rights to university-developed technologies, and some grower cooperatives are also seriously considering investing in this area.

Private organizations are also tending to sponsor certain research projects in order to have the first right-of-refusal for the innovation that they produce. This practice has already occurred in the chemical and medical fields and seems to be occurring in agriculture. Furthermore, although most California grower groups in the past supported research at the University of California, they are undertaking research contracts with other universities. This may lead to more competition among universities, and may also alter the nature of university research from more basic toward more short-term, applied questions.

SUMMARY

California agriculture is a remarkable success story. Successful capitalization of the resources provided by the state's natural endowment depended on a combination of market opportunities, water availability, and production technology. Technology was also important in the development of critical transportation linkages and irrigation.

The transformation of California agriculture that began over one hundred years ago entailed the progressive adoption and adaptation of various types of new technologies, including mechanical innovations, new chemicals, biological breakthroughs, and information systems. Improved methods of production, in conjunction with changing markets for inputs and outputs, have promoted dramatic changes in the range, mix, and total value of California's agricultural products, with a concurrent reduction in the use of land and labor. The value of agricultural production today is over twice what it would have been without post-war productivity improvements. These improvements have resulted from private and public investments in California and elsewhere, especially other countries sharing a Mediterranean climate, in a complex international web of agricultural research and technology development, where knowledge and ideas are constantly interchanged.

Of course, these changes have not been welcomed by all; there are always some who do not benefit from new technology. The agenda for agricultural R&D is shifting as a result of changing perceptions of science and society. While it remains important to continue to improve productivity, the new agenda stresses the importance of issues such as the environmental effects of agriculture, alternatives to agricultural chemicals, and food safety. Simply sustaining productivity in the face of sharper demands for more environmentally friendly, safer production practices will provide challenges for the next century that will require technological solutions. Both the private and public sectors must sustain their commitment to, and their rates of investment in, the future.

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Chapter 5

MARKETING CALIFORNIA'S AGRICULTURAL PRODUCTION

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Marketing California's agricultural production presents unique opportunities and challenges. Because of its climatic advantages, California is able to produce a great variety of products that are not grown extensively elsewhere in the United States (U.S.). The California Department of Food and Agriculture estimates that the state is the leading U.S. producer for 65 crop and livestock commodities. The fruit, vegetable, and nut industries contribute over half the value of California agriculture's $22 billion in farm gate sales. Given the importance of horticultural crops to California agriculture, our discussion will draw heavily on examples from this sector.

Many of California's fruits and vegetables are highly perishable, and production is seasonal. A major challenge in marketing is to ensure both the high quality of these products and their availability to consumers year-round. Another key challenge facing marketers is the maturity of the U.S. market. Both the U.S. population growth rate and the income elasticity of demand for food are low, meaning that the market for domestic food consumption expands only slowly over time, and firms are essentially competing for share of stomach.

California's bounty also presents opportunities. Through the diversity of its agricultural production, firms marketing California produce have the opportunity to provide food retailers with complete lines of fruits, vegetables, and nuts. Because California produces a large share of the U.S. or even the world supply of key commodities such as almonds, lemons, olives, lettuce, prunes, processing tomatoes, and walnuts, California producers and marketers have unique opportunities to exercise control over the markets for those commodities.

This chapter documents the importance of marketing in both U.S. and California agriculture and highlights the institutions that have emerged and the strategies that have been pursued by California's food marketing sector to compete effectively in this market environment.

THE IMPORTANCE OF MARKETING IN CALIFORNIA AGRICULTURE

Marketing functions account for the largest share of the U.S. food dollar, and the percentage of food costs due to marketing is rising over time. Food marketing thus has an important effect on the welfare of both consumers and farmers. The U.S. Department of Agriculture (USDA) maintains two general measures of relative food costs. The *market basket* consists of the average quantities of food that mainly originate on U.S. farms and are purchased for consumption at home. The farm share of the value of the market basket remained stable at about 40 percent from 1960–80 but has declined rapidly since then, to 30 percent in 1990 and 24 percent in 1994. Table 1 depicts the trend in farm share for selected commodities of importance to California. Although farm value has traditionally accounted for more than 50 percent of retail value for animal products such as meat, dairy, poultry, and eggs, those shares have now fallen well below half. The farm share for fruits and vegetables tends to be much lower and does not differ much between fresh and processed fruits and vegetables.

The second major measure of food marketing costs in the U.S. is the *marketing bill*, which is calculated as the difference between what consumers spend for domestically produced farm foods and what farmers receive. In 1994 the farm share of the food marketing bill was 21 percent. This measure of the farm share has also been declining steadily over time, falling from 41 percent in 1950 to 31 percent in 1980 and then to 24 percent in 1990. The marketing bill takes account of food expenditures both at home and in restaurants. The proportion of the U.S. food dollar spent outside the home has been rising rapidly. In 1995, such expenditures accounted for 44 percent of the food budget compared to 37.1 percent in 1990 and 32.2 percent in 1980.

Table 2 examines the breakdown of the retail food dollar by major marketing function for lettuce, fresh oranges, and frozen orange juice. The table highlights the importance of retailing as a cost in the food chain, e.g., over half of lettuce costs are due to retailing. Although produce commodities are generally bulky and perishable and, hence, difficult to transport, the table shows that intercity transportation costs account for relatively small percentages of the food dollar.

Table 1. Farm Share of Retail Value for Major Agricultural Commodities, 1994.

Product	Farm Value		
	1980	1990	1994
	percent		
Meat products	51	46	36
Dairy products	52	39	34
Poultry	54	44	43
Eggs	64	56	47
Cereal and Bakery Products	14	8	8
Fresh Fruit	26	23	18
Lemons			24
California Oranges			18
Fresh Vegetables	27	28	23
Lettuce			18
Processed Fruit & Vegetables	23	26	20
Pears			18
Tomatoes			8

Source: *Food Cost Review, 1995*, Agricultural Economic Report No. 729, U.S. Department of Agriculture, Economic Research Service, April 1996.

Table 2. Share of Retail Value by Market Function for Selected California Commodities, 1991.

Commodity	Farm	Processing	Intercity Transport	Wholesale	Retail
	percent				
Lettuce	14.2	11.9	9.5	0.8	56.6
Fresh oranges	37.7	8.1	6.7	14.8	32.7
Orange juice	38.5	18.6	3.0	14.4	25.5

THE FRUIT, VEGETABLE, AND NUT SECTOR: SIZE AND CONSUMPTION TRENDS

California dominates the U.S. horticultural sector. In 1995 it accounted for approximately 48, 52, and 79 percent, respectively, of the farm gate value of the principal fruit, vegetable, and tree nuts produced in the United States. California's dominant position in this $25.5 billion industry is explained by climatic, technological, and infrastructure advantages, as well as the market- and consumer-driven orientation of its agribusiness managers.

Per capita consumption of fruits and vegetables, in both fresh and processed form, increased 17 percent over the past twenty years, reaching 313 kg in 1995. However, examining only the total fruit and vegetable category masks important changes occurring within, such as changes in product form and relative preferences for vegetables versus fruits.

New consumer preferences regarding product form emerged in the 1980s, making this decade the primary growth period for fresh produce consumption. During the 1980s per capita consumption of fresh fruits and vegetables grew at an average annual rate of 1.8 percent, increasing from 111 kg in 1980 to 129 kg in 1989, while processed fruit and vegetable consumption remained stagnant at 162 kg. However, these growth patterns were almost directly inverted after the decade ended. After 1989 per capita consumption of fresh fruits and vegetables grew at a scant 0.2 percent average annual rate, reaching 131 kg in 1995, while per capita consumption of processed fruits and vegetables grew at an average annual rate of 1.7 percent, reaching 178 kg in 1995. The fresh fruit sector performed especially poorly during the 1990s. After having grown 11.5 percent in the 1980s, fresh fruit consumption stagnated in the 1990s at 43 kg per capita, the same level as in 1989, while processed fruit consumption increased 5 kg to reach 80 kg.

Vegetable consumption, in both fresh and processed form, grew more rapidly from 1975–95 than did fruit. Vegetable per capita consumption grew by 22 percent to 189 kg, while per capita total fruit consumption grew by only 10 percent to 124 kg. Key forces driving the increase in vegetable consumption include the growth in the fast food industry with its usage of processed tomatoes, primarily for pizza, and processed potatoes, primarily for french fries.

On the fresh produce side, consumption gains over the past twenty years were led by broccoli, carrots, peppers, onions, tomatoes, melons, bananas, grapes, and strawberries. Several factors contributed to consumption growth for these commodities, including improved varieties (tomatoes); greater variety selection (grapes, melons, peppers); introduction of convenient fresh-cut forms (washed peeled carrots); the development of year-round availability (broccoli, strawberries), in some cases through imports (grapes, melons); new uses through food service channels (tomatoes, onions); and new consumer awareness of the nutritional benefits of the item (bananas, broccoli, carrots).

Fifty-seven percent of total fruits and vegetables were consumed in processed form in 1995, a figure virtually unchanged from 1975. Thus, changing consumer attitudes about the link between diet and health and more diffusion of information on the benefits of fresh fruit and vegetable consumption, benefited the processed as well as the fresh fruit and vegetable industry.

Total U.S. per capita nut consumption grew somewhat more rapidly than did fruit and vegetable consumption over the past 20 years, but this growth was on a very small base. Per capita U.S. nut consumption averaged 0.80 kg per capita over 1975–80, compared to 0.98 kg over the 1990–96 period, an increase of 22.5 percent. However, growth patterns have varied for the three nuts grown almost exclusively in California: almonds, walnuts and pistachios. Per capita almond consumption ranged between 0.15

and 0.20 kg during 1975–80, compared to 0.33 and 0.22 kg from 1990–96. In contrast, walnut consumption declined slightly from 0.22 kg per capita in 1975 to 0.20 kg in 1995. Pistachio per capita consumption grew rapidly from 0.013 kg in 1975 to 0.06 kg in 1995.

KEY TRENDS IN MARKETING STRATEGIES AND U.S. FOOD CONSUMPTION

The moderate rate of growth in aggregate per capita consumption of fruits, vegetables, and nuts is not surprising, given the maturity of the U.S. food market. While the overall U.S. food market is characterized by slow growth, eating habits are becoming increasingly diverse. Hence, there is tremendous growth in specific consumer segments. Food marketers must target these specific segments rather than employing mass marketing strategies. The three broad marketing strategies of most importance to U.S. food marketers have been:

- new product introductions,
- market share growth, and
- development of new markets, including export markets.

The market power of food retailers has grown as the battle for their limited shelf-space by food marketing firms has intensified. During 1996, food marketing firms introduced 13,266 new food products, almost double the level of just a decade ago. Since the average supermarket carries about 30,000 products, competition among firms introducing new products has led to the common practice of retailers charging fees known as "slotting allowances" for allocating shelf space to new products. Supermarket space allocations and the competition for display areas are critically important to California marketing firms.

The diversity of fresh produce offerings in U.S. supermarkets has also expanded at an astounding rate. The number of items carried by the average produce department increased from 133 items in 1981 to 340 items in 1995. This reflects the emergence of more diverse eating habits, and the growing demand for specialty and ethnic fresh fruits and vegetables, as well as the introduction of a myriad of fresh-cut, value-added products like packaged salads, designed to respond to the growing consumer demand for convenience. However, despite the rapid pace of new product introductions in the produce area, overall consumption in the U.S. has, as noted, been stagnant in the 1990s. Produce marketers are thus competing for a relatively fixed share of stomach.

Firms in the U.S. food marketing sector view a large market share, including, if possible, the position of market leader, as a key requisite to success. Pursuit of market share has led to a dramatic consolidation in the U.S. food chain at all levels, ranging from the farm through food retailing. Rather than competing to capture market share from rival firms, U.S. food marketers have often pursued share growth through mergers and acquisition of rivals. Merger and acquisition mania in the food sector peaked in 1988 at 573 mergers.

These mergers have likely had important implications for the structure of competition in the U.S. food sector. About 16,000 food and tobacco processing companies existed in the U.S. in 1992, but in 1995 upwards of 80 percent of sales were by the 100 largest of these firms (Rogers). The largest sales growth has been recorded by the top

20 of these 100 firms and has been fueled mostly by mergers and acquisitions. Most of the 53 food and tobacco industries surveyed in the U.S. Census of Manufacturing have experienced increasing concentration over time. The average market share held by the four largest firms in these industries has risen from 43.9 percent in 1967 to 53.3 percent in 1992 (Rogers).

Two important growth markets for U.S. food marketers have been exports and food service. The importance of the export market varies widely by commodity. About two-thirds of California's almond crop is exported annually, but exports have traditionally been a small share of the market for California's perishable fruits and vegetables, owing in large part to trade barriers and the difficulty and expense of long-distance shipping. Trade liberalization negotiated under the recent Uruguay Round of the GATT and implemented under the new World Trade Organization, as well as through regional trade agreements such as NAFTA, has expanded market access and provided strengthened mechanisms for combating non-tariff trade barriers such as scientifically unfounded phyto-sanitary restrictions. Advances in postharvest technology, such as the development of container-level modified atmosphere technologies, have also facilitated exporting to distant markets. Total U.S. horticultural exports, including fresh and processed fruits, vegetables, and nuts, were $10 billion in 1996, up from $2.7 billion in 1985. California firms captured a sizable share of this export growth.

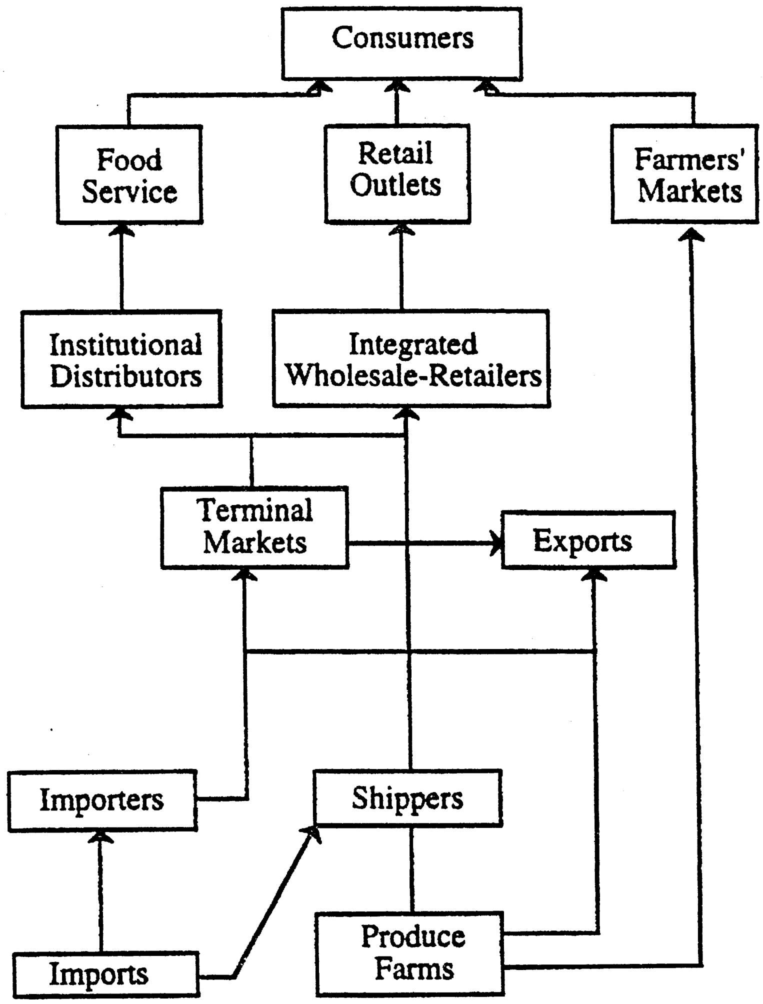
THE VERTICAL STRUCTURE OF CALIFORNIA AGRICULTURAL MARKETS

California's agricultural markets are remarkably diverse in their structure and organization. There is no single structure that can be considered a prototype. This section examines the various ways in which California's agricultural markets are organized, emphasizing the fresh produce marketing system and the marketing system for processed foods.

Both processed and fresh products reach consumers through the same final types of marketing outlets. The three primary sales outlets to consumers are: (1) retail food stores; (2) food service establishments, hotels, restaurants, and institutions (schools, the military, hospitals, nursing homes, shelters, and prisons); and (3) direct farmer-to-consumer sales via you-pick operations, farmers' markets, and roadside stands.

The principal marketing channels in the U.S. fresh fruit and vegetable marketing system are shown in Figure 1. Although the majority of fresh produce still moves through retail channels, food service now accounts for around 40 percent of total volume, and direct sales account for 1 percent. Since 44 percent of total consumer expenditures on food are made away-from-home, the food service channel is even more important for processed foods than for fresh.

Figure 1. U.S. Fresh Fruit and Vegetable Marketing System.*



*Brokers may assist in arranging sales transactions and transportation at any level of the system.

Produce sold in retail or food service outlets may be procured directly from shippers or wholesalers operating in terminal (wholesale) markets or in independent warehouses in local communities. Brokers may be used by either buyers or sellers at any level of the distribution system, and their role has grown in importance since World War II. As buyers procure broader product lines of both domestic and imported produce, many brokers have become global in their sourcing abilities and increasingly service-oriented to meet specialized buyer needs.

Since the 1950s, terminal markets have steadily declined in importance: Today there are major terminal markets serving only 22 cities, and these markets primarily handle the residual fresh market production that cannot be marketed directly to retailer or food service buyers. Terminal markets are no longer a factor in the distribution of processed food.

The decline in terminal market share is largely a result of the increased buying power of integrated wholesale-retail buying entities. Integrated wholesaler-retailers operate large-volume centralized buying operations, making it more efficient to buy directly from the source, bypassing the wholesaler and thereby avoiding intermediary margins and handling costs. Also, the retailer-buyers are able to communicate directly with suppliers concerning important issues such as desired product quality characteristics and timing of production, without the information being diffused and possibly distorted by middlemen. For fresh products, direct production-source-to-buyer shipments have the additional advantage of not breaking the cold chain, better preserving product quality.

In 1994, retail chains (defined as a food retailer operating 11 or more stores) accounted for 74 percent of supermarket sales vs. 62 percent in 1974 and 58 percent in 1954 (*Progressive Grocer*, 1996). The remainder of sales are by independent stores, although the vast majority of these stores are affiliated with each other through cooperative purchasing networks. Truly independent grocers now account for only 3 percent of supermarket sales. The United States has no truly national supermarket chains. Only five chains have over 1,000 stores, and only one of these has over 2,000 outlets. Given the large geographic size of the United States, chains tend to be regional in focus.

Within the retail channel the "super center" concept has emerged as a major industry force, which further concentrates buying power in the hands of a few very large new players. Super centers combine a full-line supermarket with a full-line discount department store. Super center stores range up to 18,900 square meters in size, compared to 3,300 square meters for the average supermarket. The largest entrant to this format is Wal-mart, with an estimated $17.5 billion in 1996 food sales, already placing it within the five largest retail chains.

Turning now to the opposite end of the marketing system, farm production of most commodities in California remains atomized in the sense that producer volumes, although often large in absolute terms, are small relative to the size of the market. However, important exceptions to this generalization exist, especially in the area of fresh produce marketing. Consolidation at the buying end of the food marketing system has driven consolidation at the production level. A few large growers have integrated their operations downstream into the marketing of their own production and the production of other growers—hence their designation as "grower-shippers." These grower-shippers control production, packing, and cooling facilities, and also arrange for both the domestic and export sale, transportation, and promotion of production.

The fewer, larger integrated wholesale-retailer and food service buyers demand more services today from their suppliers, including: (1) information on product attributes, recipes, and merchandising, (2) ripening and other special handling and packaging, and (3) year-round availability of a wide line of consistent quality fruits and vegetables. Grower-shippers have responded with improved communication programs and by becoming multiregional and multicommodity.

Many California grower-shippers obtain products from other countries during the off-season, sometimes via joint ventures. This enables shippers to extend shipping seasons and sell products produced in several locations via one marketing organization, maintaining a year-round presence in the marketplace.[1] For example, shippers based in Salinas, California, also commonly ship out of the San Joaquin Valley, Imperial Valley, southwestern Arizona, and Mexico. The rapid growth in multi-location firms has contributed to the integration of the Mexico-California-Arizona vegetable industries, in particular. Because most vegetable crops are not perennials, the location of production can shift readily, based on relative production and marketing costs and growing season.

Increasingly, buyers are contracting with grower-shippers for high-volume perishable items to stabilize prices, qualities, and volumes. While contracts have been common in the food service sector, they are new to retail. The entrance of super centers to food retailing has led this change as these mass-merchandisers focus on driving costs out of the distribution system. The introduction of contracting is likely to have structural implications at the grower-shipper level, since shippers need to offer large, consistent, year-round volumes to meet buyer contracting requisites.

The evolution of the California produce industry has enhanced its efficiency by cutting marketing costs and also has resulted in improved communication of consumer demand back to growers. However, the consolidation of purchasing within the hands of a few large buyers raises concerns about oligopsony exploitation of producers. Perishable crops, which must be harvested, sold, and marketed within a very short time frame, tend to give growers relatively little bargaining power in dealings with buyers. Sexton and Zhang analyzed this issue recently in the California lettuce industry and found that buyers were able to extract most of the returns from the production and sale of lettuce and force growers to an essentially zero profit rate of return.

Marketing arrangements are different for processed foods, including fruits and vegetables, nuts, grains, meats, and dairy. Growers in these industries are generally atomistic and sell to processing firms rather than to food retailers. The effects of increasing concentration in food processing can be especially severe in terms of their impacts on grower-processor relations. Most raw farm products are generally bulky and perishable, making shipment costly and limiting growers' access to only those processors located within a limited radius of the farm. For example, broilers are generally shipped 20 or fewer miles, and processing tomatoes are hauled 150 or fewer miles. Thus, even if many processors operate in an industry nationally, typically only one or a few firms buy from a given geographic region.

California food processors are themselves a diverse lot. A key distinction is whether or not the processor has successfully developed its own brand identification.

[1] Year-around sourcing by California marketers is controversial because some growers believe it benefits competing producers. Recent work by Alston et al. (1996) indicates that year-around sourcing has actually increased demand for California table grapes, most likely because the year-around availability reinforces consumer buying habits.

Processors with successful brands are able to capture a price premium in the market. Examples of California processors with leading brands include Blue Diamond (almonds), Sunsweet (prunes), Heinz (processed tomato products), Del Monte (canned fruits and vegetables), Sun Maid (raisins), and Sunkist (citrus). Processors who lack dominant brands sell primarily to food service buyers and to the private label market. Private labels refer to retailers' house brands. These brands generally sell at a discount compared to major brands, resulting in a lower return for the processor.

Great variety also exists in the form of business arrangements among growers and processors. Grower-processor relationships can be thought of as comprising a continuum with pure "arm's length" exchange or spot markets at one extreme, and grower-processor vertical integration (a single firm owning both production and processing facilities) at the other extreme. In between the extremes are various forms of contractual relationships between growers and processors.

Pure arm's length exchange or spot markets are increasingly rare. Two key factors have contributed to the decline. First, as the number of firms buying in a given geographic area has declined, the efficiency of price discovery in spot markets diminishes, and concerns over buyer market power escalate. Second, arm's length transacting is a poor way to coordinate activity and transmit market information between buyers and sellers, and this type of coordination has become increasingly important in meeting consumers' demands in the marketplace.

The processing tomato industry illustrates some advantages of vertical coordination and problems of conducting transactions through spot markets. Tomatoes are perishable and costly to transport. Thus, processors have an incentive to procure production near their processing facilities. Timing of production is also critical. Tomatoes must be harvested immediately upon ripening and then processed quickly to avoid spoilage. Tomatoes can be harvested in California over about a 19-week interval from the end of June through October (Durham, Sexton, and Song). The efficient operation of processing facilities and the effective processing of the harvest require that a processor's deliveries be spread uniformly over this harvest period. Similarly, processors specialize in producing different types of tomato products. Some plants produce only tomato paste, which is then used as an input in producing various processed tomato products, while others produce whole tomato products. The ideal type of tomato to grow depends upon the intended finished product.

Delivery dates and product characteristics cannot be communicated effectively through spot markets. Nor will a central market work when processors are interested in procuring product only in the vicinity of their plants. Thus, the California processing tomato industry transacts essentially its entire production through grower-processor contracts. These contracts specify the specific acreage the product is to be grown on, variety of tomato to be grown, delivery dates, and premiums and discounts for various quality characteristics.

This high level of vertical coordination enhances the California processing tomato industry's competitiveness in the international marketplace. Unlike tomato sectors in many other countries, tomato production in California consists of two completely separate, dedicated industries rather than a single, dual usage industry; tomatoes are grown either for processing or for fresh usage. In this way, deliveries to processors are not dependent on fresh market tomato prices, and processors are assured of stable supplies of varieties with the appropriate processing rather than fresh market attributes.

In general processors seldom have incentive to integrate upstream into farm production, because farming traditionally earns a low rate of return and processors have been successful in achieving desired levels of grower-processor coordination through production contracts. Growers, on the other hand, may well have incentive to integrate downstream into the processing and marketing of their production for several reasons, including avoidance of processor market power, margin reduction, and risk reduction (Sexton and Iskow). The minimum efficient scale of operation in farming is ordinarily much smaller than in processing and marketing, making it infeasible for most farmers to integrate unilaterally. A solution is to integrate collectively by forming a marketing cooperative of farmers with common interests. Such marketing cooperatives are a very important part of California's agricultural marketing system. Nationwide, it is estimated that cooperatives' share of agricultural product marketings at the farm gate is 31 percent. Cooperatives are most active in the first-handler functions of storage and processing and have comparatively less involvement in wholesaling and retailing. The market share comprised by cooperatives thus often declines rather rapidly as the product moves downstream to consumers. In California, the share of product marketing conducted through cooperatives varies widely depending upon the industry, as Table 3 indicates.

Several industries feature a dominant marketing cooperative that controls upwards of half or more of the California market volume. Examples include Sunkist (citrus), Sunsweet (prunes), Calavo (avocados), Sunmaid (raisins), Blue Diamond (almonds), and Diamond Walnut. Sunkist is the largest California marketing cooperative, generating annually a billion dollars or more in gross revenue. The second largest cooperative marketer is Tri Valley Growers, which processes a variety of fruit and vegetable products. Tri Valley, however, is not a major branded marketer, selling instead through various regional and private label brands.

These companies are traditional marketing cooperatives in the sense that they obtain, process, and sell members' production, while operating on a zero profit basis. Some facets of California's marketing cooperatives are rather unique, however. For example, some do not have open membership policies. Some also restrict the amount of product that their members can deliver. Such strategies are generally undertaken by the cooperatives who control successful brands. These cooperatives face downward-sloping demands for their products and can exploit this demand to earn a price premium relative to the rest of the market. In order to earn this premium, however, the cooperative must restrict the amount of product that flows into its branded market(s). Restricting entry into the cooperative and/or limiting members' deliveries helps ensure the price premiums.[2]

[2] Sunkist provides a good illustration of the value in a well-established and widely recognized cooperative brand. Fresh citrus bearing the Sunkist name commands a premium price in both domestic and foreign markets, and the Sunkist cooperative earns millions of dollars of royalty income by licensing the trademark. The 1992 capitalized value of the brand name was almost $1 billion, based on 1992 royalty income of $15.5 million, an estimated Sunkist premium of almost $58 million on 82 million cartons of fresh fruit, and a capitalization rate of 7.4 percent.

Table 3. Cooperatives' Market Share in Selected California Agricultural Industries, 1986.

Commodity	Market Share
	percent
Fruit and Nut Crops	
Almond marketing	47
Prune marketing*	61
Table grapes	5
Raisins*	78
Wine grapes	11
Fresh peaches, plums, nectarines	10
Canned cling peaches*	92
Avocados	48
Olives	70
Field and Seed Crops	
Cotton ginning	39
Cotton lint marketing	45
Rice drying	70
Hay	2
Wheat and barley	4
Dry beans	60
Sugar beets	99
Vegetables and Strawberries	
Lettuce	6
Processing tomatoes*	91
Strawberries	22
Livestock and Poultry	
Dairy processing	58
Eggs	8

*Includes bargaining cooperative share.

Source: Smith and Wallace, 1990.

Another avenue to achieving price premiums in branded markets is through market segmentation and price discrimination. Depending upon the product, segmentation may be accomplished between the domestic and export markets or the fresh and processed markets. Blue Diamond represents a good example of the first strategy. Blue Diamond is the only leading retail almond brand in the U.S., but about 60 percent of Blue Diamond's production is exported in any given year. Examples of the second strategy include Sunkist, which can support prices in the fresh citrus markets by channeling excess supplies into the frozen juice market, and Calavo, which can support fresh avocado prices by moving supplies into the production of guacamole dip. A problem with market segmentation strategies occurs when rival marketing firms are able to take advantage of the leading cooperative's strategy by increasing their own sales into the premium market, thereby undercutting the effectiveness of the segmentation strategy. One response to this problem has been to make the segmentation strategy mandatory for all firms in the industry through government intervention in the form of marketing orders. Such mandatory programs are discussed in the next section.

Two other forms of cooperative behavior by growers are relatively unique to California. They are information-sharing cooperatives and bargaining cooperatives. Information-sharing cooperatives are exclusive to California. These organizations perform no handling or other traditional marketing activities for their members. Rather, they serve as devices for their members to communicate, share information on production plans and market conditions, and formulate pricing strategies. Industries where these cooperatives have emerged include iceberg lettuce, melons, kiwifruit, table grapes, fresh stone fruits, mushrooms, and fresh tomatoes. The activities undertaken by these cooperatives would ordinarily be illegal under the U.S. antitrust laws but are rendered lawful because the U.S. Capper-Volstead Act grants an exemption from the antitrust laws to farmers acting collectively through a cooperative. The major examples of this form of cooperative are industries where the product is highly perishable and production is concentrated in the hands of relatively few grower-shippers. Successful coordination of production and marketing in these industries can be a major advantage in terms of managing the flow of product to the market to avoid the periods of over supply and low prices that have been common in these industries. Membership in these organizations tends to fluctuate, however, and there is little evidence to date that they have been successful in either raising or stabilizing grower prices.[3]

Bargaining cooperatives also engage in little or no actual handling of product. Rather, they function to enable growers to bargain collectively the terms of trade with processors. Iskow and Sexton identified 10 active bargaining cooperatives in California and 29 nationwide. Prominent California bargaining cooperatives are the California Tomato Growers, California Canning Peach Association, California Pear Growers, Prune Bargaining Association, and Raisin Bargaining Association. These cooperatives are a response to the asymmetry in power that might otherwise characterize dealings between farmers and processors. Bargaining associations are especially common in processed fruit and vegetable industries, where products are generally grown on a contract basis and there is no active spot market. In addition to increasing growers' relative bargaining power, these associations play a valuable role in facilitating exchange and minimizing transactions costs. Rather than having to negotiate terms of trade with each individual grower, a processor need strike only a single agreement with the bargaining association. Generally the bargaining association will negotiate first with a single leading processor, with similar contract terms then applying to other processors.

In no case is a cooperative the sole marketer or bargainer in California. Farmers always retain the option not to participate in a cooperative. In fact, many of the benefits that a cooperative provides are available to a grower whether or not he is a member of the cooperative. For example, Blue Diamond was a leader in opening new

[3] Sexton and Sexton discuss the experience with an information-sharing cooperative in the California iceberg lettuce industry.

export markets for almonds. However, once these markets were established, other handlers were easily able to sell into them. In industries with cooperative bargaining, a farmer who is not a member of the bargaining association generally receives the same terms of trade as growers who are members. Thus, farmers have an incentive to free-ride on the activities of the cooperative.

MANDATED MARKETING PROGRAMS

U.S. legislation at both the national and state levels allows producers and marketers of many agricultural products to act collectively to control various aspects of the marketing of their products. In California, enabling legislation for federal and state marketing orders and agreements is provided by the Agricultural Marketing Agreement Act of 1937 (AMAA) and the California Marketing Act of 1937, with amendments. California has also passed more than 20 individual laws for the formation of commodity commissions and councils. Federal marketing orders can cover a production region in more than one state, while state orders are effective only within the state boundaries. Federal marketing orders tend to focus on quality regulations and sometimes volume controls, while California state marketing programs tend to focus more on research programs and promotion. Federal marketing orders are applicable to milk and specified groups of fruits, vegetables, and other specialty crops, while California marketing programs are available for all agricultural commodities. Several California commodities utilize different programs for different activities. For example, California-grown kiwifruit has a federal marketing order program that administers grades and standards and a state commission that conducts advertising and promotion; California walnuts have a federal marketing order with provisions for grades and standards and quantity control and a state commission used only for export advertising and promotion.

California agricultural producers were at the forefront in adopting both federal and state marketing order programs when they first became available in the 1930s. The mandatory nature of the programs overcame the free-rider problems that had earlier led to a breakdown of cooperative-organized quality and supply control marketing efforts.[4] The popularity of government-mandated commodity programs is clearly reflected by their continued use by a large number of commodity producers. Currently, California has 13 federal marketing orders and 48 state marketing programs. These programs have recently covered commodities that accounted for over 50 percent of California's agricultural output, based on value (Table 4). A total of 24 new state programs have been added since 1980, and 15 were terminated. Of the 17 federal marketing orders operating in 1993, four were eliminated by January 1996, with none added. The terminated federal programs included the marketing order of desert grapes

[4] In 1924, the California Fruit Growers Exchange (Sunkist Growers) established a formal shipment and grade control agreement with their local associations, who controlled about 90 percent of the annual crop, to prorate weekly lemon shipments. While it was initially successful in increasing and stabilizing fresh market prices by diverting specified quantities of lemons to processing, it was dropped after about 10 years when Exchange membership began to slip. Non-members gained a marketing advantage over Exchange members because they did not have to divert any of their lemons to the lower priced processing outlet (Kirkman, p. 16). California-Arizona lemon producers were one of the first commodity groups to request and approve a federal marketing order prorate program under the AMAA.

and the long-standing marketing orders for California-Arizona Navel oranges, Valencia oranges, and lemons.

Table 4. Value Shares of California Commodities Under Mandated Marketing Programs, 1993.

Category*	California Total	Commodities Under Marketing Programs	Ratio of Value Under Programs to Total
	*--value of production ($1,000) --***		
Field Crops	3,125,108	557,582	0.18
Fruits and Nuts	5,701,396	2,948,804	0.52
Vegetables	4,206,762	2,765,730	0.66
Animal Products	5,233,145	4,455,566	0.85
Nursery	1,920,876	241,042	0.13
Total	20,187,287	10,968,724	0.54

* Fishery and forestry products are excluded.
** Commodities listed are based on 1995 marketing programs but value of production data are for 1993, the most recent year that consistent value data were available for all of the categories.

Source: Lee, Alston, Carman, and Sutton, 1996.

Government-mandated marketing programs operate under legislation that empowers growers to act collectively to improve their profitability through orderly marketing. They are requested by producers to solve their marketing problems; the Secretary of Agriculture (or his state counterpart) holds public hearings on provisions to be included; the finalized orders are approved by a producer vote, and are binding on all producers in the designated geographic area covered by the order. Marketing order activities are financed by the affected producers, who are required by law to participate in the program. Each producer pays an assessment levied on each unit (quantity or value) of the commodity marketed to provide funds to operate the program.

Marketing orders authorize three broad categories of activities: (a) quantity control, (b) quality control, and (c) market support, such as advertising and research. Quantity or supply control provisions may take the form of producer allotments, allocation between markets (foreign and domestic or fresh and processed), reserve pools, and market flow regulations (handler prorates). Orders may also have quality control provisions that permit the setting of minimum grades, sizes, and maturity standards. Advertising and promotion account for the majority of market support expenditures, with research in a distant second place; other market support activities include container regulations, price posting, and prohibition of unfair trade practices. A listing of active programs and authorized activities for fruits, vegetables and specialty crops appears in Table 5.

Table 5. Authorized Activities for California Commodity Marketing Programs.*

Commodity	Grade and Size	Quantity Controls	Advertising and Promotion	Research	Year Effective
Federal Marketing Orders					
Almonds	A	A	I	A	1950
Dates	A	I	A	A	1955
Grapes-Tokay	A	I		A	1980
Kiwifruit	A			I	1984
Nectarines	A		A	A	1958
Olives	A		A	A	1965
Peaches-Fresh	A		A	A	1939
Pears-Winter	I		A	A	1939
Potatoes, Oregon-California	A			I	1942
Prunes-Dried	A	I		I	1949
Raisins	A	A	A	A	1949
Walnut Marketing Board	A	I		A	1948
Far West Spearmint Oil		A		A	1980
State Marketing Orders					
Alfalfa Seed Production				A	1973
Apricot			A	A	1971
Artichoke Promotion			A	I	1960
Carrot (fresh)			A	A	1992
Celery				A	1976
Cherry			A	A	1993
Citrus Research				A	1968
Figs (Dried)	A	A	A	A	1944
Iceberg Lettuce Research				A	1973
Melon Research				A	1972
Manufacturing Milk			A	A	1970
Market Milk			A	A	1969
Milk (Fluid)			A		1969
Peach (Cling)	A		A	A	1984
Pear	A		A	A	1992
Pistachio Agreement					1994
Plum Order	A		A	A	1994
Potato Research				A	1974
Rice Handlers			A		1984
Rice Research				A	1969
Prunes (Dried)			A	A	1947
Strawberry (Processing)	A		I	A	1960
Tomato (Fresh)**			A	A	1972
Tomato (Processing)	A				1986
Wild Rice		I	A	A	1968
State Commodity Commissions					
Apple Commission	I		A	A	1994
Asparagus Commission			A	A	1990
Avocado Commission	I		A	A	1978
Egg Commission			A	A	1984
Cut Flower Commission			A	A	1990
Forest Products Commission			A	A	1991
Grape Commission-Table			A	A	1968
Grape Rootstock Commission				A	1993
Kiwifruit Commission			A	A	1980
Pepper Commission			A	A	1988
Pistachio Commission			A	A	1981
Strawberry Commission (Fresh)			A	A	1955
Walnut Commission			A		1986
Wheat Commission			A	A	1983
Lake County Winegrape Com.			A	A	1992
Lodi-Woodbridge Winegrape Com.			A	A	1991

*A designates active use; I designates inactive use.
**Fresh tomatoes switched from a state marketing order to a Commission program in 1996.

Table 5 continued on next page.

Table 5. (continued)

Commodity	Grade and Size	Quantity Controls	Advertising and Promotion	Research	Year Effective
Councils					
Beef Council			A	A	1957
Dairy Council			A	A	1945
Salmon Council			A	A	1991
Seafood Council			A	A	1991

Source: Lee, Alson, Carman and Sutton, pp. 20-23.

FINANCING AND EXPENDITURES

The Secretary of Agriculture (or California counterpart) approves assessment rates for each marketing year based on the recommendation of the marketing program administrative committee. To facilitate payment, marketing program assessments are usually collected at the first handler level of the marketing chain. Thus, for fruits and vegetables, the assessments are paid by packing houses and processors on behalf of the producers who deliver the product. Handlers and processors may in turn deduct such assessment payments from any money owed to their producers. For example, the marketing order for processing cling peaches established a rate of assessment upon producers of $5 per ton delivered to the processor and upon processors of $3 per ton of cling peaches accepted for processing during the 1995–96 crop season. Each processor is required to remit the total assessments of $8 per ton to the Cling Peach Advisory Board, and deduct $5 from the payment owed to producers.

THE ECONOMIC EFFECTS OF MANDATED PROGRAMS

While the primary objective of mandated marketing programs has been to improve producer returns, precise estimates of program impacts have been difficult to develop. This has often led to discussions among producers concerning the returns realized from their expenditures on such things as advertising and promotion and quality control programs. Some producers have also questioned the benefits of industry supply control efforts. Because of their possible impacts on other groups, such as consumers and trading partners, and their effects on producers, marketing program provisions have often been controversial. Several California marketing order and commission commodity promotion and research programs have recently been involved in litigation as a small minority of unhappy producers and handlers have turned to the courts with requests to modify or terminate the programs. Recent court cases involving constitutional challenges include actions against the marketing orders for peaches and nectarines, kiwifruit, plums, apples, grape rootstocks, cut flowers, almonds, milk, cling peaches, and table grapes.

QUANTITY CONTROLS

Marketing order quantity controls can be a powerful economic tool when the commodity group controls most of the production of the commodity and when there are different (separate) markets with different elasticities of demand. Under these conditions, the commodity group can gain a measure of monopoly power and enhance returns through price discrimination. However, since they are unable to control entry, any short-run price enhancement will lead to a longer-run supply response. It is not surprising that quantity controls have been controversial—monopoly pricing practices reduce the welfare of some consumers and may distort resource allocation decisions, while producers face all of the problems of maintaining a cartel.

Marketing orders for several California commodities have included quantity control provisions, although the use of quantity controls has decreased over time as a result of problems noted above. Research on four California commodities provides evidence on the economic effects of marketing order quantity controls. These include the weekly prorates for California-Arizona lemons and Navel oranges, and the reserve pools for California raisins and almonds.

Citrus

The federal marketing orders for citrus, with their prorate provisions, were terminated at the end of the 1993–94 crop year after more than 50 years of almost continuous use. Opponents of the citrus volume regulations, who had been sued in 1983 by the United States for violations of prorate, discovered evidence of over shipments by a large number of competing orange and lemon packing houses. Because of these violations of prorate rules, a series of lawsuits, investigations, and proposals for penalties under AMAA forfeiture rules threatened to keep the industry in court for years and create economic hardships for many industry participants. To minimize long-term damage to the industry and "to end the divisiveness in the citrus industry caused by over ten years of acrimonious litigation," the Secretary of Agriculture terminated the California-Arizona citrus marketing orders, effective July 31, 1994, and dismissed all litigation brought pursuant to the AMAA.

The citrus prorates set the amount of lemons and oranges that could be shipped to the domestic fresh market on a weekly basis. For example, the Lemon Administrative Committee (LAC) met weekly and, on the basis on their annual marketing plan and current market conditions, determined the number of carloads of lemons that could be shipped to the domestic fresh market (including Canada) the following week. This shipment quota was then "prorated" among all lemon packing houses based on a multi-week moving average of each handlers share of all lemons picked. Lemons in excess of a handler's fresh market prorate could be exported or processed without limits.

The price elasticity of demand facing packers is inelastic in the fresh market, very elastic in the processing market, with the export demand elasticity somewhat in the middle. These markets may be separated, making price discrimination both possible and profitable. Thus, the LAC typically restricted the quantity placed on the domestic fresh market to maintain prices above the competitive level and increase total crop revenues. Market conditions for Navel oranges were similar to lemons, and the Navel Orange Administrative Committee used prorate in a similar manner.

Empirical evidence indicates that the fresh market citrus prorate reduced the quantity of lemons and Navel oranges sold on the domestic fresh market and increased both producer prices and total revenues during a given crop year. There are also indications of more stable f.o.b. prices when prorate was used. At the same time, prorate increased the proportion of the annual crop that was processed and exported and tended to reduce prices in export markets, other factors being equal.

Short-run producer price enhancement without any controls on entry led to an acreage response for both lemons and Navel oranges. As new plantings reached bearing age, the Administrative Committees were forced to divert increasing proportions of the annual crop to exports and processing to maintain fresh market prices. Producer returns from all markets decreased over time, until new plantings were no longer profitable. However, when compared to a competitive solution, prorate resulted in increased acreage and production of citrus, as well as increased exports and processed products (Thor and Jesse; Shepard).

Raisins

California is the largest volume raisin producer in the world, and this industry has operated under a federal marketing order program with volume controls since 1949 (Nuckton, French and King). Under the raisin marketing order, annual production is divided between free tonnage and a reserve pool, and the Raisin Administrative Committee (RAC) controls the reserve tonnage. Only free tonnage can be sold on the domestic market, but the RAC can allow packers to buy additional tonnage for free use from the reserve when the RAC determines that such actions are justified by supply and demand conditions.

Until 1977, the majority of raisins in the reserve pool were exported at prices that were much lower than for raisins sold on the domestic market. Raisins from the reserve were also used for the school lunch program, government subsidized exports, other government programs, sales to wineries for distilling into alcohol, donations to charity, and cattle feed. Thus, the raisin industry working through the RAC successfully used the reserve pool to practice price discrimination in separate domestic and export markets. Conditions and markets changed, however, and beginning in 1977, exports were considered free tonnage shipments, and the initial free tonnage was increased to serve favorable export markets. Since 1977, the RAC has often exported reserve pool raisins at prices competitive with world prices but below prices on the domestic market (Nuckton, French and King, p. 79).[5]

[5] Using an econometric model of the California raisin industry, French and Nuckton (1991) found that termination of volume controls would result in a reduction of the quantity of grapes dried into raisins, and increase both the price and price variability of grapes sold for drying. Most of the reduction in raisin production was felt in exports rather than domestic shipments.

Almonds

The federal marketing order for California almonds includes provisions for market allocation and a reserve pool. At the beginning of each marketing season, the Almond Board of California recommends (subject to the Secretary of Agriculture's review and approval) a maximum annual quantity to be sold in domestic and export markets (the market allocation) and the quantity that cannot be sold (the reserve pool). The reserve may be designated as either unallocated or allocated reserve. The unallocated reserve is essentially forced storage; nuts can be released from the unallocated reserve as the season progresses or carried over to the following season. The allocated reserve must be utilized in noncompetitive outlets such as almond butter, almond oil, airline samples, or cattle feed.

The reserve provision of the almond marketing order was used to encourage export sales through 1972, while maintaining higher prices in the domestic market than in the export market. This price discrimination ended when export markets became an important outlet for California almonds, with price elasticities tending to equalize between domestic and export markets. Recent work indicates that the price elasticity of demand for almonds is now more elastic in the domestic market than in major export markets, leading to the result that short-run revenue maximization through price discrimination could involve restricting sales to export markets (Alston et al., 1995). Recent models of acreage response to changing returns indicates that U.S. and Spanish producers each increase production when returns appear favorable (Murua, Carman and Alston). Thus, if the Almond Board were to use the reserve to practice price discrimination and raise world almond prices, increased prices would stimulate production in Spain as well as the United States.

QUALITY CONTROLS

All existing federal marketing orders for California fruits, vegetables, and nuts include provisions for grades and minimum quality standards. However, only eleven of the California state marketing programs include quality standards and inspection provisions, and just seven actively use the provisions.

Given typical seasonal price relationships for fresh fruit, with high early season prices, there are strong incentives to ship fruit as early as possible, even though it may not be fully matured. Most consumers are unable to judge the maturity of fruit from appearance and may find that fruit that "looks good" does not "taste good." The result is a classic example of the economic problem of adverse selection, also known as the "lemon problem" based on the classic work by Akerlof. Sellers are aware of the product's characteristics, but buyers are unaware. In these settings, low-quality products can drive high-quality products from the marketplace.

Indeed, representatives of many commodity groups believe that shipments of immature fruit have a negative impact on total sales, because consumers may delay repeat purchases after being dissatisfied with their original purchases. Maturity standards based on sugar content, firmness, and color are used by several marketing orders to determine when fruit is mature enough to be shipped.

Minimum quality standards may: (1) increase the retail demand for a product, resulting in higher prices and/or increased sales; (2) reduce marketing margins, with benefits accruing to both producers and consumers; and (3) reduce supply, which with inelastic demand can increase total revenue to producers. Any effective minimum quality standard will restrict the quantity of commodity marketed, but supply control is not the usual focus of such standards. Federal marketing order regulations on grade, size, quality or maturity also apply to imports of the same commodities from other countries during the period the marketing order is in effect.

The use of some minimum quality standards has been controversial, with criticism coming from representatives of consumer organizations and a few producers and handlers. Concerns include charges that quality standards are a hidden form of supply control, that quality standards waste edible fruit with the primary impact being on the poorest consumers, and that quality standards are sometimes not equitable because of regional variations in production conditions. While empirical analyses of the economic impact of minimum standards of grade, size, and maturity for California commodities are limited, those available indicate that it is probably relatively small (U.S. GAO).

ADVERTISING AND PROMOTION

California commodity producer groups spend annually about \$90–\$100 million on demand expansion activities—mainly generic advertising and promotion (Carman, Green, and Mandour). Promotion has accounted for about three-fourths of commodity group total expenditures. For fruits, nuts and vegetables, the largest 1992 promotional budgets were for raisins (\$11.9 million), walnuts (\$10.2 million), avocados (\$8.6 million), prunes (\$6.7 million), and table grapes (\$5.6 million).[6] Groups allocating over 75 percent of their budgets to promotion for the period 1970 through 1994 included walnuts, raisins, plums, table grapes, prunes, and avocados (Lee et al.).

The purpose of commodity group expenditures on generic advertising and promotion is to increase the demand for the commodity so that more commodity can be sold for the same price, or the same amount can be sold for a higher price. The rationale for mandatory support by all producers is based on the distribution of documented program benefits and the "free-rider problem."[7] While the effects of commodity promotion have been examined in a number of contexts, research completed on California programs is limited. Work completed and underway, however, documents significant increases in product demand as a result of commodity advertising and promotion programs, with net monetary benefits to producers being much greater than costs. For example, Alston et al. (1996) estimated that the elasticity of demand with respect to promotion for California table grapes was 0.16. Using this promotion coefficient, they estimated that the promotional activities of the Table Grape Commission had increased per

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[6] The raisin program, which featured the popular dancing raisins, was terminated by the State Director of Food and Agriculture after handlers accounting for the majority of volume signed a petition to end the program.

[7] It is not economic for an individual commodity producer to advertise, even with extremely high returns, as can be shown by a simple example. Suppose that returns from a generic advertising program are \$200 for each dollar spent and there are 1,000 equally small producers of the commodity. If an individual producer spends \$100, the benefits to the industry will be \$20,000 but since the benefits are distributed equally based on sales, the individual will obtain a return of only \$20 for his \$100 expenditure.

capita consumption by about 1.5 pounds over that which would have existed in the absence of a promotional program. This increase was about one-third of recent total per capita consumption. The benefits to producers were very high in both the short- and long- run. The short-run marginal benefit-cost ratio was estimated at over 80:1—for every $1 spent on the program, the industry gained net benefits of $80. When producer supply response was factored into the analysis, the benefit-cost ratios decreased. Using a supply elasticity of 5, the average benefit-cost ratio was about 10:1 and the marginal benefit-cost ratio was about 5:1.[8]

The U.S. government has funded agricultural commodity groups, as well as private firms, to conduct promotional programs in export markets. The Market Access Program and its predecessor programs, the Market Promotion Program, and the Targeted Export Assistance Program, have provided matching funds for the promotion of a number of California commodities. Federal allocations of funds to Commodity Boards, Commissions, and other groups promoting California fruits, nuts, and vegetables totaled $17.56 million in fiscal year 1996. These funds accounted for 19.5 percent of total funding to all organizations.

RESEARCH

Research and development provisions are included in most of the California marketing programs. In 1992, there were 28 programs with research expenditures totaling almost $8.5 million (Lee et al.). The largest research budgets were for rice ($1.4 million), citrus ($1.1 million), fresh strawberries ($897,000), dairy ($681,000), eggs ($494,000), avocados ($475,000), and iceberg lettuce ($475,000). Overall, research expenditures accounted for about 7.5 percent of total 1992 commodity group expenditures. In terms of the total farm level value of production, research on production remained nearly constant during the period from 1973–1992 at less than 0.1 percent of production value.

Summary statistics on the economic impacts of commodity group research expenditures are limited, but those available indicate attractive rates of return. Most of the research funded by commodity groups operating under state marketing orders and commissions is done at the University of California. A study valuing California agricultural research concluded that the average annual internal rate of return for public investment in California agricultural research and extension for 1949–85 was about 20 percent (Alston, Pardey and Carter). This study included case analyses for dairy, grapes and wine, and strawberries. While each of these commodities funded research through their mandated marketing programs, the connection was most direct for strawberries. California has become the world's pre-eminent strawberry producer, now accounting for about 80 percent of U.S. fresh and processed production. California's average yields of 26.8 tons per acre in 1991, the highest in the world, are due largely to

[8] Carman and Craft estimated that the price flexibility of demand with respect to advertising and promotion of California avocados was approximately 0.13 at average values. While their estimated benefit-cost ratios for advertising and promotion were below those for table grapes, estimated returns were still quite attractive in both the short-and long-run.

sustained research efforts over a long period of time. These efforts, which included variety testing, culture, soil fumigation, disease-free plants, drip irrigation, mulching, and annual replanting, are documented in Alston, Pardey and Carter (pp. 76-90). California Strawberry Advisory Board grants accounted for 42.5 percent of all state funds for strawberry research during the 15-year period from 1978 to 1992.

The distribution of the returns from production research is an issue that has been studied extensively by agricultural economists. Alston, Norton, and Pardey provide an excellent summary of this work. Depending upon the relative elasticities of demand and supply, consumers may receive half or more of the short-run benefits from production research. Huang and Sexton demonstrated recently that market power can have an important effect on both the level and distribution of benefits. Processors with market power may be able to capture a large share of the benefits at the expense of both consumers and producers. To the extent that the benefits from producer-funded research accrue to consumers and processors, it diminishes the farm sector's incentive to fund such research.

FUTURE PROSPECTS FOR MANDATED MARKETING PROGRAMS

As Table 5 shows, some commodity programs have been effective for a long period while others are of more recent origin. Many programs have been terminated as a result of changing economic and political relationships. Despite the turnover, the number of government-mandated commodity programs has grown over time, and the group approach to solving commodity marketing problems remains popular. The periodic renewal votes conducted for most programs reveal their popularity, with positive votes typically above 90 percent.

A number of marketing programs have, however, encountered problems. As a group, the programs using quantity controls to practice price discrimination have lost governmental and legislative support, due to perceived possible adverse impacts on U.S. consumers. The programs with the strongest potential for increasing producer prices, including hops, lemons, Navel oranges, and Valencia oranges, have been terminated by the Secretary of Agriculture. Those orders with quantity controls use them infrequently. Informed observers agree that it will be very difficult to gain approval for a new marketing order with strong quantity controls.

The effects of the legal challenges to mandatory producer and handler support of commodity advertising programs, which are working their way through the legal system, are difficult to forecast since they are dependent on court findings. If the courts find that producers and handlers cannot be compelled to support an industry advertising program, then many, if not all, will probably fail due to free-rider problems. If the courts decide in favor of mandatory support, current programs will continue and new programs may emerge. There will, however, be increased monitoring of program costs and benefits to assure program supporters that their funds are being well-spent.

Research funding pressures may require commodity groups to increase their support for research programs, if they want research to be done. The mandated programs provide a proven means for commodity-based research support, and they may take on an increased research role, as has been done by the California strawberry industry.

OTHER REGULATIONS AFFECTING MARKETING

In the U.S. food marketing system, the main role of the government is to facilitate commerce through market information and to define the rules of the game through trade practices regulation. The government also plays an important facilitating role by providing the legal framework for growers to come together for common purposes, through cooperatives or the mandated marketing programs described earlier.

In the vast majority of day-to-day buying and selling transactions, the government is not called upon to enforce market regulations since firms perform according to legal standards without the need for government inspection and intervention. While mandatory grades and standards established by federal or state marketing orders for certain crops in certain regions and seasons represent an exception, most government grades and standards are not mandatory, but rather used voluntarily by industry. Thus, the U.S. approach has been limited direct intervention, opting instead to establish a legal foundation that facilitates commerce through workable and clear "rules of the game." This approach has served to reduce transaction costs and, hence, marketing margins.

One of the most important federal regulations governing trade practices in the fresh produce industry is PACA, the Perishable Agricultural Commodities Act of 1930, administered by the USDA. PACA was recently restructured and strengthened with the passage of The Perishable Agricultural Commodities Act Amendments of 1995.

Most firms buying and selling fresh produce in the U.S. must be licensed with PACA. Failure to pay produce creditors means that firms risk suspension or revocation of their licenses. Since fresh fruits and vegetables are generally sold on an FOB basis with quick turnaround, payment is rarely received until after product delivery, hence providing the justification for some payment protection to produce sellers.

Market information on shipment volumes and commodity prices at the first-handler, processor, and wholesale levels is collected and publicly reported by the Agricultural Marketing Service (AMS) of the U.S. Department of Agriculture (USDA), through state-federal cooperative arrangements. In addition, the USDA collects data on commodity acreage, production, and value through its National Agricultural Statistics Service (NASS); reports on international trade volumes via the Foreign Agricultural Service (FAS); provides economic analysis of each commodity sector through the Economic Research Service (ERS); and conducts research on agricultural production methods and postharvest handling via the Agricultural Research Service (ARS).

Finally, the U.S. land-grant university system conducts important research on both agricultural production methods and marketing and trade, diffusing this research-based information to the private sector through Cooperative Extension. These facilitating functions greatly enhance the transparency of agricultural markets, thereby increasing marketing efficiency. Furthermore, mandated programs and public sector research enable growers to take advantage of the public good characteristics of market promotion and development, research, and quality standards. The University of California has played an important role in the public-private sector partnership that has evolved over the last century as a foundation for the development of a highly efficient U.S. food marketing system.

CONCLUSIONS

Marketing-related expenditures now account for the majority of retail food expenditures for nearly every major commodity. Thus the performance of the food marketing sector is a major determinant in the United States of both food costs and farmer income. This chapter has highlighted the institutions and strategies that California marketing firms have utilized to respond to consumers' demands and to the challenges of increasing global competition. California agribusiness has successfully substituted technology and information for labor, enabling the state to compete despite relatively high labor costs. Firms have also reduced marketing costs through increased vertical coordination.

California food marketers have embraced the globalization of food markets. They have expanded exports and developed innovative arrangements for international sourcing, particularly for fresh fruits and vegetables. Timely responses to marketing and consumer trends have enabled California agriculture to maintain and in many instances increase market share relative to other agricultural regions in the United States.

Importantly, the industry has evolved and maintained its competitiveness largely without active government intervention. Direct government price and income supports apply to only a few major California crops, notably rice, cotton, and dairy. The role of state and federal government in the mandatory marketing programs discussed in earlier sections is merely that of a facilitator. Government supplies the legal framework for industries to undertake collective action, but decisions on whether and how to use these programs are made by the industries, and they are self-funded. Undeniably, California owes much of its success in agriculture to its rich soil and desirable climatic conditions, but the importance of private enterprise, operating in free markets backed by a stable legal environment, should not be understated.

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Chapter 6

HIRED FARM LABOR

Philip Martin and Jeffrey Perloff

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Agriculture is a major industry in California. The 30,000 crop and livestock farmers who hire workers, plus custom harvesters and farm labor contractors, comprise about four percent of California employers. These agricultural employers employ about 800,000 individuals during a typical year, which works out to about 5 percent of California employees being classified as "farm workers" at least part of each year. There is a general racial/ethnic difference in California between farm employers and employees; most farm employers are native-born non-Hispanic whites, while most workers are Hispanic immigrants.

California agricultural workers earn less than manufacturing workers. Average hourly earnings in California agriculture are about half of average manufacturing levels, $5 to $6 per hour versus $10 to $12 per hour. Farm workers average about 1,000 hours of work per year, about half as many as manufacturing workers, so that farm workers in California have annual earnings that are one-fourth the $20,000 to $25,000 average for factory workers.

The nine unions active in California agriculture have fewer than 30,000 members, although the organizing activities of the dominant union, the United Farm Workers, have increased since 1994. There may be about 300 collective bargaining agreements in California agriculture—one for every 75 farm employers. Most union agreements are with dairy farms; the only commodity in which a majority of farm employees are represented by unions is mushrooms.

Significant changes in the California farm labor market in the near future are unlikely. Most workers are expected to continue to be immigrants, assembled into crews by intermediaries and deployed in crews of 20 to 40 to relatively large farms. Unions are expected to be important in some high-value crops, but the major factors influencing the farm labor market in the twenty-first century are expected to be government regulations, including minimum wages, immigration policies, and housing and related working conditions (Martin et al., 1995).[1]

[1] The best source of current information on development in the California farm labor market is *Rural Migration News* (quarterly).

FARM EMPLOYERS

Farming in California is often compared to manufacturing in factories. Most farm workers in California are employed in open-air enterprises that turn raw materials into finished products. A farm factory brings together people, land, water, and machines to transform seeds into crops. Because the agricultural production process is biological, farm factories face risks that do not arise in manufacturing production processes governed by engineering relationships.

California agriculture has been and is dominated by specialized enterprises that hire hundreds of workers for a three-to-six-week harvest. Unlike the stereotypical midwestern farmer, who does most of the farm's work with his hands every day, the hired managers responsible for most of California's labor-intensive crops rarely hand-harvest themselves. Indeed, many are unable to communicate with the workers who do in their native languages. A familiar adage captures many of the differences between California agriculture and midwestern family farms: California agriculture is a business, not a way of life (Fisher, 1953).

Most farm workers are employed by farms that produce fruits and nuts, vegetables and melons, and horticultural specialties such as flowers and mushrooms, the so-called Fruits, Vegetables and Horticultural (FVH) commodities sector. The production of FVH commodities is considered "labor-intensive," an adjective that suggests that the cost of hired workers is often the single largest production expense. Labor costs in FVH production range from 20 to 50 percent of total production costs—higher than the 20 percent average in manufacturing, but less than labor's 70 to 80 percent share of costs in many service industries.

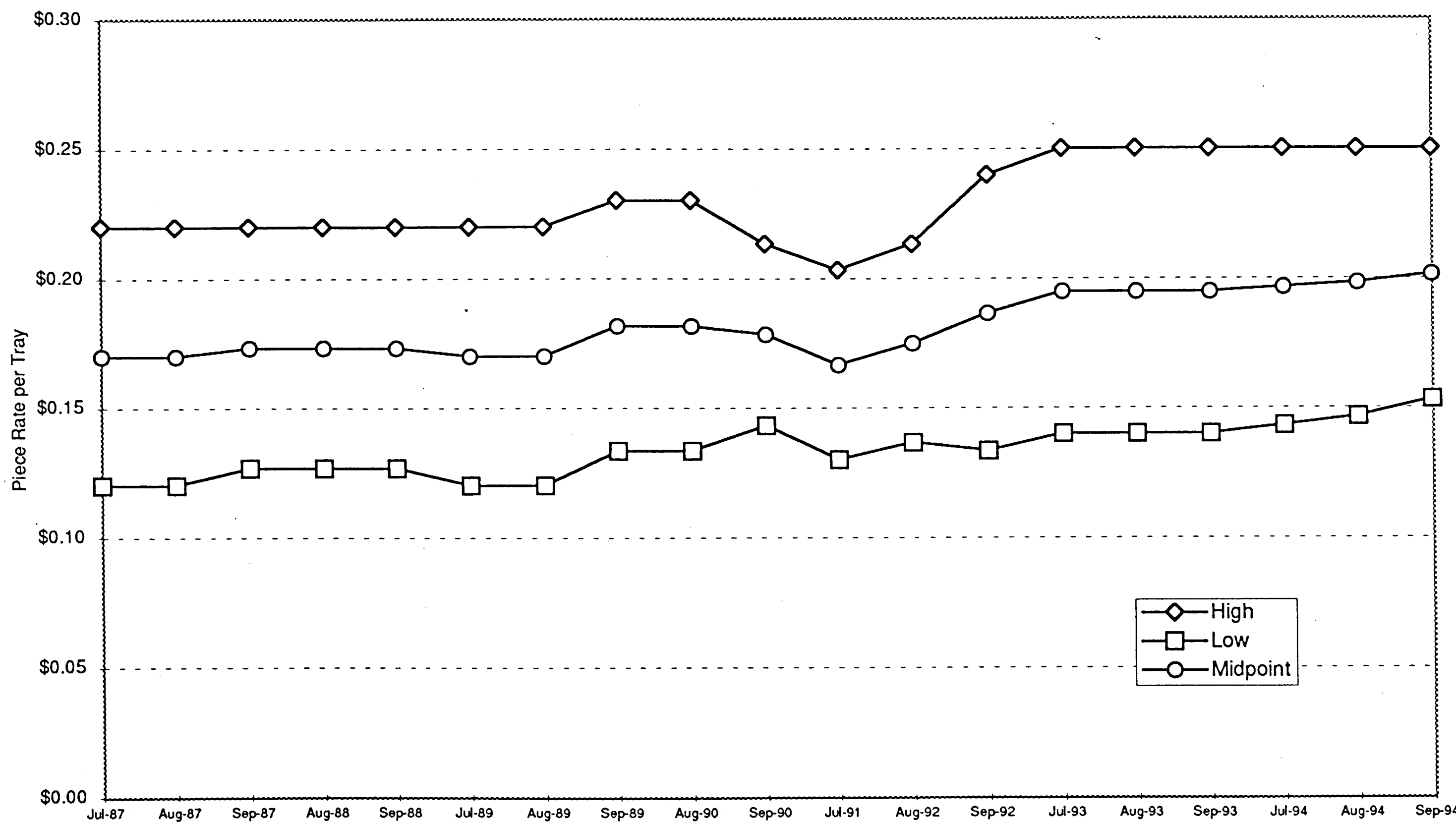
For example, the singe most labor-intensive activity in U.S. agriculture is cutting raisin grapes for six to eight weeks each August and September. Some 50,000 farm workers spread through vineyards around Fresno cutting bunches of 20 to 25 pounds of green grapes and laying them on paper trays to dry into raisins. Workers receive $0.16 to $0.28 per paper tray of raisins cut and laid, and the farm labor contractor (FLC) who typically recruits and supervises them receives $0.04 to $0.05 for payroll taxes and business expenses and profits (Figure 1).

Most of the vineyards are small: 20 to 50 acres. Many employers hire workers directly, often recruiting with a sign at the entrance to the vineyard that says in Spanish "workers wanted." Frequently, workers looking for work drive the public roads through the vineyards, and stop and ask each foreman for a job. If a raisin harvester can find work 10 hours daily for eight weeks, he will have 560 hours of raisin harvest employment which, at $5 hourly, yields $2800 in farm earnings.

Most farm employment and wages are paid by the largest FVH operations. According to state unemployment insurance tax records, 24,500 California farm employers paid $4.6 billion in wages to 900,000 employees in 1990.[2] The largest 1,250 farm employers—5 percent—paid about two-thirds of California's farm wages. The "average" farm employer is very small. Half paid less than $10,000 in farm wages in

[2] These "employees" are unique social security numbers. Some farm workers, who may often change employers during one year, utilize several social security numbers, so that the number of individual farm workers may actually be less than 900,000.

Figure 1. Fresno Raisins: Piece Rate Wages, Three Month Moving Average.



Source: California Employment Development Department, Report 881A.

1990. The large farm employers, who hire most of the state's farm workers, may each employ as many as 5,000 workers at the harvest peak and have a weekly payroll of $1 million, which makes them large employers by any definition.

Many of the largest California farms are corporations. A 1992 survey of 900 California farm employers reported that only about 30 percent of all farm employers were corporations, but 60 percent of the sample farms with annual payrolls over $500,000 were corporations, usually family-run (Rosenberg, 1995).

Most of California's labor-intensive farming operations have 10,000 to 15,000 acres of farm land, which, at an average value of $5000 per acre, gives them $50 million to $75 million each in assets. Villarejo (1980) reported that the largest California farms that hire significant numbers of farm workers included Giumarra farms, a 12,000-acre grape grower; Pappas Farms, a 12,000-acre melon and rice grower; John Norton, a 12,000-acre lettuce and citrus operation; Abatti Brothers, an 11,000-acre vegetable operation; and Bruce Church, a 10,000-acre lettuce and vegetable operation. Farm workers usually prefer to work for these large corporate farms, since they tend to pay higher wages and to offer more benefits such as pensions and health insurance. Most other workers receive few optional benefits.

An example of a California farming corporation is the Zaninovich table grape farm in California's San Joaquin Valley, an operation that sells about 5 million 25-pound boxes of grapes annually at an average price of $10 per box. Zaninovich typically hires 1,000 farm workers to help generate $50 million in annual grape sales. Nearby Gerawan Ranches is a partnership, controlled by a husband and wife, that grows peaches, plums, and nectarines on 2,600 acres of land near Reedley, California, and has another 2,800 acres of peaches and grapes near Kerman. Gerawan Ranches employs over 2,000 farm workers.[3] The related Gerawan Company is a California corporation whose majority shareholders are the same husband and wife; it packs, sells, and ships the fruit grown and harvested by Gerawan Ranches.

The Dole Food Company is probably the largest California farm employer, issuing over 25,000 W-2 employee-tax statements annually. Dole's farming operations are divided into a series of legally separate businesses. Dole's Bud Antle subsidiary, based in Salinas, California, hires 7,000 farm workers each year to harvest lettuce and other vegetables. Their workers are represented by the Teamsters Union. Dole also has a vegetable and strawberry operation in southern California, a citrus operation in southern California, a grape and tree fruit operation in central California, and a nut operation in central California. Each is legally independent for employment purposes.

DEMAND FOR LABOR

As in agriculture elsewhere, Californian employment is highly seasonal. Perhaps more so than elsewhere, mechanization and the potential for more mechanization have dominated the debate on farm employment for decades.

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[3] This information is from Gerawan 18 ALRB 5 (1992) and refers to the size and structure of the company in 1990.

Seasonal Patterns

California fruits and vegetables do not ripen uniformly, so the peak demand for labor shifts around the state in a manner that mirrors harvest activities. Harvest activity occurs year-round, beginning with the winter vegetable harvest in Southern California and the winter citrus harvest in the San Joaquin Valley. The major activity in January and February is pruning/cutting branches and vines to promote the growth of larger fruit. In fruits such as peaches, pruning accounts for 10 to 20 percent of the seasonal labor required to produce the fruit but, because pruning occurs over several winter months, there are fewer workers involved. During these winter months, employment on farms is only half its peak September levels.

Harvesting activity moves northward into the coastal plains in March. Workers harvest lemons and oranges in southern California, and they are hired to work in flower and nursery crops as well as to thin and weed vegetable crops in the Salinas area of northern California. By May, workers are picking strawberries and vegetables, and these harvesting activities continue to employ them throughout the summer.

In June, harvest activities move inland to the San Joaquin Valley. So-called tree fruits such as apricots, peaches, plums, and nectarines must be thinned, meaning that workers must remove some of the fruit buds so that the fruit that develops is larger. This is labor intensive. For example, there are almost as many hours devoted to thinning peaches as to harvesting them. Some tree fruits (such as cherries) are ready to be harvested in late spring, and with the harvesting of table grapes and vegetables in the Coachella Valley of southern California, there is a statewide mini-peak in the demand for labor in June.

Harvest activities continue to require large numbers of workers throughout July and August. During the summer months, vegetables continue to be harvested in the coastal valleys. In California's Central Valley, up to 150,000 farm workers harvest tree fruits as well as cantaloupes, melons, tomatoes, and Valencia oranges. Thousands of farm workers are also hired to irrigate crops and to weed field crops such as cotton.

September is the month in which farm worker employment reaches its peak. A series of short but labor-intensive harvests, best symbolized by the employment of 50,000 workers to harvest the state's 300,000 acres of raisin grapes, keeps employers whose harvests are ending in August worrying about whether their workers will remain to finish the harvest of peaches or melons, and raisin employers worry that too few workers will show up before rain threatens to ruin the drying grapes. In the mad scramble for workers, vans ferry workers between farm worker towns or the farm worker sections of cities and fields.

By October, only a few late harvests remain, including olives and kiwifruit. Most of the food processing and packing workers are laid off, and these nonfarm operations shut down for the year. Some workers migrate to southern California and Arizona for the winter vegetable harvest, while others return to Mexico.

Workers willing to follow the ripening crops can find 8 to 10 months of harvest work each year. However, relatively few workers follow the ripening crops within California. A 1965 survey found that 30 percent of the workers migrated from one of California's farming regions to another, and a 1981 survey of Tulare County farm workers found that 20 percent had to establish a temporary residence away from their usual home because a farm job took them beyond commuting distance (California Assembly, 1969; Mines and Kearney, 1982). A national survey of farm workers in the early 1990s found that fewer than 10 percent of the farm workers followed the crops (Gabbard, Mines and Boccalandro, 1994).

Three reasons why many workers stay in one area of California are that the harvesting of some crops has been stretched out for marketing and processing; temporary housing for migrants is scarce; and the availability of unemployment insurance and service programs makes migration less necessary. Most California fruits and vegetables are sold in U.S. and foreign fresh markets in order to obtain the highest prices. "Surplus" production is directed to the lower-priced processing market or not harvested. In order to maximize the period during which fruits and vegetables can be sent to the fresh market, growers plant early-, mid-, and late-season varieties of fruits, or they plant more acres of a vegetable such as lettuce each week.

The reduction in follow-the-crop migration does not mean that there is no migration. It means that the nature of migration has changed. In theory, migrant camps open for 6 months annually should experience considerable turnover as families move on to the next harvest. The fact that they do not highlights the importance of housing—the lack of it—in explaining migration behavior; once a "migrant family" finds suitable housing, it is reluctant to move out and have to search for housing again. Many workers shuttle into the United States from homes in Mexico and then remain in one location rather than follow the crops after their arrival in California.

Until the 1940s, it was common for the wives of field workers to be employed in the packing houses. After unions pushed packing-house wages to twice field worker levels, packing-house jobs became preferred jobs, often a first rung up the American job ladder for immigrant field workers. About 50,000 workers are employed in the preserved fruits and vegetables subsection of the state's manufacturing industry,[4] and additional workers are employed in packing fresh fruits and vegetables and in trucking and distributing them. Some nonfarm California packing jobs have been turned into farm worker jobs by field packing,[5] and some processing jobs have migrated abroad. For example, jobs involved in freezing cauliflower and broccoli moved to Mexico.

There are no consistent data on farm worker employment by commodity. A common approach is to ask farm advisors to estimate the hours of regular and seasonal labor required per acre to produce a commodity, but there are often unexplained differences between reports for the same commodity in two counties. In 1990 Mamer and Wilke reported that the 40,000 acres of processing tomatoes in Yolo County required six regular and 38 temporary hours of labor per acre in 1989, while the 63,000 acres in Fresno County required 22 regular and 31 seasonal hours. (These numbers were combined to generate a statewide average of 16 regular and 34 seasonal hours per acre for labor in processing tomatoes.) The major reason for the difference in hours appeared to be that in Yolo County, irrigation hours were reported to be 0, while in Fresno, they were seven hours per acre. The Fresno report also included five hours of regular supervisory labor per acre, while the Yolo report had none.

Both county reports estimated that harvesting required 11 to 13 hours per acre, or

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[4] Annual average employment was 50,600 in 1987, and ranged from 38,500 in January to 77,100 in August.

[5] Field packing means that farm workers pick and pack the commodity in the field for shipment to market. Most iceberg lettuce is picked and packed in the fields for shipment to grocery stores, and farmers are increasingly picking and field packing other vegetables, including broccoli, melons, and table grapes. In many instances, workers walk behind a slow-moving conveyor belt, pick and place the lettuce or melons on the belt, and then packers riding on the machine wrap and pack the commodity. Field packing is increasing because it involves less handling, portable cooling technologies have been widely available, and field worker wages are lower than packing house wages.

fewer hours per acre than thinning and weeding (14 hours). At 12 hours per acre, sorting the tomatoes from California's 330,000 acres in 1990 required 4 million hours of labor. Sorters sometimes work 12 hours per day and six-day weeks; if they average 72 hours weekly for 10 weeks, they average 720 hours per season. These calculations suggest that a total 5,500 sorters would be required; at the usual wage hourly wage of $4.50 in 1993, sorters averaged $3,240 each for the season.

Mechanization Trends

The number of farm jobs in California has been remarkably stable since the 1960s. The loss of jobs due to picking a crop by machine rather than by hand in many commodities has been offset by the growth of jobs in other farm commodities and the substitution of hired workers for family workers on many farms (Figure 2).

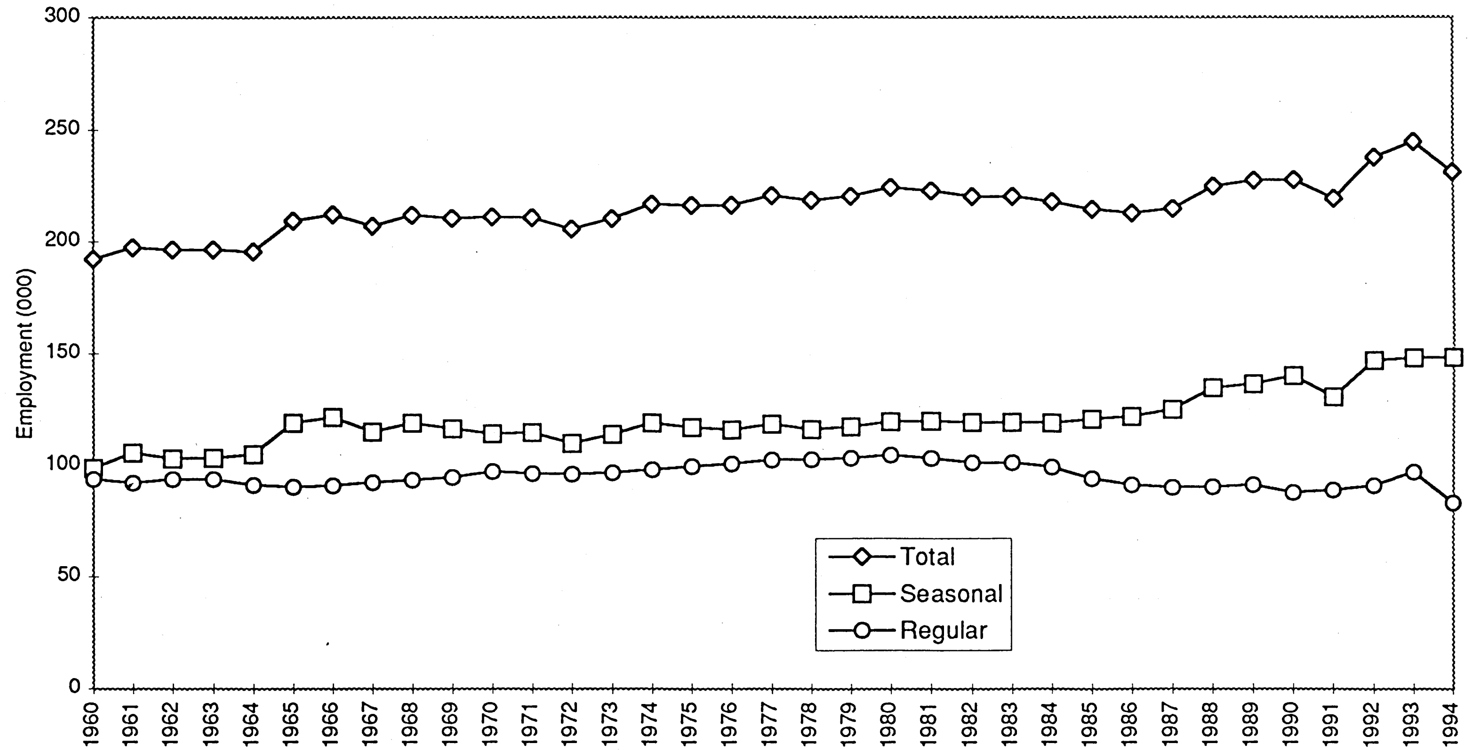
Processing tomatoes provides an example of labor-saving mechanization. In 1960, a peak 45,000 workers (80 percent workers from Mexico who were working legally under the Bracero program) were employed to hand pick 2.2 million tons from 130,000 acres of the processing tomatoes used to make ketchup. In 1996, about 5,500 workers were employed to ride on machines and sort almost 12 million tons of tomatoes harvested from 360,000 acres, a record crop. Per-capita consumption of processing tomato products almost doubled as real prices fell over the past 30 years.

Instead of developing a mechanical harvester that could repick a tomato field many times, scientists redesigned the tomato itself. The new tomatoes are more uniform in size, ripen at the same time, and firm enough that they can be picked without damage. Engineers developed a mechanical harvester that cut the plant, shook off the tomatoes, and then relied on electronic eyes to quickly pick up and sort red and green tomatoes. Most of the research was done at the University of California, Davis, at a cost of about $700,000. The major private manufacturer spent an additional $500,000 to do research on machines in the 1960s.

In 1960, no processing tomatoes were harvested by machine; by 1970, all were machine harvested. Mechanization changed the work force and the wage system changed. Local women, paid hourly wages to sort machine-picked tomatoes, replaced Mexican men who were working legally under the Bracero program and earned piece rate wages to hand-pick tomatoes. The tomato harvest labor force changed from over 95 percent male in the early 1960s to over 80 percent female by the late 1960s (Friedland and Barton, 1975).

Tomato harvest mechanization was expected to be the pioneer in a wave of labor-displacing mechanization. A major 1970 study (Dean et al., 1970) predicted that "California farmers will continue the intensive search for labor solutions, particularly mechanical harvesting." The federal government began programs to help farm workers adjust to the nonfarm jobs they were expected to have to seek (Martin and Martin, 1994).

Figure 2. California Average Annual Hired Worker Employment, 1960-1994.



Seasonal employment has increased from 50 to 64 percent of average employment. Data are extrapolated for 1982-1983. Regular workers are employed 150 days or more by one employer. Excludes Braceros. Source: State of California, EDD Report 881-X, 1995

The massive labor-displacement due to the mechanization of the tomato harvest, however, proved to be the exception rather than the rule in California agriculture. As immigrant workers streamed in from Mexico in the late 1970s, grower interest in mechanization waned. University of California (UC) agricultural engineers were surprised in 1979 by a lawsuit that charged that efforts to develop labor-saving machines were an unlawful expenditure of public funds to benefit farmers (Superior Court of California, Case 516427-5, September 4, 1979). The suit asked that UC mechanization research be halted until the university created a fund to assist farm workers equal in size to what UC earns from royalties (Martin and Olmstead, 1985). Although the suit was eventually abandoned, UC agricultural engineers have engaged in little further research in mechanization since then.

There have been important labor savings in California agriculture, and most less visible than machines replacing hand harvesters. Changes in production practices for perennial crops have saved labor. Drip irrigation reduces the need for irrigator labor. Dwarf trees and vines are trained for easier hand or mechanical pruning and harvesting. Precision planting and improved herbicides reduce the need for thinning and hoeing labor.

IMMIGRANT FARM WORKERS

Most California workers today are Hispanic immigrants. The percentage of male and unauthorized farm workers is about the same in California as in the rest of the United States. As with most hired farm workers interviewed in the National Agricultural Workers Survey (NAWS), most California farm workers do not speak English (only 11 percent spoke English in 1990-91), and few (only 13 percent) finished high school.[6]

In the nineteenth century, U.S. agriculture in general and California agriculture in particular were considered land-abundant and labor-short. Labor shortages were compounded in California by the dominance of large farms growing fruit and vegetable crops that required large numbers of harvest workers.

California agriculture began in the 1850s and 1860s with a legacy of large Spanish and Mexican land grants, which were necessary for grazing cattle and farming grain without irrigation. These large farms were expected to be broken up into family-sized parcels during the 1870s and the 1880s, when irrigation, advances in agricultural science, and the completion of the transcontinental railroad brought settlers to California and made labor-intensive fruit farming profitable. Many of the large estates were in fact divided, but many large farms remain in California, for various reasons.

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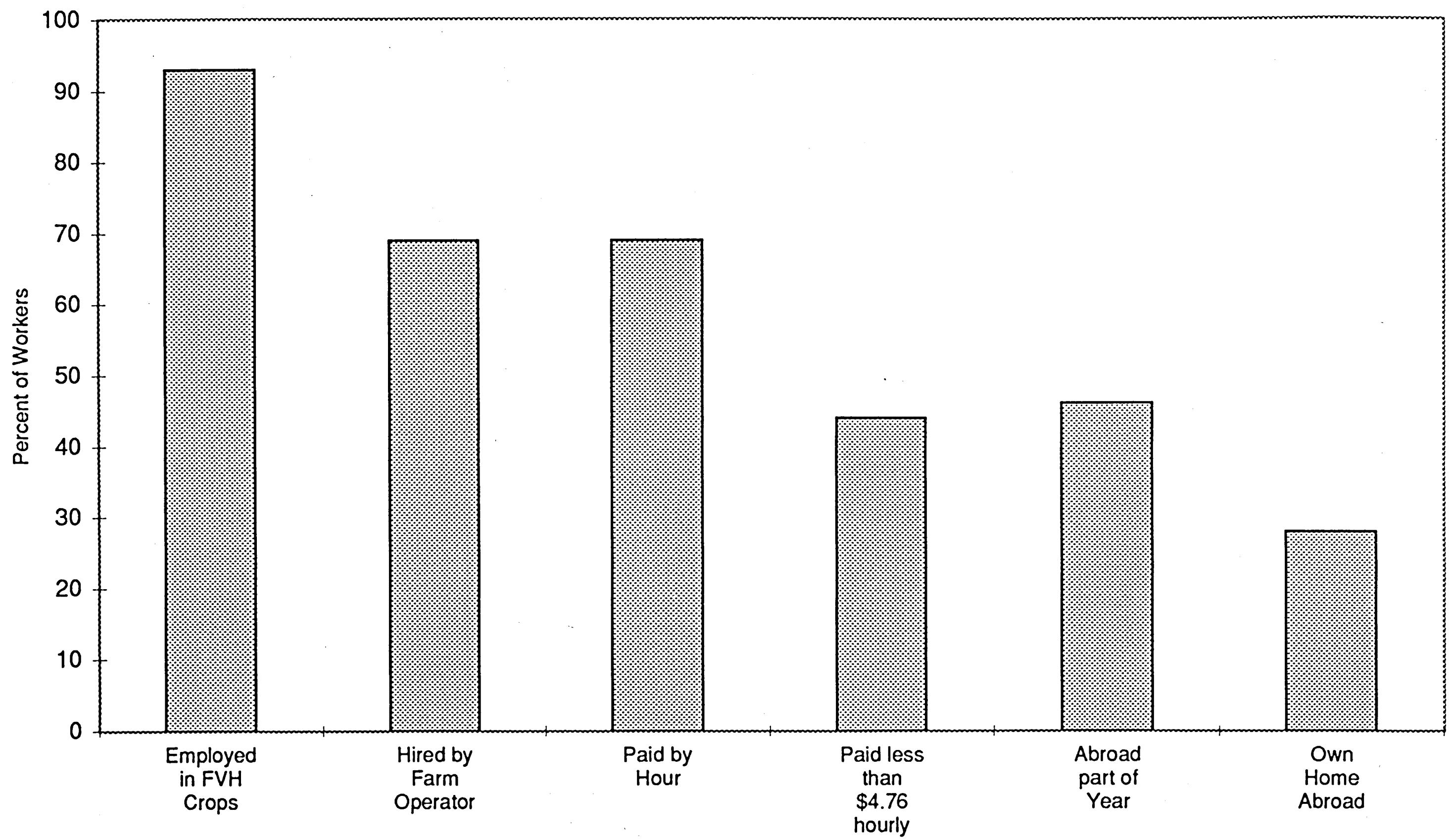
[6] The fact that ever less educated farm workers are employed in an ever more sophisticated agriculture raises important questions about pesticide and safety training. Beginning in January 1996, the Environmental Protection Agency's Worker Protection Standard requires that workers employed in areas where pesticides have been used in the past 30 days must be told within five days that pesticides can be dangerous, and that workers should wash themselves and change their clothes after work, and wash their work clothes separate from other clothes.

Figure 3. Selected Employment and Earnings for California Farm Workers, 1990-91.



Source: U.S. Department of Labor 1993b.

For decades, there has been a debate among farm labor reformers in California over whether to press for breaking large industrial-type farms into family-sized parcels, thus eliminating the need for so many seasonal farm workers, or whether "factories in the fields" should be acknowledged as a valid pattern, and factory labor and immigration laws applied to agriculture. At this time, there is no reason to expect that large farms will be broken up but since most U.S. and California farms are "family farms," agriculture has several exemptions under U.S. labor and immigration laws.

California farm labor history is the story of how seasonal farm work emerged as a major port of entry for succeeding waves of immigrant workers. The wages and working conditions that immigrant farm workers were willing to accept largely determined wages and working conditions for all farm workers. The availability of immigrant workers permitted agriculture to continue to offer seasonal jobs that paid only about half of average manufacturing wages. Thus farm workers and their children have been attracted to non-farm jobs offering higher wages, better working conditions, and year-round work. These exits from the farm work force led to importing more immigrant workers, repeating the cycle.

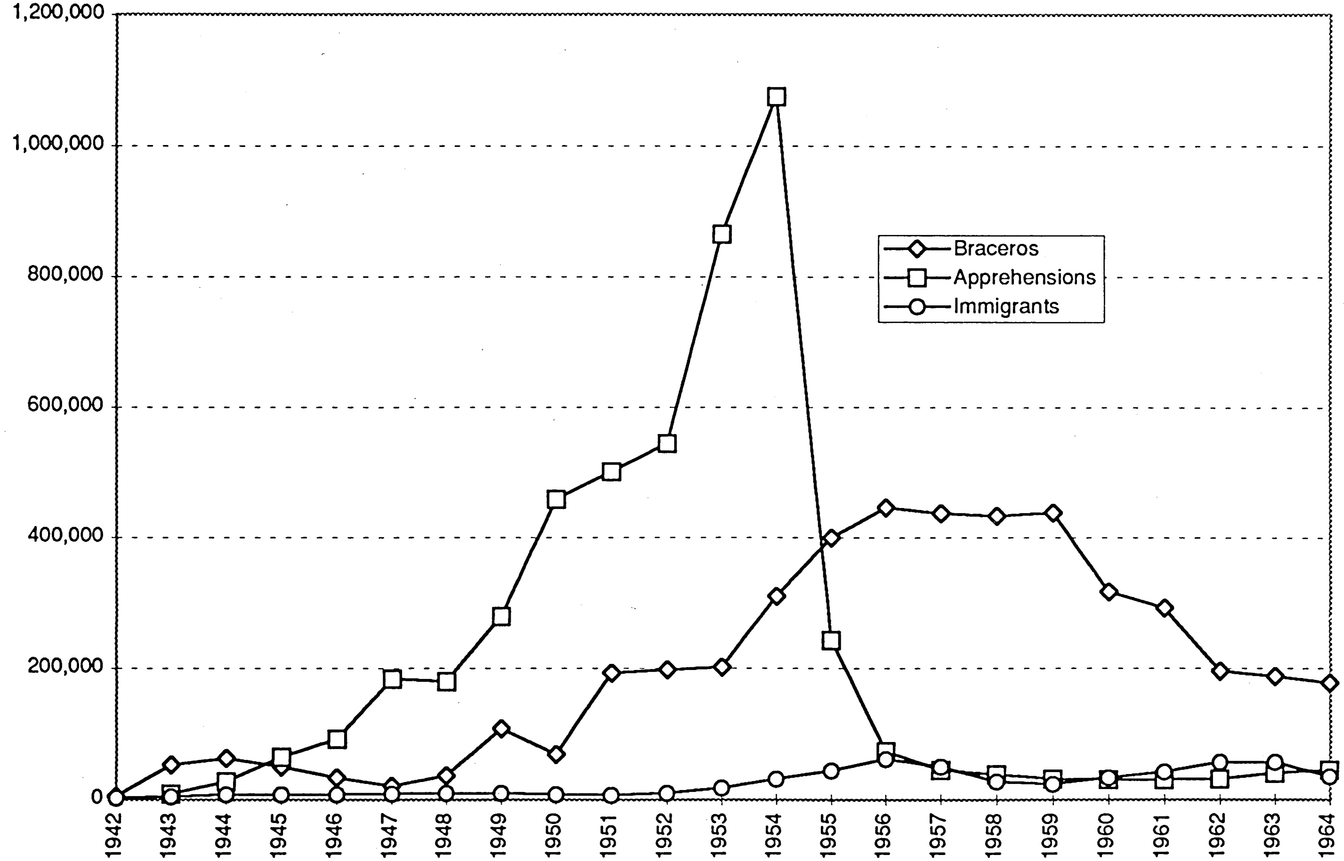
The first seasonal farm workers were the 12,000 Chinese workers who had been imported to build the railroad through the Sierra Nevada mountains. When they were released by the railroad companies in 1870, they were kept out of urban jobs by anti-Chinese movements (Fuller, 1940). Chinese immigration was halted in 1883, and the next wave of immigrant farm workers came from Japan. Japanese immigration came to a standstill in 1907, and workers then arrived from present-day India and Pakistan.

After World War I, the United States began to restrict immigration. The 1917 Immigration Act, for example, imposed a head tax on immigrants and excluded immigrants over 16 who could not read in any language. California farmers, however, asked the U.S. government to suspend the head tax and literacy test for Mexican workers coming to the United States for up to one year to work on U.S. farms, and the government agreed. Thus began the U.S.-government-approved recruitment of Mexican farm workers.

Mexican migration for U.S. farm work was stopped and repatriations occurred during the Depression, when farmers and farm tenants from the dustbowl states moved to California. With America's entry into World War II, Mexican migration for farm work resumed in 1942, and continued until 1964 under the Bracero program, which allowed Mexicans to legally enter and work in agriculture under a number of agreements. Between 1942 and 1964, however, more Mexicans were apprehended in the United States than were admitted as legal farm workers. Figure 4 shows the number of legal workers under the Bracero program, the number of unauthorized workers, and the number of Mexican immigrants. The count of apprehensions and Bracero admissions measure events and not unique individuals. The same person could be apprehended several times, and the same person could be legally admitted as a Bracero several times.

The availability of Braceros permitted fruit and vegetable production to expand at relatively constant wages. California, fruit and nut production rose 15 percent during the 1950s, and vegetable production rose 50 percent. The U.S. Department of Agriculture's estimate of average hourly farm earnings rose 41 percent—slightly more than the 35 percent increase in consumer prices—from $0.85 in 1950 to $1.20 in 1960. (Average factory wages in California rose 63 percent, from $1.60 per hour in 1950 to $2.60 in 1960.)

Figure 4. Mexican Braceros, Apprehensions, and Immigrants, 1942-1964.



Source: INS Statistical Yearbook, various years.

After the Bracero program ended in 1964, some Mexican workers became U.S. immigrants who commuted seasonally from homes in Mexico to farm jobs in the United States. During the 1960s, Mexicans could become so called "green-card" commuters by obtaining a letter from a U.S. employer offering a job, and certifying that the employer had sought and failed to find a U.S. worker to fill it. Most of the 50,000 to 60,000 Mexican immigrants admitted each year in the mid-1960s were believed to be ex-Braceros who got immigrant status as a result of a U.S. employer offering them jobs.

During the 1970s and early 1980s, U.S. citizens and green-card commuters were joined in the fields by unauthorized or illegal alien workers. As the Immigration Reform and Control Act (IRCA) of 1986 moved toward approval, California farmers argued strongly that they needed easy access to Mexican and other foreign workers, and the "farm labor" compromise in IRCA permitted illegal alien farm workers who had done at least 90 days of U.S. farm workers to become immigrants. The Special Agricultural Worker (SAW) rules permitted one million Mexicans—about one-sixth of the adult men in rural Mexico—to become legal U.S. immigrants.[7]

If SAWs did not remain in U.S. agriculture, U.S. farmers could obtain legal foreign workers through two programs. The H-2A program is a non-immigrant program that admits foreign workers to fill vacant jobs after the U.S. government certifies that the farmer tried and failed to recruit U.S. workers. The Replenishment Agricultural Worker (RAW) program, by contrast, was a four-year safety valve—if SAWs left agriculture, and labor shortages developed, then RAW probationary immigrants could be admitted.

For these programs to admit additional workers, IRCA required that the U.S. Department of Labor and the U.S. Department of Agriculture had to report a finding of a labor shortage. These agencies have not reported any farm labor shortages in the 1990s, largely because illegal immigration has continued, and workers and employers find it relatively easy to use counterfeit documents to satisfy employee verification requirements. In 1996, the United States enacted additional laws aimed at reducing illegal immigration, and farmers tried again to include a special non-immigrant worker program, which would have allowed farmers to attest that they tried and failed to recruit U.S. workers, thus permitting special workers to enter the United States to fill the need. Congress rejected the growers proposal in March 1996.

TURNOVER

Unlike many other sectors of the economy, long-term relationships between workers and employers in California agriculture are rare. Frequently farmers hire workers for only brief periods of time, as for example during harvests. Many immigrant farm workers move in and out of U.S. agriculture over time. These workers may engage in U.S. farm work for only a season or a few weeks or months, and then return to Mexico or find a nonfarm job in the United States.

Turnover is a major problem for many farm employers. Employers may have a

[7] In the mid-1980s there were about 28 million rural/agricultural residents in Mexico, including 4 to 6 million household heads, their spouses, and children. The U.S. approved SAW applications from almost one million, mostly Mexican men, and usually with rural Mexican roots.

hard time getting good seasonal workers to return in the following year and even find it difficult to keep good year-round workers. According to one survey, only 16 percent of farm workers work more than 10 months per year for a single farm employer. Half the harvest workers in Michigan and a quarter of those in Washington did not return to growers a year later (Amendola, Griffith and Gunter; Kissam and Garcia). Due to turnover, the number of individuals hired to keep a crew of 20 at full strength can actually go as high as double the number of crew jobs, a rate of replacement that may reach 100 percent or more *monthly*. Such turnover rates are among the highest in the U.S. work force.

California farm workers are less likely to return than workers elsewhere (Gabbard and Perloff, 1996). Workers in the Midwest return 17 percent more often than those in California. Workers in the Southwest are 31 percent more likely to return. Even in nearby Arizona, workers are 39 percent more likely to return.

One reason why worker turnover is so high in California is that there are few incentives for workers to remain employed by any one employer. Wages usually do not vary across employers for a given task, and most employers offer few benefits that a worker would forfeit by quitting, such as health insurance or vacation pay. Seniority does not even lead to a preferred place in the crew next year. Frequently personal ties or favors earn a worker a preferred job, not length of service.

HIRING

How do 900,000 mostly immigrant farm workers find jobs with the 25,000 California employers who hire them? Farmers have sought to assure an ample supply of seasonal workers by working collectively to maximize the supply of farm workers rather than trying to identify the best workers and retain them for their farms.

Farmers usually have workers recruited by bilingual foremen or FLCs fluent in the language of the worker. Many farmers never recruit or speak directly with prospective employees.[8] Of the NAWS workers, only 14 percent were actively recruited by their current employer. In comparison to farm workers in other states, California farm workers are more likely to be employed by farm labor contractors than directly by growers.

Farm Labor Contractors

Farm labor contractors (FLCs) serve as intermediaries between workers and farmers. For a fee, they find and supervise farm workers for employers. FLCs in western agriculture originally were bilingual go-betweens. The Chinese workers who had been imported to build the transcontinental railroad in the 1860s were barred from urban jobs, and a bilingual "head boy" both worked and arranged seasonal farm jobs for

[8] Only about one-third of California's crop workers were hired using a FLC in 1990–91 (U.S. Department of Labor, 1993b), but bilingual foremen do much of the recruitment of the two-thirds of workers who are listed in surveys as being hired "directly" by growers.

his 20 to 30 compatriots. Japanese immigrants in the early 1900s also followed this intermediary-as-fellow-worker model, but in the 1920s the role of the FLC evolved into an independent business person. In a few cases, farm workers went on strike against farmers who insisted on hiring workers through FLCs.

The federal government began to protect farm workers in the 1960s. The first protective legislation was aimed at forcing FLCs to identify themselves by registering with the U.S. Department of Labor. Many states also require FLCs to register. The federal government and many state governments seek to discourage unscrupulous FLCs by requiring that FLCs be finger printed, bonded, and tested for their knowledge of labor and pesticide regulations. In California, an FLC must pay a $350 annual license fee, post a $10,000 bond, undergo a character investigation, and pass pesticide safety and labor law tests.

The intent of ever-stricter regulation was to drive out of business those FLCs who were not operating lawfully. This strategy has not been entirely successful. The nation's 4,000 FLCs, and their 8,000 crew bosses, are as numerous as ever, and enforcement data suggest that labor law violations are common. Coordinated federal-state labor law enforcement in California between 1992 and 1995 found major violations committed by 9 of 10 FLCs inspected.

Unscrupulous FLCs evade labor laws to make more money. As the U.S. Industrial Commission explained in the early 1900s, contractors can "drive the hardest kinds of bargain" with immigrant workers because they know the circumstances from which farm workers come (Fisher, 1953). Immigrant farm workers rarely complain about labor law violations and, even if they do, the general absence of written contracts makes it hard for often illiterate and non-English speaking workers to provide the evidence needed for effective enforcement.

Turnover rates are higher for farm labor contractors than farmers. In the NAWS, overall 43 percent of California field workers returned the next season, compared to only 33 percent of workers employed by farm labor contractors. Not all intermediaries are FLCs. Non-Spanish speaking employers often use foremen or crew bosses to recruit labor. The workers' crew boss becomes in most instances the person on whom the worker depends. It is very difficult for a union to substitute for this often personal relationship.

Crew bosses are often more than just employers. Especially when the workers are recent immigrants, the boss may be the worker's banker, landlord, transportation service, restaurant, and check-cashing service. Crew bosses provide such services to workers both to make money and because newly-arrived workers often need such services. Federal and state governments have enacted an ever-growing body of laws and regulations to regulate these sideline activities.

Recruiting

Workers are recruited in several ways. The most common way occurs when the crew boss tells the crew that more workers are needed, and the workers currently in the crew inform their friends and relatives that a job is available. Such "network recruiting" is very helpful to employers, since there is no need to spend money on help-wanted ads, and workers who are often grateful for the chance to tell friends and relatives about jobs tend to bring only "good" workers to join the crew. Once hired, the friend or relative who brought the new worker to the workplace is usually responsible for her: the experienced worker teaches the new hire how to work, the work rules, and other job-related information. In this decentralized hiring system, a worker may pay the crew boss to get a job, or the crew boss may allow a worker to bring his children to work.

A few large farms do all of their hiring from a central site and require prospective workers to go to that site to fill out a job application. Fewer than 5,000 workers are sent to California farm jobs annually by union hiring halls, and fewer than 10,000 are sent to field worker jobs by the public employment service; together, these two institutions account for less than 2 percent of the annual hires.

In some "farm worker towns," especially those along the U.S.-Mexican border, workers are recruited in the so-called "day-haul labor market." Workers begin to congregate in parking lots at 3 or 4 a.m., contractors arrive with buses, tell the workers the task and the wage, and the workers then board the bus that seems to offer the best job. Some workers board the same bus everyday, while others switch from bus to bus.

COMPENSATION

Workers may be paid piece rates (say, $10 per bin or oranges picked), hourly wages, or a combination. Usually, only the largest employers provide optional benefits such as health insurance and pensions.

Farmers motivate workers by paying piece rates or using supervisors. By paying workers a piece rate, farmers encourage them to work rapidly. Piece rates are paid in jobs in which it is difficult to regulate the pace of work, where quality is not of great importance, and when an employer wants to keep labor costs constant with a diverse work force.

Employers usually pay hourly wages:

- when they want slow and careful work, as for example in pruning trees and vines;
- when the employer can easily control the pace of the work, for example in field-packing broccoli, where the workers walk behind a machine whose pace is controlled by the driver/employer;
- or by tradition for certain tasks, such as early season picking and thinning and hoeing.

If an hourly wage is paid, farmers frequently hire "crew pushers" to maintain the work pace, or they control the pace of work by having workers follow a conveyor belt that moves slowly through the field. Combination wages are paid when the employer wants careful but fast work, such as harvesting and packing table grapes in the field.

The average hourly earnings of workers paid piece rates are typically higher than hourly wages, but weekly wages are similar for hourly and piece-rate workers. For example, according to the U.S. Department of Agriculture, California farm workers paid hourly wages in July 1993 were paid about $6 hourly, while piece rate workers had average hourly earnings of almost $7. However, hourly workers averaged 40 hours per week or about $240, while piece rate workers averaged 35 hours, about $245.

The average hourly earnings of farm workers have traditionally been about half of nonfarm private sector earnings in California and throughout the United States.

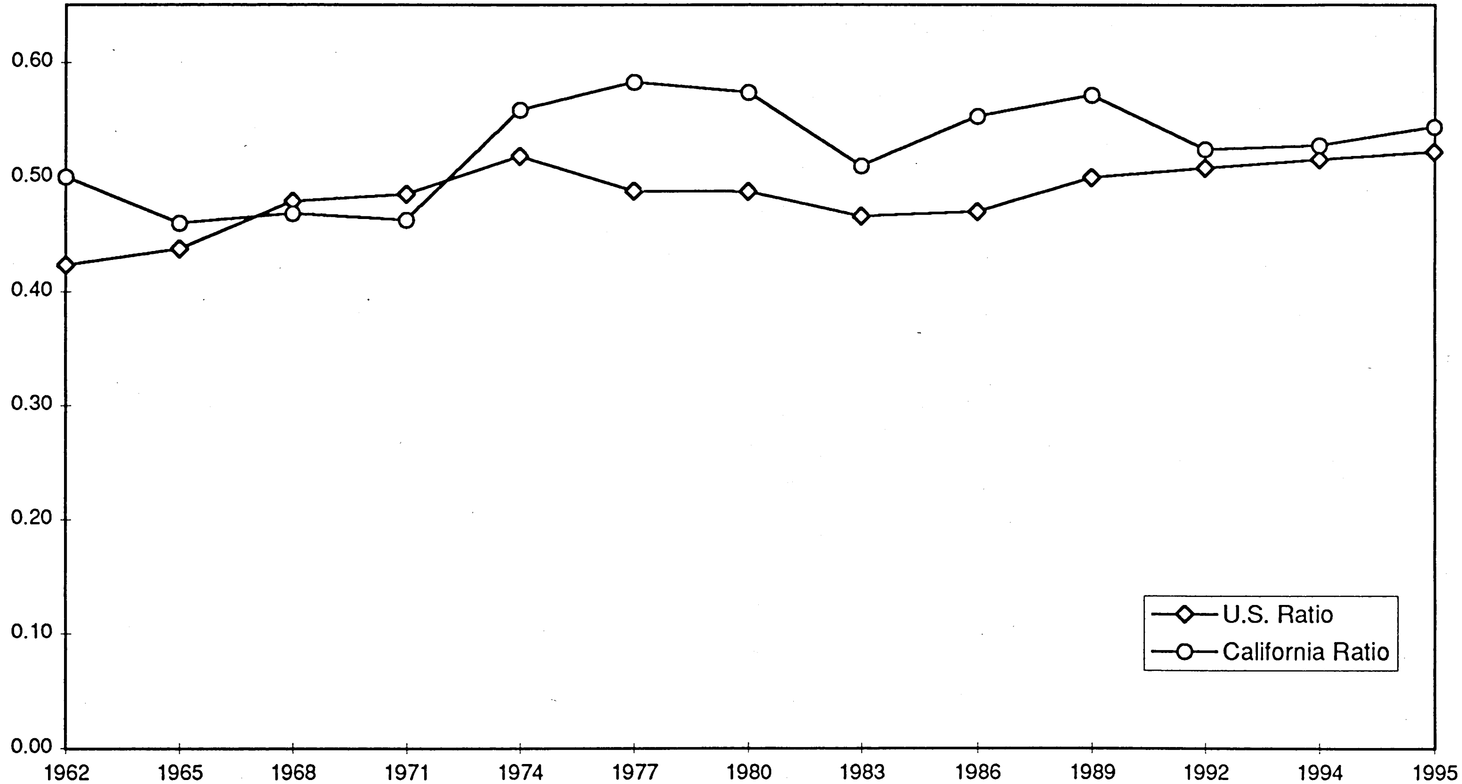
Beginning with the end of the Bracero program in the mid-1960s, the ratio of farm-to-nonfarm earnings crept steadily upward, reaching 58 percent of nonfarm levels in 1977. The California farm-to-nonfarm earnings ratio fell to 51 percent in 1983, rose in 1989 after the minimum wage was increased, and then fell sharply in the early 1990s (Figure 5).

In the rest of the United States, by contrast, the farm-to-nonfarm earnings ratio behaved differently. The ratio remained below 50 percent throughout much of the 1970s, and hit 50 percent only in 1989, again in response to the 1988 increase in the minimum wage, which affected most farm workers.

According to the NAWS, 70 percent of the jobs held by California farm workers in the early 1990s paid hourly wages, and 30 percent paid piece rate wages, or a combination of hourly and piece rate wages (U.S. Department of Labor, 1993b). The benchmark wage for most entry-level workers is the minimum wage, which rose to $4.25 hourly in California on July 1, 1988; $4.75 on October 1, 1996; $5 per hour on March 1, 1997; and will be $5.75 per hour in California after March 1, 1998.

Some employers pay more than the minimum wage so as to be able to select the best workers. Reports that hourly wages average as much as $6 (the figure reported for California field workers by the U.S. Department of Agriculture for mid-July 1993) can be misleading, because "average" wages are weighted by the hours that the various subgroups of hourly workers work. Thus, the average hourly wage of a tractor driver paid $7 hourly for 10 hours of work daily, and two minimum wage hoers who each work 35 hours, are reported to have an average hourly wage of $5.62, even though neither the tractor driver nor the field laborer is earning this average wage.

Figure 5. Ratio of Farm to Nonfarm Hourly Earnings, 1962-95.



Sources: Economic Report of the President, 1996, using 1977=100; Employment & Earnings, U.S. Department of Labor, October 1995, data for month of July; USDA Farm Employment & Wage Rates 1910-1990; USDA Farm Labor Report, July data.

UNIONS

The California Agricultural Labor Relations Board (ALRB) certified nine unions to represent farm workers in California agriculture between 1975 and 1995. During that period, the ALRB supervised over 1,600 elections, of which 775 or almost half resulted in a union being certified to represent farm workers. There are, however, fewer than 300 contracts today on California farms. Even a favorable legal framework does not result in union success when farmers face a virtually unlimited supply of low-wage immigrant labor.

Table 1 provides contract and membership data on California farm worker unions in 1996. The data are approximate, since the ALRA does not require unions or employers to file membership and contract data with the ALRB.

The United Farm Worker (UFW) membership data illustrate the problem of counting unionized farm workers. In 1996, the UFW had a reported 26,000 members, but even when the UFW had a reported 80,000 members in 1970, it has never paid dues to state and national labor federations for more than 10,000 to 15,000 members (*AFL-CIO News*, May 3, 1993). [9]

The UFW has been most successful bargaining in commodities that are produced by a handful of large growers, where workers have specialized skills, and where profits tend to be greater, for example, in mushrooms, flowers, and vegetables such as lettuce and broccoli (Martin, 1996). The only commodity in which the UFW has represented a majority of workers over the past two decades is mushrooms—a $100 million per year commodity in which California production is dominated by a handful of companies in the Salinas area.

In 1976, when the federal minimum wage was $2.30 hourly, the average hourly earnings of California farm workers was $3.20, and the entry-level general laborer wage in UFW contracts was $3.11 hourly. During the late 1970s, statewide farm worker earnings rose in step with UFW wages, suggesting that the UFW had statewide impacts on average farm wages. Based on 1970s Current Population Data, unionized farm workers in California earned $6.16 hourly, while non-union farm workers earned only $3.34 hourly, an 84 percent union wage premium (Perloff, 1985).

This relationship was broken in the early 1980s, after the UFW achieved 40 percent wage increases with a few employers, some of whom then went out of business (Martin and Abele, 1990). During the late 1980s, the UFW and other farm worker unions have been forced to accept wage and benefit reductions, so that in many cases entry level wages are at or below early 1980s levels.

[9] In 1995 the UFW reportedly paid AFL-CIO dues for 16,000 members. Dolores Huerta, in an April 1993 letter, asserted that the UFW had 20,000 members under contract and another 20,000 associate members in the UFW's Community Union. In summer 1995, the UFW reported 10,000 associate members (*Los Angeles Times*, April 11, 1993, D8); *Wall Street Journal*, June 7, 1995, B1), associate UFW members receive legal and other services for a $20 annual fee.

Table 1. California Farm Worker Unions in 1996.

Union	ALRB* Certifications 1975-1996	Current Contracts	Percent of Certifications	Jobs Covered[1]	Members[2]	Major Commodities	Region
United Farm Workers	450	40	9	20,000	26,000[3]	All	All
Independent Union of Ag. Workers	12	6	50	800	1,500	Vegetables	Oxnard, Salinas, Bakersfield
Fresh Fruit & Vegetable Workers Local 78-b	22	15	68	900	1,200	Vegetables	Salinas and So. California
Christian Employees Union	173	173	100	585	585	Dairy	Central and So. California
TEAMSTERS							
Teamsters 63	28	28	100	250	250	Dairy	Los Angeles
Teamsters 890	29	4	14	3,400	7,400	Vegetables	Bud-Dole multiregion contract
Totals	775	263	34	12,235	21,835		

* Includes unions with 10 or more certifications. Unions with fewer than certifications include: Comite de Campesinos Unidos, Teamsters Local 87, 166, 389 and 624, United Stanford Workers, Dairy Employees Union Local 17, and the Wine and Allied Workers Union. Unions without certifications and other farm labor organizations include: American Friends Service Committee Proyecto Campesino, San Joaquin Valley Workers Organizing Committee, Laborers International Union of North America, Anti-Racist Farm workers Union, Laborers International Union Local 304, and Trabajadores Agricolas Unidos Independientes.

[1] Average employment on farms under contract.

[2] Persons who pay dues to the union sometime during the year.

[3] About 12,000 UFW members are covered by the UFW's MLK pension plan.

Source: Telephone survey conducted in May 1996.

The UFW's difficulty in securing and maintaining contracts affects its finances. In recent years, the UFW has had an annual income of $4 to $5 million, of which one-fourth comes from worker dues,[10] one-fourth from the profits of UFW-affiliated organizations,[11] and the rest from donations. In 1993, the UFW reported an income of $3.8 million, and expenses of $4.3 million.

Table 2. UFW Chronology, 1962–96.

- 1962: Established as a mutual assistance organization in Delano.
- 1965: Joined strike called by Filipino table grape harvesters; boycotted liquor products of conglomerate grape grower; FBI begins to compile what became a 1,434-page dossier on Chavez.
- 1966: Delano to Sacramento march; first contract provides a 40 percent wage increase for grape harvesters.
- 1968: Launched a consumer boycott of California table grapes "La Causa."
- 1969: UFW began union-operated medical plan.
- 1970: Falling grape consumption forces table grape growers to recognize the UFW; UFW asks lettuce growers to recognize the union as bargaining agent for their workers; most responded by signing Teamster contracts.
- 1972: UFW-Coca Cola contract covering a few orange pickers in Florida.
- 1973: Teamsters largely replace UFW as bargaining agent for California farm workers.
- 1975: ALRA enacted in California; UFW wins most of the first wave of elections; short-handled hoe banned in CA because of feared damages to workers' backs.
- 1976: ALRB runs out of money and closes temporarily; UFW campaigns for Proposition 14, which would have amended the CA constitution to require that the ALRB be funded.
- 1978: California extends unemployment insurance to almost all farm workers.
- 1979: UFW calls strikes in support of its demand for a 40 percent one-year wage increase; strike settled with an increase in the entry level wage from $3.75 to $5 hourly in the fall of 1980.
- 1981: UFW testifies in favor of employer sanctions and ample funds for the INS to enforce them.
- 1982: Many of the large vegetable growers with UFW contracts go out of business; others bargained hard, so that their contracts were not renewed.
- 1982-84: Republican Governor elected; courts overturn some make-whole remedies in favor of the UFW, and there are internal changes within union leadership.
- 1984: UFW launches "wrath of grapes" campaign, urging Americans not to buy California table grapes because they are allegedly tainted with pesticides.
- 1988: Chavez fast brings publicity to the grape boycott effort.
- 1993: Cesar Chavez dies on April 23, 1993.
- 1994: UFW repeats Delano to Sacramento march; wins elections on 8 farms, including Dole's Oceanview division, which grows and packs celery, broccoli and strawberries in Oxnard.
- 1995: UFW negotiates three-year contract for 1400 Bear Creek/Jackson-Perkins rose workers; entry level wage is $5.82; UFW signs agreement covering 200 workers at Chateau Ste. Michelle Winery in Washington; entry level wage is $7.10; UFW reports 26,000 farm workers under contract, and 10,000 associate UFW members.
- 1996: UFW negotiates five-year contract with Bruce Church Inc. in March 1996, ending 17 years of disputes and litigation affecting 450 workers employed by the third largest lettuce grower; entry-level wage is $6.62 per hour. In April 1996, UFW launches "Five Cents for Fairness" campaign to persuade 270 strawberry growers in the Watsonville, CA area to increase piece-rate wages for 20,000 strawberry harvesters by $0.05 per pint, or $0.60 per 12-pint tray of strawberries picked.
- 1997: UFW wins endorsement of AFL-CIO for the largest union organizing campaign in the US—the effort to unionize 20,000 strawberry harvesters; UFW holds march that attracts 20,000 to 30,000 people to Watsonville on April 13, 1997. As of May 1997, the UFW did not request that the state of California supervise any elections on strawberry farms.

Sources: *Rural Migration News*. Quarterly; Martin, 1996.

[10] If the average UFW member earned $12,000 annually, and paid 2 percent union dues or $240, then the UFW's $990,000 dues income would be generated by 4,125 members. If the average UFW member earned $6,000, this calculation would indicate 8,250 members. According to the *Los Angeles Times* (April 24, 1993, A1), two-thirds of the UFW's $3 million income in 1986 came from dues, and one-half of $2 million income in 1990 came from dues.

[11] There are a number of not-for-profit and for-profit organizations associated with the UFW. The not-for-profit organizations include the Cesar Chavez Foundation and the National Farm Workers Service Center. The for-profit organizations include ETG Specialty Advertising, Ideal Mini Mart, and American Liberty Investments. In 1993, profits from these affiliated organizations contributed about as much as worker dues to the union's $3.8 million income (UFW, 1994).

The longest and largest farm worker contract in California agriculture is that between Teamsters Local 890 and Bud of California, a subsidiary of the Dole Food Company. This three-decade long agreement covers 7,000 lettuce and other vegetable workers in California and Arizona.[12] The union with the most farm worker contracts is the Christian Labor Association (CLA), with 182, but each covers an average of only three workers, employed in dairies. The other unions with contracts include several begun by ex-UFW leaders.[13]

While farm worker unions seem to be splintering rather than consolidating, there has been a significant increase in the activities of self-help farm worker groups. As more indigenous migrants from southern Mexico and Guatemala arrive in California, a proliferation of ethnic organizations has arisen. Some have been recognized as unions by the ALRB. For example, the Mixtec and Zapotec Indians from the southern Mexican state of Oaxaca have formed "civic committees" in a number of California towns, and one of these committees won an election in 1991 at a San Diego packing house.

CONCLUSIONS

The most remarkable feature of the California farm labor market is how little change there has been over the past century. A farmer brought from 1897 to 1997 would be baffled by today's laser leveling of land, drip irrigation, vacuum cooling, and the widespread use of computers, but he would be very familiar with the use of bilingual contractors and crew bosses to assemble immigrant farm workers to perform seasonal harvesting tasks.

There is little reason to expect the current pattern to change significantly in California agriculture, viz., immigrant farm workers are likely to continue to be hired in crews to fill seasonal jobs on large farms. As in the past, there seems to be little indication that individual farmers and farm workers will develop persisting employment relationships, or that average hourly farm earnings will close the gap with manufacturing wages.

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[12] This relationship has become more rocky as Dole insisted on wage cutbacks and the workers paying more of their health care premium. The union called a strike in September 1989 to protest an employer demand—based on the argument that FLCs paid lower wages and offered no benefits—for an 18 percent wage cut, from \$7.30 to \$6 hourly, which the union accepted after a three-week strike. In November 1992, the union agreed to a six-year contract that maintained base lettuce harvesters pay at \$7.25 hourly for three years, and then granted 1 to 2 percent increases. (Testimony of Crescencio Diaz, December 6, 1990, CAW Appendix II, p. 415, and the *Packer*, November 28, 1992).

[13] Labor union organization in the U.S. in general is undergoing transformations. In July 1995, three large industrial unions—the United Auto Workers union with 800,000 members, the United Steelworkers of America with 700,000 members, and the International Association of Machinists with 490,000 members—announced plans to merge by 2001. All three unions have lost about half their members since the mid-1970s. In 1994, there were 16.7 million union members in the United States, including 13.3 million members of 78 unions affiliated with the AFL-CIO. The largest U.S. union is the National Education Association, a non-AFL-CIO affiliate with 2.2 million members.

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Chapter 7

CALIFORNIA WATER

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Water is one of California's most precious natural resources. As an input into the state's economy, water is currently used for everything from growing vegetables to manufacturing silicon chips. The development of the state's water supply infrastructure has allowed for the growth of one of the world's largest agricultural production regions. It has also enabled the state's population to grow and become the most populous state in the nation, producing the eighth largest economy in the world. As the state's population continues to increase, an adequate residential and industrial water supply is essential.

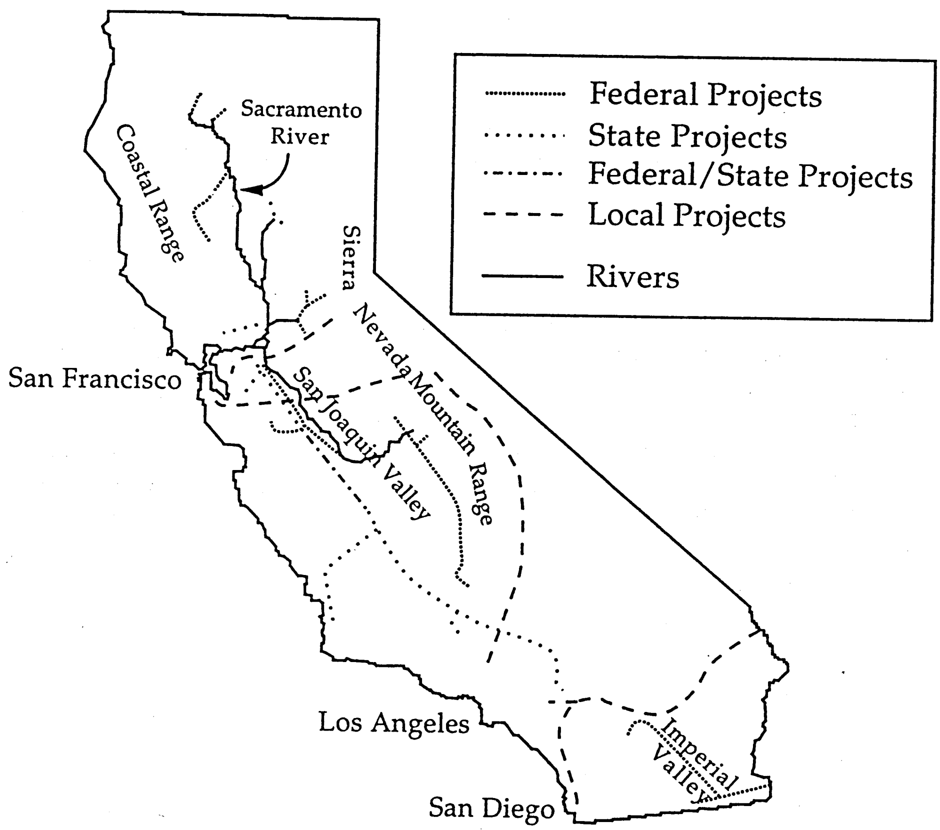
WATER SUPPLY

The development of California's water systems is a response to four conditions: geographical distribution of the natural water supply and the geographical distribution of society's use of the resource, the short-term temporal aspects of the natural supply, the long-term temporal aspects of the natural supply, and the availability of abundant groundwater reserves.

The state receives approximately 236 billion m^3 of precipitation each year. The majority of this water either evaporates or is used by native vegetation. The state's developed supply is about 28 billion m^3, with an additional groundwater replenishment rate of 6 billion m^3 per year.

The majority of the state's water supply originates in the northern and mountainous regions of the state (Figure 1). Over two-thirds of the state's water supply originates in the northern one-third of the state. There is also abundant rainfall and snowfall in the Sierra Nevada mountain range as far south as the Bakersfield area.

Figure 1. California Water Map.



Source: Douglas D. Parker, "California's Water Resources and Institutions," In *Decentralization and Coordination of Water Resources Management*, Douglas D. Parker and Yacov Tsur, Editors. Kluwer Academic Publishers, Norwell, 1997.

Water planners have modified this spatial heterogeneity in the natural water supply by using the state's natural river systems in conjunction with canals to move water to areas where demand is greater than the local supply.

The state also receives a significant amount of water from the Colorado River. Historical treaty rights grant California a supply from this system of over 4.9 billion m^3. This water supply serves the southern desert agricultural regions and supplements the supplies of the southern urban communities.

The state's water storage infrastructure serves three objectives: to smooth out seasonal variations in the natural supply, to smooth out annual variations in the supply, and to provide for flood control.

The state's natural water supply is quite seasonal. Almost all of the state's rainfall and snowfall occurs during the winter season—November through March. As the snow pack in the mountain areas melts, an abundant natural supply is available through June. In order to provide a supply of water to its citizens from July to November, the state needed to develop its own storage systems.

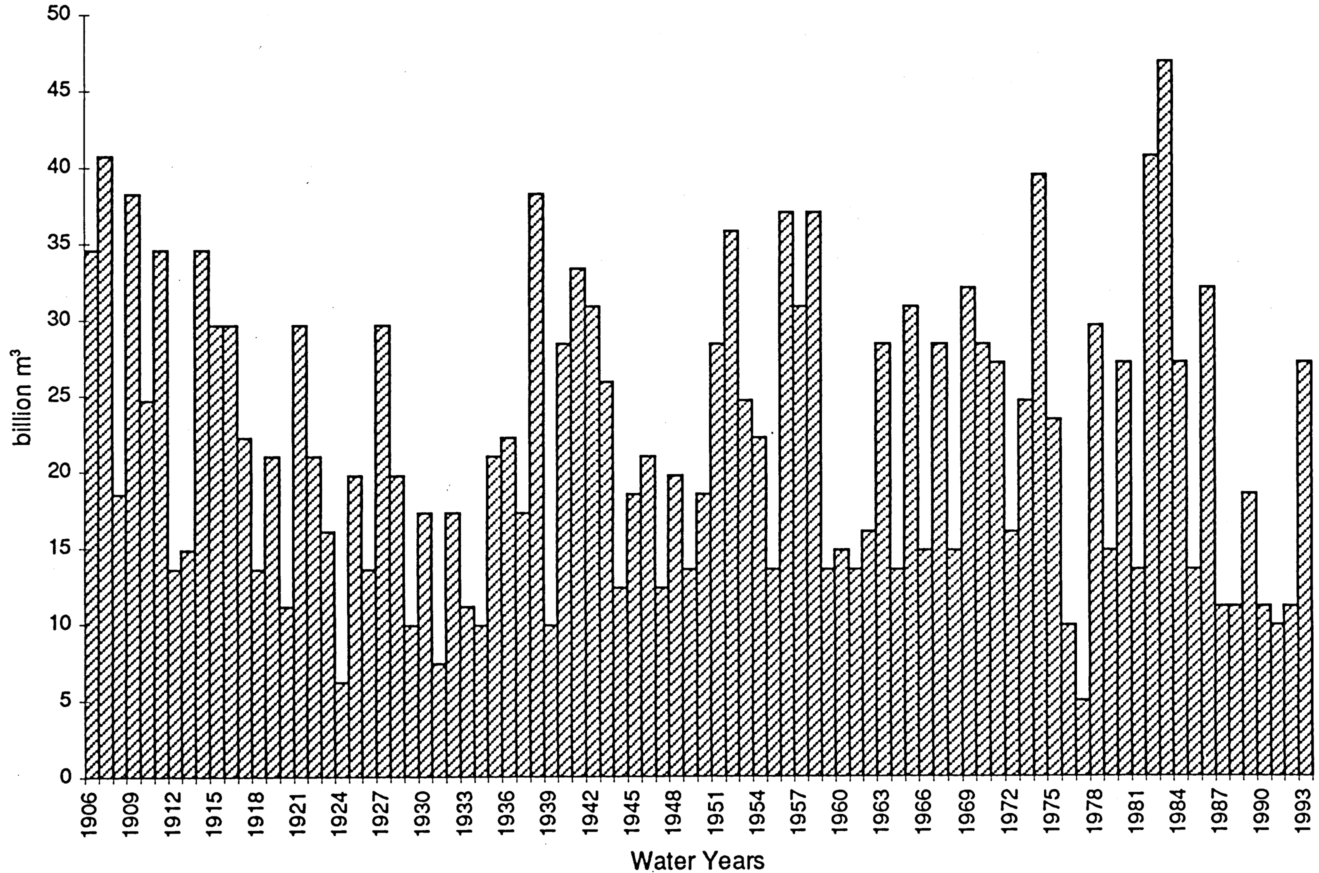
These storage systems also serve to reduce the variations in the annual supply. The state is known to have years with devastating flooding followed by years of severe drought (Figure 2). An analysis of river flows shows that the mean flow in the San Joaquin River is 33 percent greater that the median. This implies that there are some very wet years pulling up the average flow figures. In order to smooth out the annual water supply, the state has built large storage systems to hold the rain and snow melt and allow for its release in times of need. Furthermore, because the Colorado River originates from a different mountain range system—the Rocky Mountains—than the local Sierra Nevada, the timing of variations in supply from this system does not always correlate with variations in the local systems. Thus, this water supply can serve to reduce the total yearly variations in supply.

Capacity in the storage reservoirs is managed in such a way as to provide space for flood control during the winter and early spring. In the late spring the reservoirs are allowed to fill with the snow melt. Thus flood control objectives are combined with seasonal water storage needs. Furthermore, the reservoirs are designed with sufficient capacity to allow for some carryover of annual supplies.

The groundwater supply to the state is also quite significant. In the main growing regions of the state, groundwater reserves may account for as much as 50 percent of the local supply. These groundwater reserves are often used to stabilize the fluctuations in short-term and long-term supplies. Groundwater use during a drought may rise to 80 percent or more of total water supply. In most areas, recharge rates are very good, making groundwater an excellent substitute for surface water during droughts.

These four aspects of the state's water supply (geographic distribution, short-term variability, long-term variability, and groundwater availability) have all led to the development of the state's massive water storage and transportation infrastructure. Many of the state's water projects address these aspects simultaneously. For instance, a large dam on a river can serve to smooth out both short-term and long-term variations in supply, and provide flood protection. Furthermore, releases into the natural stream system may allow for the transportation of that water to areas of greater need. The potential for this spatial redistribution increases when the river serves as a feeder to canals that move the water to other areas of shortage. Conjunctive use of the surface supply with local groundwater reserves can further stabilize seasonal and annual supply fluctuations.

Figure 2. Estimated Natural Runoff of Sacramento River.



Source: California Department of Water Resources, 1994.

The historical development of water supplies in California was driven by historical and projected water imbalances. These imbalances were a product of both the physical nature of the water supply as well as the institutional and legal nature of how the supply was allocated. Most early water development was related to agriculture or to the mining of minerals. At the end of the California Gold Rush in the mid-1800s, many miners turned to agriculture as a way to make a living. The state's abundant supply of high quality soils and ideal climatic conditions left agricultural enterprises with only one constraining input, water.

Historically, all of the waters of the state belonged to the people of the state. Users of water have acquired rights to that use through several legal mechanisms. In the early to mid 1800s water use was restricted to riparian areas. Thus land owners could establish a right to use water by simply diverting it from an adjacent stream and putting it to beneficial use on the adjoining lands. As the mines in close proximity to the water course became exhausted, the need to move water greater distances grew, and a system whereby water use rights could be obtained for non-riparian lands was needed. Thus the doctrine of appropriation was developed. This allowed users to gain a first-in-time right to water use by diverting it from a stream to non-adjoining lands.

This second type of water use right, appropriative rights, has allowed for the construction of the state's massive inter-basin water supply infrastructure that supports our current agricultural and urban centers. By allowing water to be moved to non-riparian lands, that water can be used for agricultural or urban purposes hundreds of miles away. Forward thinking urban centers such as San Francisco and Los Angeles began to look large distances for an abundant and stable water source. Los Angeles turned to the Eastern Sierra Nevada mountain range and the Owens Valley. The City purchased land in the Owens Valley that would allow it to have both riparian rights as well as access to the Owens Valley's groundwater aquifers. Constructing a supply system to intercept fresh water supplies before they made their way to the saline Mono Lake, city engineers diverted the water south into the Owens Valley and passed it through to Los Angeles.

San Francisco turned to the Tuolumne River as its water source. In the early part of the twentieth century this river had an abundant untapped supply. The City of San Francisco obtained rights to use its waters and built a dam and delivery system that stretched from the Sierra Nevada westward to the reservoirs of the city.

In the early 1900s agriculture was busy securing its own access to surface water. With the advent of the deep well pump, the amount of acreage under agricultural production in the state soared. Lands that had no surface supplies were suddenly able to produce crops through the use of deep groundwater supplies. As technology improved, more acres were brought into production, and eventually this led to declines in groundwater tables in much of the central portion of the state. As these groundwater reserves were depleted, the established agricultural communities began to seek surface supplies to alleviate the overdraft problem.

WATER INFRASTRUCTURE

The federally operated Central Valley Project is the largest single supplier of water in the state. It is composed of two main systems: the Shasta-Trinity Unit and the Friant-Kern Unit (see Figure 1). The Shasta-Trinity Unit stores water in Shasta Dam on the Sacramento River and in Trinity Dam on the Trinity River. The water is released from the reservoirs into the Sacramento River, which runs towards the south. A portion of this water is used by several contractors along the river. The remainder of the water flows into the Sacramento River-San Joaquin River Delta. From the southern end of the Delta, large pumps move the water into a concrete canal, and this canal system delivers water along the west side of the San Joaquin Valley.

The Friant Kern unit of the Central Valley Project stores water in dams along the southern Sierra Nevada and moves that water southward through a canal along the east side of the San Joaquin Valley. This unit terminates south of Bakersfield. The Central Valley Project yields an average of 8.6 billion m^3 per year. Its customer base is 95 percent agricultural and 5 percent urban. As noted previously, much of this water is being delivered to agricultural regions that were previously reliant upon a declining groundwater supply. Groundwater continues to play an important role in the system, helping to smooth out the inter-temporal supply.

The State Water Project (SWP) is constructed and operated like the Central Valley Project. It stores water behind Oroville Dam on the Feather River (Figure 1), releasing and allowing it to flow down the Sacramento River to the Delta. There it is pumped into a canal for deliveries southward. A portion of the SWP canal along the western side of the San Joaquin Valley is shared with the Central Valley Project; further along, the canal is owned entirely by the State. This project provides water to the southwestern San Joaquin Valley lands that were not supplied by the Central Valley Project. The canal continues to the southernmost point of the San Joaquin Valley, where the water is pumped over the Tehachapi Mountains, a height of more than 700 m. This water then serves the southern urban regions. Customers of the State Water Project are 30 percent agricultural and 70 percent urban. Originally designed to yield 5.4 billion m^3, the project has yet to be completed and has a current yield of approximately 3.4 billion m^3. Because of political, environmental, and fiscal concerns, there is doubt that this project will ever be completed to yield the expected 5.4 billion m^3 supply.

Local Infrastructure

During the past century California's water infrastructure has been developed by local, state, and federal agencies. While the state and federal projects move large amounts of water over long distances, local supplies make up more than 47 percent of the state's total developed supplies. The three largest local urban suppliers are the San Francisco, East Bay, and Los Angeles projects (Figure 1). As noted previously the San Francisco supply originates in Yosemite National Park on the Tuolumne River and is piped across the state to the City's local reservoir system. Los Angeles receives water from the eastern Sierra Nevada via pipes through the Owens Valley. The East Bay system is similar to San Francisco's, taking water from the Mokelumne River on the western slopes of the Sierra Nevada and delivering it via pipelines to the east side of the San Francisco Bay Area.

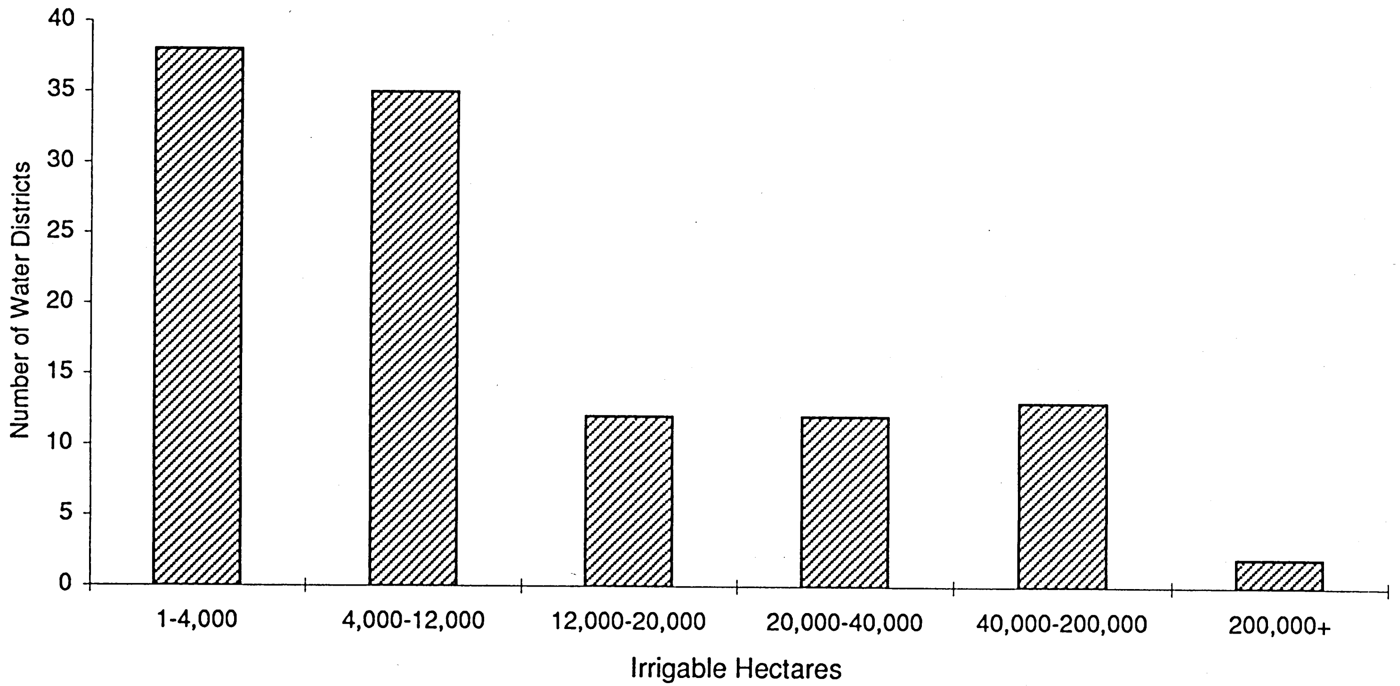
The majority of the state's water supply is delivered by relatively smaller local water districts. These districts either have their own water supplies or contract with a larger wholesaler such as the Central Valley Project or the State Water Project. In 1993 the University of California undertook a survey of agricultural water districts in California. A total of 134 responses were received. The information gathered in this sample show substantial and interesting variations among California's water delivery districts.

The districts that responded to the survey include a large portion, approximately one-third, of California's water districts. The water districts surveyed range greatly in size and geographic location. The variation in gross acres (size) among water districts is large, with a low end of 12 hectares (ha) to a high end of 485,000 ha. The number of irrigable acres ranges from 1 ha to 323,700 ha (see Figure 3). The average number of gross acres for the water districts is 37,300 ha, while the average number of irrigable acres is 22,570 ha. The number of landowners in a given water district ranges from 1 to 2,725, with an average of 878. The number of farms operated ranges from 3 to 25,000. The average number of farms operating in the districts sampled is 700.

Information was solicited concerning the different services offered by the water districts. The percent of water districts offering particular services are as follows: 91 percent offer surface water for irrigation; 32 percent offer groundwater for irrigation; 41 percent offer surface water for urban use; 23 percent offer groundwater for urban use; 26 percent offer groundwater recharge; 25 percent offer drainage control; 17 percent offer flood control, and 23 percent offer electricity generation and sale. Districts were also given an opportunity to report other services they offered. The categories of those services reported is as follows: parks and recreation/fishing; tail water return/master tile drainage system; sewage and waste water reclamation; meter monitoring/installation of water meters; canal operations/land reclamation/impose levies; and conservation programs.

Ease of access to water is important to farmers' cropping and irrigation decisions. The type of water delivery arrangements offered to growers will determine their ability to use precision irrigation technologies. Forty-two percent of the water districts offer a demand delivery system, where demand delivery is defined as customers' instant access to water any time of day. Thirty-seven percent offer water delivery on an arranged schedule. Water districts with arranged water delivery are those where customers make prior arrangements for water delivery with the district, subject to time constraints. One of these time constraints is called lead time and refers to the amount of time a customer must call ahead of the actual time requested for water delivery. Water districts were asked to report their lead times under the arranged schedule, with 24 hours being the most common response. The final water delivery arrangement reported was rotational, offered by 21 percent of the water districts. (The definition of a rotational water delivery system is where customers are put on a pre-arranged schedule of rotation for water delivery.)

Figure 3. Size Comparison of Districts by Irrigable Hectares.



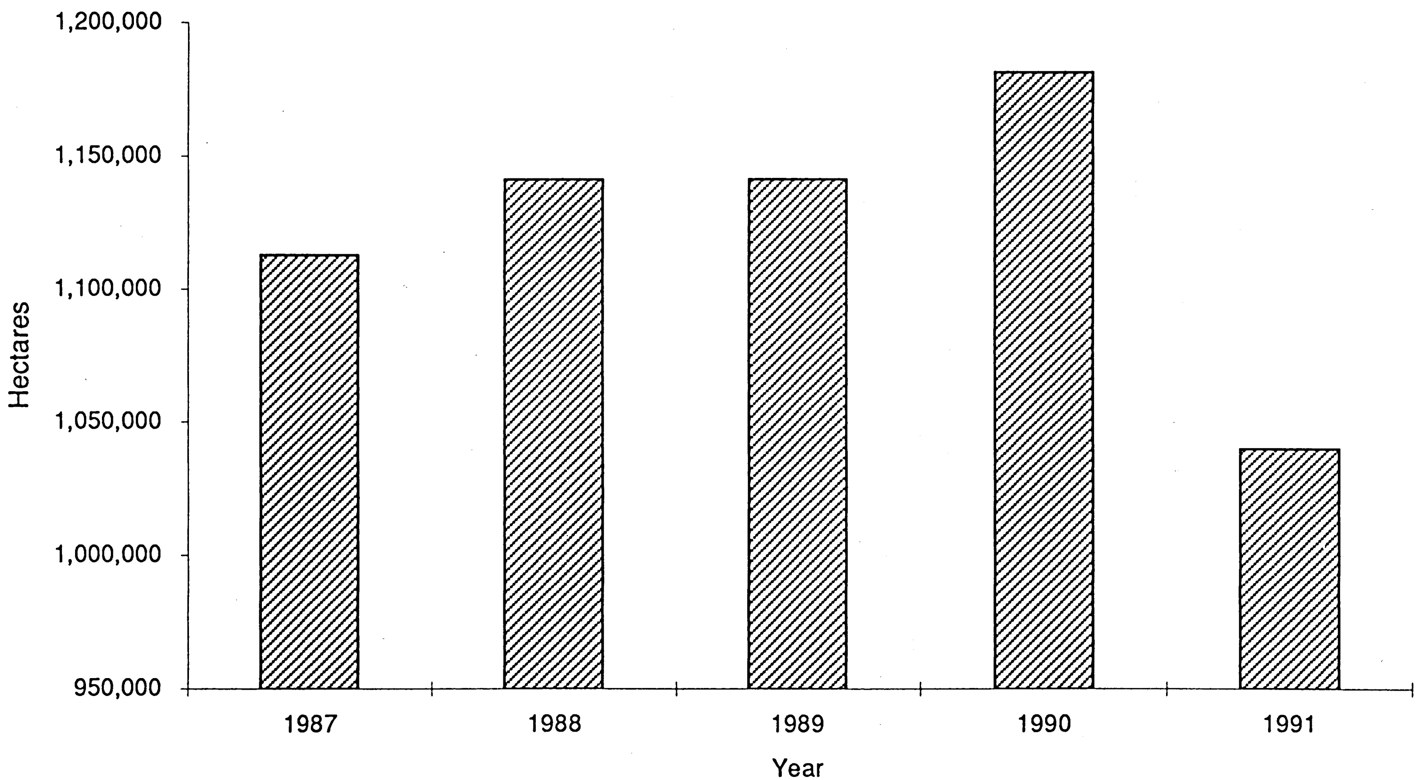
Source: Parker, 1994.

Along with water delivery arrangements, a series of general questions on water storage and conveyance facilities were included in the survey. Forty percent of the water districts have their own storage facilities. Storage capacities range from 4 thousand m^3 to 1,157 million m^3, with the average being 48.4 million m^3. Some districts supplement surface water by providing customers with groundwater. Eighteen percent of the water districts have groundwater wells. The number of wells in a district range from 1 to 200 wells, with an average of 19 wells.

To ascertain the intensity of water service in the districts, water districts were asked to report the number of miles of unlined canals, lined canals, and pipeline or pressurized conveyance systems. Forty-eight percent of the districts have between 1 kilometer (km) to 5,800 km of unlined canals, with an average of 280 km. Thirty-three percent of the districts have between 1 km to 1,570 km of lined canals, with an average of 100 km. Sixty-six percent of the districts have between 2 km to 2,500 km of pipelines, with an average of 240 km.

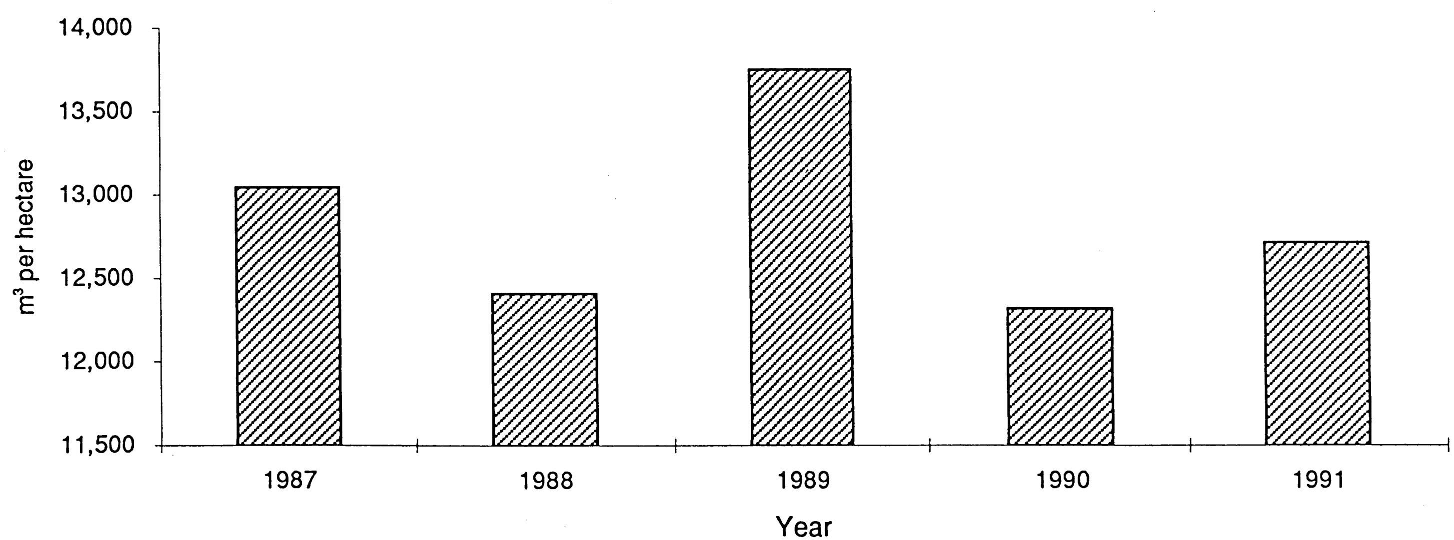
The districts reported the actual number of hectares irrigated in their district for five different years, 1987 to 1991. The information gathered shows a trend of increasing average hectarage under irrigation from 1987 to 1989 followed with a small decline in 1990 and a sharp decline in 1991 (see Figure 4). This decline can be attributed to the lengthening drought of the time. The per-district average area under irrigation across the entire sample of five years is 18,400 ha, with the average minimum for a single district at 46, the average maximum at 203,000 ha. Total water use per irrigated hectare (the number of hectares actually irrigated each year from 1987 to 1991) follows the same drought-related trend, with a maximum depth of 1.37 meters in 1989 to a low of 1.22 meters in 1990 (see Figure 5).

Figure 4. Total Hectares Irrigated, 1987 to 1991.



Source: Parker, 1994.

Figure 5. Total Water Delivered per Hectare Irrigated.



Source: Parker, 1994.

The districts also reported information on the irrigation systems used in their district by percentage of use. The four categories given are drip, sprinkler, furrow, and border. The reports show furrow with the largest percentage use at 39 percent, followed by sprinkler at 29 percent, border at 24 percent, and drip at 8 percent.

Water districts were asked to report their water rights and water contract entitlements. Information on water supplies are shown in Table 1.

Table 1. Water District Entitlements.

Entitlement	Minimum	Maximum	Average	Total
	--------million m^3--------			
CVP class 1	1.48	1,418	122	3,285
CVP exchange	24.9	657	341	682
SWP	3.7	201	111	669
Riparian	0.64	40.7	21	41
Appropriative	1.6	3,207	446	5,800

Source: Parker, 1994.

Districts also reported on surface and groundwater deliveries from 1987 to 1991. The amount of water delivered varies greatly. Most districts deliver from 1,500 m^3 to 24.5 million m^3, but many are delivering in the range of 50 million m^3 to 600 million m^3.

Statewide Infrastructure

The combined annual yield of California's local, state, and federal surface systems is 34 billion m^3. Water use in the state's agricultural and urban industries, along with residential use and dedicated environmental flows, combine to create a demand estimate of 44.4 billion m^3. The difference between these figures, 10 billion m^3, is made up by local groundwater pumping. Groundwater use in California is not currently regulated except in a few select regions. The state estimates that its groundwater potential is 8.7 billion m^3. Thus we see that water users in the state are currently overdrafting groundwater aquifers by 1.3 billion m^3 on an average annual basis. Because the groundwater supply is often used to smooth out the variable surface supply, these figures imply that in some years there is a net gain in groundwater recharge, while in others the overdraft may reach 3.3 billion m^3.

This water supply imbalance is cause for concern among the state's water regulators. Efforts are being made to provide for greater local control of groundwater reserves. Yet new demands for water are expected to cause major conflicts between water users in the near future. Urban populations are projected to grow by 63 percent, to over 48.9 million people, by the year 2020. These urban centers do not currently have excess supplies to meet the projected needs this increase in population will create. Furthermore, as the demands on the state's water supplies increase, environmental concerns will continue to grow. Concerns for endangered fish species have already altered water allocation in the state, and new pressures on the limited supply are sure to increase these environmental constraints.

FUTURE WATER CONCERNS

California's water users—urban, agricultural, and environmental—have different objectives concerning future water use and allocation. The traditional user of most of the state's supply is agriculture, using nearly 80 percent of the developed supplies. As other water needs increase in importance, agriculture is usually looked upon to make up the water shortfall. It has become necessary for agricultural users to communicate their own needs to policy makers and others who control the state's supplies. Agricultural use can be split into two sub-categories, permanent and annual cropping. Permanent crop growers are concerned with maintaining a reliable yearly supply. They may have access to groundwater to carry them over in years of drought. These crops tend to be of higher value, which may allow for greater investment in water-saving technologies and management schemes. Annual crop growers are also concerned about a reliable supply, but their short-term options to deal with a drought are more flexible. These water users have the option of fallowing lands in very dry years. While this option will allow the unused water to be used elsewhere, annual crop growers are concerned about getting some aid in those years to cover long-term land and capital rents.

Urban water users are most concerned with maintaining a reliable supply. The costs of temporary water shortages to an urban area are very high. If industrial production plants were forced to temporarily shut down, the costs could be an order of magnitude higher than agricultural land fallowing. These industries also tend to have less flexibility in dealing with short-term fluctuations in supply. In the long run, industries may improve water use efficiency and substitute capital or reclaimed water for some fresh water supplies. Another long-run strategy for dealing with short-run uncertainty would be for these firms to move to other states with firm supplies.

Environmental water needs are a growing concern throughout the state. The water needs of the environment are very complex. Environmental water needs may vary greatly during the year to meet the needs of specific migratory species—fish and birds. Other resident wildlife may have differing needs. The state has been reacting on a species-by-species basis to environmental needs. The failure to stabilize the environment has led to an effort to take an ecosystem approach in the Sacramento River-San Joaquin River Delta. Here there are a number of threatened or endangered species, often with conflicting needs. A state-federal team know as CALFED has been established to work with all interested parties to seek solutions to the environmental needs of the Delta. Because the majority of the state's developed surface supplies pass through the Delta, this process is of major importance. Its outcome will determine not only the environmental health of the ecosystem but will affect agricultural and urban water users as well. Concerns of water quantity, water quality, and habitat suitability for several species must be balanced with the state's need for a reliable water supply.

As the state faces an increased demand for water from a growing urban sector and growing environmental concerns, the need to better manage the system and allow for water reallocation becomes more important. Many institutions in the state are involved in promoting better management of existing water supplies, but there remains a need for those institutions involved in water allocation to become more flexible.

WATER MANAGEMENT AND OTHER ACTIVITIES

Making more water available to alternative current and future users can be done in several ways. Existing supplies can be reallocated through a variety of voluntary and non-voluntary mechanisms. New sources of supply can be developed through new projects or better management of existing supplies. In this section we look at several methods of water reallocation as well as methods to increase water use efficiency in the hopes of creating new supplies through reductions in demand.

The two methods of reallocation of interest are water marketing (voluntary) and water reallocation through legislative or judicial means (non-voluntary). Increasing water use efficiency can lead to voluntary reallocations if conserved water is made available for other uses. This conserved water may be reallocated through marketing or other mechanisms. We look at conservation through traditional educational and assistance programs and through conservation-oriented changes in pricing.

Water Reallocation by Water Markets

California's water institutions are changing to allow for more flexibility in water management and allocation decisions. Water marketing, water pricing, and water conservation programs all have a role in helping the state to better meet its future needs. Water marketing or trading has been taking place between neighboring water districts for many years. More recently, there has been an increase in the level of activity, the size of the transactions, and the distance the water is being moved. Whereas most previous water transactions occurred between agricultural water districts located along a common river or canal, current transactions are being made between distant districts, and agricultural-to-urban transactions are occurring. Nevertheless, the majority of trades remain within agriculture.

The University of California, in cooperation with the U.S. Bureau of Reclamation, the Natural Heritage Institute (a nonprofit environmental organization), the Westlands Water District, and the Arvin-Edison Water Storage District, has been involved in a project to increase the value of water to agricultural users without necessarily increasing the cost of this water. This is being done through the promotion of water marketing in one district (Westlands) and through pricing reform in the other (Arvin-Edison).

The water marketing program in Westlands, which has only recently begun, provides an electronic water marketing, and ordering and information services for individual farmers. Subscribing farmers provide their own personal computer and modem, the project provides the software and services for the central server that is located in the water district office. The electronic system called "WaterLink" can be used to submit electronic trades through the central server, or as a source of on-line information about the current water market. Farmers who wish to buy or sell water can post the quantities, priority, and location of the water on WaterLink. The trades have to be checked for feasibility by the central office before they are implemented, but currently the reporting of prices is voluntary.

Initial response to WaterLink has been encouraging, in that seventy farmers are currently on line, with some farmers using both the electronic trading and water ordering options and others participating in the non-market options. Given the relative abundance of water in the region during this first year of operation, the system promises to fulfill its role of providing an easily accessible and low-transaction-cost water market for dry years. While the proportion of water traded is small, the existence of a widely known market price provides an incentive for conservation and efficient water use. The market enables the opportunity cost of water to reflect its value marginal product without changing the cost of water. (We emphasize that the market is selling consumptive water on an annual basis, not hypothetical water rights on a permanent basis.) This short-term spot market and option approach to reallocating water has been successfully used in the State-sponsored Water Banks that operated in 1991, 1992, and 1994. The banks traded water in a simple fixed price system that kept uncertainty and transaction costs low. However, estimates of the prices and quantities demanded changed as the dry years progressed. Accordingly, an option-based water bank was initiated in 1995 to provide better reliability against a looming dry year.

The water banks of 1991, 1992, and 1994 generated significant direct and indirect benefits for water users in the state. In 1991, 1,012 million m^3 of water was purchased by the Water Bank, of which 685 million m^3 was traded with a direct benefit in excess of \$104 million. Tables 2 and 3 show the net monetary and employment benefits from the Bank. These values can be regarded as a lower bound on the benefits, since the urban values are low and the excess water bought in 1991 and carried over to 1992 was valued at the price paid for water in the subsequent 1992 Water Bank. It could be argued that the purchase price in 1992 was suppressed by the 1991 carryover.

Table 2. Statewide Net Benefits from the 1991 Water Bank. ($ Million)

Exporting Regions		
Income Lost from Crops		–76.02
Income Gain from Water Sales		63.27
Export Region Income Loss		–12.75
Importing Regions		
Income Gain in Agriculture		45.40
Urban Consumer Surplus Gain		58.77
Benefits to Importing Regions		104.17
Net Benefits		
Agriculture Benefits		32.65
Urban Benefits		58.77
Value of Surplus Water		13.0
Total Net Benefit	104.42	

Source: Howitt, 1994.

The sale of water between regions had a positive net effect on employment. Jobs were lost in the water-exporting regions, but the gain in jobs in the importing regions far outweighed the losses. Table 3 shows the estimated impacts on employment by sector. In estimating the effect on urban employment, we face the same problem as with the urban income multipliers. The job multipliers used for the urban sector are low compared to the average industrial use multiplier, but reflect a change in water availability to the urban "green" industry of landscaping and horticulture. The average multiplier used was 17.6 jobs generated per 110,000 m^3 of water, where a job is defined as employment of unskilled labor for a period of six months. This value is considerably below many of the urban employment multipliers used, but probably more accurate for the actual use of the additional water in 1991.

Table 3. Statewide Employment Impacts of the 1991 Water Bank.

Exporting Agricultural Regions	
Jobs Lost from Crops	–3133
Jobs Gained from Revenues	1485
Net Effect	–1648
Importing Agricultural Regions	
Jobs Gained from Water Imports	1153
Net Job Change in Agriculture	–495
Importing Urban Regions	
Jobs Gained from Water Imports	4236
Net Statewide Gain in Jobs	3741

Source: Howitt, 1994.

Table 3 shows that, unlike the income effect, the agricultural industry had a net reduction in jobs due to its sales and purchases with the Bank. However, only 22 percent of the purchased water was resold to agriculture, and the state of California as a whole had the benefits of an additional 3,741 jobs from the movement of water by the Bank. In addition, we can conclude that for the water that was traded within agriculture, there were net gains in agricultural jobs from trade.

These broad measures show that in terms of both income and jobs, the Water Bank generated substantial net gains to the state and most regions. When considering any resource reallocation, the benefits and losses should be jointly reviewed. In terms of income, the net loss of \$12.75 million has a favorable ratio of 8:1 net income gain to the state. The equivalent ratio for job gains to losses is lower at 2.3:1, but still shows substantial net gain.

Water supplies improved slightly in 1992, but drought conditions persisted. Accordingly, the drought Water Bank was continued in 1992. Given the improved water supplies, the 1992 bank operated at a lower purchase and sale price and smaller quantities. Water was not purchased by fallowing crops in 1992, and supplies came from surplus reservoir storage (20 percent), and groundwater substitution (80 percent).

The total quantity purchased was 234 million m^3, and the price paid for the water was \$0.04/m^3 (\$50.0/acre ft). Sales were 197 million m^3 at a price of \$0.06/m^3 (\$72.0/acre ft), which was less than half the price of the previous year's bank supplies. In addition to supplies sold to agricultural and urban uses, 15 percent of the 1992 bank water was sold for environmental purposes. Public funds had been allocated to assist in the purchase of this environmental water. The differences in the price and quantity equilibria between the 1991 and 1992 Water Banks strongly support the contention that both the demand and supply of water in California is price-elastic, even under severe drought conditions.

Water supplies improved in California in 1993, and the State DWR did not need to run a water bank. However 1994 was once again dry, and a third drought Water Bank was established. Given past experience and the similarity with 1992, the 1994 Bank bought 272 million m^3 from reservoir and groundwater exchange contracts. The average purchase price was the same as 1992, at $0.04/$m^3$ ($ 50.0 acre ft). 209 million m^3 was sold to urban and agricultural interests in 1994 at a price of $0.06/$m^3$ ($68/acre ft), which is fractionally lower that the 1992 price. The administrative transaction costs of the drought water banks were low, in the region of 7 percent or $0.0033/$m^3$ (Steven Macauley, 1992). The main reason for the substantial price spread between sellers and buyers was the need to finance the "carriage water" requirement of approximately 30 percent of the delivered quantity required for salinity control in the Sacramento River Delta. This latter cost can be thought of as an environmental transaction cost of moving the water across the Delta. In short, the banks worked well within the politically required restrictions of rigid price levels and regulatory controls on third-party effects.

At the start of the 1995 water season, precipitation and river flows were at low levels. To add some security and flexibility to a potential water bank, the California DWR initiated an option market in December 1994. The market took the form of purchasing options to buy water in the event of a drought at the fixed price of $0.004/$m^3$ ($3.50 /acre ft), and selling options to purchase water at $.008/$m^3$ ($10/acre ft). The demand for options peaked at 380 million m^3 in early December before increased river flows reduced demand (Jercich, 1997). In the intervening years there has been considerable activity in private water market agreements. Relatively few option agreements have been consummated, however; a few have been negotiated that are contingent on the availability of water at given dates.

Water marketing has now become one of the management tools available to California water users. The development of markets that can accurately reflect the differences in time and value of water still has a way to go, but the advantages of the approach outweigh the concerns about third-party costs in exporting regions.

Legal and Judicial Reallocation of Water

Introduction of water markets has been hastened by the supply pressures induced by several involuntary reallocations, or the threats thereof. The largest and best known reallocation of water from urban and agricultural uses to environmental restoration is the Central Valley Project Improvement Act (CVPIA). The act has several aspects, but is dominated by the reallocation of 1,480 million m^3 of water to environmental uses in normal water years and two thirds of this quantity in drought years. In addition to this reallocation, the act also allowed farmers with federally subsidized water to sell some of their supplies. Another case of the interaction of legislative pressures stimulating market responses occurred in the Imperial Valley, where the threat of condemnation for inefficient use stimulated farmers to negotiate an agreement with a large urban area, under which conserved water was traded to pay for the conservation costs. Other legislative initiatives are also relying on the ability to purchase water for environmental mitigation to reduce the social costs of obtaining additional supplies. There is substantial legislative reallocation of water under negotiation; however, the trend is to use legislative methods in conjunction with markets to reallocate existing supplies.

Water Conservation

Promoting efficient water use through proper price signals encourages voluntary water conservation. University of California researchers and extension economists have been working with the Arvin-Edison Water Storage District to revamp its pricing structure to promote water conservation while maintaining other objectives of the district (revenue stability and conjunctive use of groundwater). Most agricultural water districts in California have several revenue-raising methods at their disposal—property tax assessments, contract charges, and usage charges. In order to maintain revenue stability, many districts recoup a large share of their costs of operation through property tax assessments. Use of property taxes to raise revenues decreases reliance on usage charges and thus lowers the marginal cost of a unit of water to the users. Furthermore, the contract charges may force water users to pay for the right to a certain quantity of water whether they actually use it or not. Thus actual per-m^3 charges are often quite low.

The Arvin-Edison Water Storage District has served as a case study in lowering the fixed charges and raising the variable charges for water. While the total revenue collected by the district remains unchanged, the per-unit charge for water has more than doubled. This should lead to changes in water use either through changes in cropping patterns, changes in irrigation technology, or changes in irrigation management.

Water pricing modifications are also taking place in other agricultural districts as well as in most urban water districts. In urban districts there is a switch to tiered pricing of water. Under this system the price per unit of water increases as the number of units used increases. Usually this is done by creating two or more usage levels and pricing differently across each level.

Traditional water conservation programs include urban measures such as low flow fixtures in residential units and conservation credits for industries. The greatest potential for water conservation in industry is usually for cooling purposes. Alternative cooling systems, especially ones that use reclaimed water, can save significant quantities of fresh water.

In agriculture, the University of California and the California State University Systems have taken the lead in promoting water conserving technologies and management. These efforts have been complemented by programs at the California Department of Water Resources and the U.S. Department of Agriculture, as well as programs in local water districts. The University of California has been instrumental in importing and developing new irrigation technologies for use in California agriculture. Irrigation efficiencies in the state have improved from levels near 50 percent to 70 to 95 percent in some areas. The introduction of drip and microsprinkler irrigation has been possible through the testing and educational efforts of these groups.

Along with new irrigation technologies have come new methods of irrigation management. A joint University of California and California Department of Water Resources program to provide growers with weather information was started in the early 1980s. This system, now known as the California Irrigation Management

Information System (CIMIS), consists of nearly 100 weather stations located throughout the state. A central computer provides modem access to weather information from any one of the stations. Using available weather information, growers can calculate how much water a particular crop has used or needs. Combining this with soil information and knowledge of local drainage and other conditions, growers can budget water use and determine proper irrigation amounts and timing. A recent study of this system showed a net benefit to users of over $20 million per year in water savings and yield increases, as well as many other additional benefits for both agricultural and nonagricultural users (Parker et al., 1996).

CONCLUSIONS

The programs described above seek to lessen the strain on the state's water infrastructure through the creation of mechanisms that reduce demand and allow for flexible reallocation of water. One area of water conservation that is just beginning to be analyzed is environmental water conservation. The concept behind this type of conservation is that water used for environmental purposes should be used in the most environmentally efficient manner. Thus water that is released into a river system to maintain or increase a fishery should be managed in a manner that maximizes the environmental returns, i.e., the timing and quantity of releases should be based upon the best biological information available. This type of environmental water allocation and use is being explored in the previously mentioned CALFED process that is seeking to increase the health of the fisheries dependent upon the Sacramento River-San Joaquin River Delta. By putting environmental water to its best use, we can help assure adequate supplies for all three of California's major water use sectors.

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Chapter 8

ENVIRONMENTAL ISSUES IN CALIFORNIA AGRICULTURE

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Many human activities have had a significant effect on the environments in which they take place, and agriculture is no exception. California's natural waterways have been greatly modified to enable conveyance of water to its farmlands as well as its cities, and to provide facilities for flood control, navigation, and hydroelectric power generation. Most of the natural wetlands in the state have been drained and transformed into fertile, highly productive agricultural land. Farmers have introduced many new species of plants and animals to California and in the process changed many of its ecosystems.

While modifications of California's environment have generated immense good, they have also increasingly become a cause of concern. Over the last 40 years many policies and regulations have been introduced to control some of the effects that California agriculture has had on its environment.

Two main types of policy intervention have been made. First, numerous policies have sought to control agricultural externalities. These center on reducing groundwater contamination from animal waste; worker safety, environmental contamination, and food safety problems associated with pesticide use; water-logging problems associated with excessive irrigation and lack of drainage; air pollution from agricultural waste burning such as rice, and earth mining activities; odor pollution associated with livestock, etc. A second set of policies has specifically attempted to preserve ecosystems and species. These policies identify and protect the environmental amenities that may be threatened or damaged by agricultural activities.

Environmental policies affecting California agriculture have continually evolved over the last 40 years. The evolution has been affected by changes in technology as well as by changes in the political environment and public beliefs and preferences. For example, new knowledge about the impact of agricultural chemicals on human health and the environment, the discovery of new methods of pest control, and the introduction of new monitoring or pollution-detecting strategies have led to changes in environmental laws and regulations affecting agriculture. Similarly, changes in the relative political power of environmental groups or various farm groups and/or changes in public perception and concern about certain environmental issues have led to changes in regulations.

Farming in California is subject to policy-making and regulation by a wide variety of agencies. In addition to traditional agencies in the U.S. Department of Agriculture, they include other federal agencies such as the U.S. Environmental Protection Agency and the U.S. Wildlife Service; state agencies such as the California Environmental Protection Agency, California Department of Food and Agriculture, California Department of Public Health, State Air Quality Control Board, and State Water Quality Control Board; and country and municipal agencies. These many agencies that control various aspects of California's environment have operated under a complex set of policies that are not necessarily consistent and are subject to modification.

The complexity and the changing nature of environmental policies in California have provided an ample background for research in agricultural and environmental economics. Agricultural economists have assessed the impacts of various policy proposals, attempted to provide an economic rationale for proposed policies, and introduced proposals for policy reform and modification. Some of this research may have affected the existing policies and regulations in California; some has provided general background knowledge for the body of literature in agricultural and environmental economics.

An overview of the environmental policies affecting California agriculture identifies some of the difficulties that policy makers are faced with in their attempts to establish environmental regulations. Problems with detecting and monitoring agricultural pollutants (for example, difficulties in monitoring the process of groundwater contamination by animal waste runoff) have sometimes led to over-policing of environmental activities that are likely to cause environmental side effects. Thus, a chemical may be banned or its use restricted even though policy makers may be concerned only with the environmental side effects of some of its residue. Similarly, animal production in a certain area may be restricted or limited even though the only local concern may be with the waste that the animals are producing. The evolution of new technologies will likely help to develop policy measures that will relate more to specific environmental side effects (e.g., contamination of groundwater) rather than to the general related activities (e.g., dairying as a whole).

Establishment of straightforward and efficient policies is influenced by difficulties in measuring impacts of externalities. The assessment of health risk effects and environmental side effects associated with pesticide use, for instance, is subject to much uncertainty. These uncertainties have contributed to the constant debates and controversies regarding environmental regulation affecting agriculture. One of the challenges facing the scientific community is to provide data to reduce such uncertainties. As Baumol and Oates have suggested, uncertainty regarding outcomes has led to policies that aim to reach a target level of environmental quality based mainly on biological or ecological considerations, whereas balancing marginal benefits with marginal costs might actually be more appropriate.

Another practical difficulty in determining environmental quality is its multi-dimensionality. The same chemical can cause several types of environmental problems—worker safety, food safety, groundwater contamination, or damage to wildlife. The benefits of chemicals, as well as the magnitude of their environmental side effects, can vary significantly according to crop and location. The way a chemical is applied can affect its impact on the environment; a chemical sprayed from an airplane is likely to generate more environmental side effects than one applied by low-pressure, precise-application techniques. Thus the social costs associated with the use of certain chemicals may vary significantly across locations and applications, and policies such as uniform taxation or direct regulation of agricultural chemical use may be economically inefficient in many situations. Efficient regulation of the environmental side effects of agriculture may call for policies that vary by location and agricultural activity, and the need for flexibility may also provide a challenge in terms of design and implementation.

Much of the economic research on the environmental regulation of agriculture has simply estimated the economic impacts of proposed regulation. However, some research has also suggested improvements in policy design and demonstrated how changes in policy instruments might result in attaining environmental objectives at much lower economic costs. This chapter discusses some of the major environmental regulations that have affected California agriculture and describes the conclusions of economic research that has analyzed the efficacy of various approaches. The diversity of problems and policy issues is illustrated through the use of five case studies on dairy waste management, Central Valley drainage problems, methyl bromide fumigation, endangered species regulation, and control of exotic pests.

DAIRY WASTE DISPOSAL AND ENVIRONMENTAL POLICY

The dairy industry in California has been closely concentrated near the larger population centers in Los Angeles and Northern California. The largest dairy-producing region in the state has been the Chino region near Riverside, not far from Los Angeles. Dairy production in this area is very intensive; productivity of cows is among the highest in the nation. The disposal of animal manure in this area has historically caused severe groundwater contamination problems. Dairies in this region have designated certain lands as disposal areas where all liquid and solid animal wastes are disposed of. In many cases, one acre of land is needed for disposing of the wastes from more than 30 or 40 cows, and most of the salt content in this waste percolates into the groundwater.

The Clean Water Act was introduced in the early 1970s. One of its most important purposes was to reduce groundwater contamination and especially salinization by animal waste. The standard regulation proposed by the State Water Quality Control Board restricted the ratio of cows' disposal acres—the tons of manure disposal compared to the animal waste produced by one cow—to be no greater than 1.5. Studies to assess the economic impacts of this standard (Moffitt, Just and Zilberman; Hochman, Zilberman and Just) showed that it would reduce the dairy cow population drastically and reduce the economic surplus that this industry generates by about 80 percent. Of course the proposal encountered strong objections by dairy farmers and resulted in heavy litigation. An alternative proposal was to treat solid and liquid wastes separately; the solid waste was to be hauled to safe disposal areas outside the Valley, and restrictions were to be imposed on the disposal of liquid waste so that the original target of salt reduction could be met. On analysis this policy proposal was found to meet regional water quality targets at less than 50 percent of the cost of the original proposal. Therefore this policy was adopted and has enabled the industry to survive for another 18 to 20 years.

The use of disposal areas for animal waste is not optimal and is not sustainable in the long run. A major challenge for the California dairy industry is to find better solutions for disposal of animal wastes. Indeed, some dairies have moved from the Chino area to the San Joaquin Valley, where growers could find both larger disposal areas and better opportunities to market their manure as fertilizer. Difficulties in meeting environmental standards have also been the cause of migration of dairies from California to New Mexico and Texas. There is growing recognition that one of the challenges facing agricultural scientists and economists is to develop technologies and incentives that will result in the recycling of animal waste as an agricultural production input. Recycling waste would help enable a transition to a more sustainable dairying system, ending the inefficient and costly system that merely accumulates contamination.

The Santa Ana River Basin Case Study

An example of policy analysis in addressing the dairy waste issue is found in the Moffitt-Zilberman-Just study.[1] Although dealing with the Southern California dairy industry specifically, this study has potential application to other parts of the state and to other agricultural industries. While this study was completed in the early 1970s, its conclusions are still valid today.

Concern over deteriorating quality of groundwater in Riverside and San Bernardino Counties led to dairy waste disposal regulations in one of California's largest Grade A milk-producing regions, the Santa Ana River Basin (SARB). SARB dairymen had traditionally held strong preference for this region because of its proximity to the Los Angeles milk market. Hence there was reason to believe that most dairymen would continue dairying in this region as long as it was economically feasible. The study was undertaken to determine the economic effect of the waste regulations on the SARB dairy industry and to examine possible alternatives. It concluded that milk production could be maintained in the near future if sufficient credit were available to dairymen for new waste disposal technology; otherwise, the dairy industry would eventually leave the SARB.

Dairies in the SARB produced three forms of waste: stormwater runoff from corral areas, washwater from cleaning cows and milking areas, and manure. These wastes contributed tons of salts to SARB groundwater annually. To control the pollution, the California Regional Water Quality Control Board, Santa Ana Region, required dairies to: (1) provide facilities to contain 1.3 times the runoff from a 10-year, 24-hour rainfall (a storm of 24-hour duration which yields a total precipitation of a magnitude that has a probability of recurring only once every 10 years); and (2) discharge no more than 3 tons of manure (1.5 times the annual waste produced by one cow) per acre each year. (This rate of discharge would result in an annual salt contribution to groundwater of

[1] Originally published in *California Agriculture* (September 1976), this study is titled "Wastewater Regulations in Santa Ana River Basin," by Joe Moffitt, David Zilberman and Richard Just.

approximately 0.3 ton per acre.) The total acreage used for waste disposal in 1973 was approximately 12,000 acres. A maximum annual salt contribution by the dairy industry of 3,600 tons per year (0.3 x 12,000) was the implicit goal of the regulations.

The typical method of compliance with these requirements consisted of: (1) a system of pumps, culverts, and a pond to hold wastewater until it could be spread on disposal land; and (2) disposal of solid waste by hauling it to land with available absorption capacity. (Since wastewater cannot be hauled away economically, a dairy needed surrounding land for wastewater disposal.)

A computer simulation was performed to estimate the availability of financing for each dairy's waste disposal system at various credit levels—$100, $200, and $300 per cow. As expected, the results varied, depending on credit availability and also on whether the discharge limit of 3 tons per acre included the estimated 10 percent of total manure contained in washwater (Table 1). If it did, the pollution goal could be achieved, but at high cost to the industry. Indeed, expenses might be so great as to cause many dairies to migrate out of the SARB, which would lead to higher transportation expenses for milk shipped to Los Angeles.

Table 1. Industry Results Under Current Regulations.

Regulation	Credit per cow	Cows*	Dairies	Profit	Waste**	Cost
	dollars	---*number*---		*dollars*	*tons*	*dollars*
Preregulation	-----	172,616	418	7,077,215	50,000†	-----
Discharge limit includes manure contained in wastewater††	100	70,413	165	1,401,676	2,294	5,675,540
	200	110,266	255	1,741,204	3,866	5,336,111
	300	126,206	287	1,778,343	4,243	5,298,972
Discharge limit excludes manure contained in wastewater†††	100	162,154	293	3,307,113	6,583	3,770,202
	200	172,113	411	3,421,078	6,824	3,656,237
	300	172,113	411	3,421,078	6,824	3,656,237

* Counting heifers as one-half cow and calves as one-fifth cow.
** Tons of salt contributed to groundwater.
† Estimated.
†† Equivalent to restricting solid waste disposal to 1.5 cows per acre and washwater disposal to 15 cows per acre.
††† Equivalent to restricting solid waste disposal to 1.5 cows per acre and washwater disposal to 40 cows per acre.

Sources: For preregulation (waste) figure, see Albert A. Webb Associates, *Dairy Waste Management Plan*, Riverside, CA, October 15, 1973, p. 139. Computed using herd size data from California Regional Water Quality Control Board, Santa Ana Region, *1973 Dairy Report*, Riverside, 1973.

An alternative solution was also evaluated, based on the following factors:

1. Total disposal acreage would be different under the requirements. For land prices in a neighborhood of $6,000 an acre (an approximation of existing land prices in the

SARB), disposal acreage might decrease if restrictions included manure contained in washwater but would increase if they did not.
2. Disposal of waste contained in liquid would be very costly if additional land had to be purchased.
3. The number of cows per disposal acre varied among dairies. While the industry as a whole had enough land to dispose of washwater in accordance with existing regulations, distribution of the disposal acreage was uneven; some dairies had more than enough disposal land to meet the requirements, but others, often with large herds, had little or none.

Cost-waste trade-off curves were estimated for three credit levels considering separate restrictions which indicated the minimum cost possible for each waste level and vice versa. According to the analysis, water quality goals could be achieved at lower cost through proper implementation of separate restrictions. The implementation of restrictions and the resulting effects on the industry were calculated in Table 2. The cost of compliance was still great but improved from the single restriction case. A review of both Tables 1 and 2 shows that aggregate herd size would vary with credit availability, but this was not the case with industry profit.

Table 2. Industry Results with Separate Disposal Restrictions.

Credit per cow	Solid Waste	Wash-water	Cows*	Dairies	Profit	Waste**	Cost
dollars	*-cows per acre-*		*---number---*		*dollars*	*tons*	*dollars*
100	1	20	107,030	250	2,084,473	3,600	4,992,841
200	1	16	115,965	270	1,806,291	3,600	5,271,024
300	1	15	118,636	266	1,528,158	3,600	5,449,156

*Counting heifers as one-half cow and calves as one-fifth cow.
**Tons of salt contributed to groundwater.

Source: Computed using herd size data from California Regional Water Quality Control Board, Santa Ana Region, *1973 Dairy Report*, Riverside, 1973.

In the preceding analysis, the method of waste disposal was limited to the hauling and pond procedures discussed earlier. However, other technologies are currently available. The most promising new waste disposal technology is the CERECO manure recycling process discovered by Auburn and Colorado State Universities and developed by the Ceres Ecology Corporation of Sterling, Colorado. This process produces: (1) a fermented roughage feed, (2) a high protein concentrate, and (3) a substance that may be used as a potting mix from cow manure. It is possible that the revenue from the sale of the feed products would more than compensate for the expenses associated with the construction of a recycling plant in the SARB. This new process might offer a much better solution to the solid-waste management problems of the SARB dairy industry, because manure hauling expenses would be eliminated or greatly reduced.

In summary, the conclusions of the study are as follows:

- First, any level of water quality could be achieved at lower cost by using separate restrictions for the disposal of solid waste and waste contained in liquid. In particular, more strict regulation of solid waste relative to the disposal of washwater was suggested.
- Second, production as reflected by aggregate herd size could be maintained in the short run if sufficient credit were available. However, this might not be the case in the long run, since profit and possibly future investment could fall regardless of credit availability.
- Finally, a better solution to the problem might be found in manure recycling processes.

CENTRAL VALLEY DRAINAGE PROBLEMS

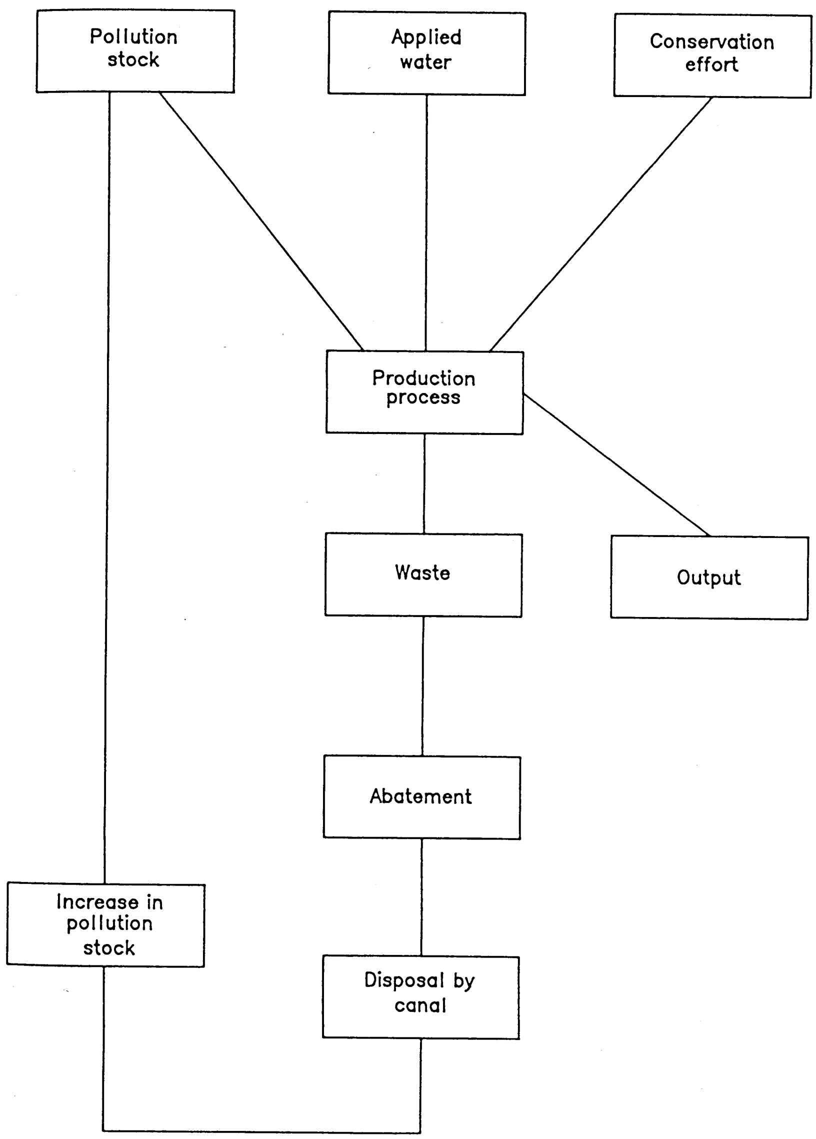
Water logging, a major side effect of agricultural production, occurs when deep percolating irrigation water encounters impenetrable barriers close to the ground. Rising water levels accumulate and, as they reach the top soil, harm agricultural production and in the long run cause salinity and loss of production. Water-logging problems can be eliminated by installation of drainage pipes to divert the water to a drainage canal that takes it to a disposal area.

The western side of California's Central Valley has had a water-logging problem as a result of irrigation following the establishment of the Central Valley Project (CVP). Originally, there were CVP plans for a drainage canal to transport water from the Central Valley toward San Francisco Bay and the Delta. Because of resistance by environmentalists and budgetary constraints, however, an alternative solution was implemented, draining the water into an artificial wetland called Kesterson Reservoir. Unfortunately, this solution did not work. After several years, high levels of selenium found in the drainage water began to accumulate in Kesterson area plants. High selenium levels also caused severe deformities in water fowl in the area. As a result, the U.S. Bureau of Reclamation banned the disposal of drainage water in Kesterson, and farmers were challenged to find other solutions to the drainage problem.

A significant body of interdisciplinary research has emerged from the Kesterson problem. The flow chart in Figure 1 from Chakravorty, Hochman, and Zilberman identifies some solutions for the problem. Because the source of the problem is deep percolating groundwater from irrigation, one solution might be to reduce the volume of deep percolating water by input reduction activities such as adoption of irrigation technologies—drip and sprinkler irrigation—that increase the percentage of water consumed by crops and reduce excess runoff and percolation.

Another policy solution that could help manage the drainage problem would be to provide economic incentives to reduce drainage. For example, higher water prices or taxes on drainage would encourage adoption of water-conserving technologies.

Figure 1. Relationships of the Source Region Subsystems.



The drainage problem might also be reduced by abatement activities such as the use of evaporation ponds to which drainage water will be diverted. Evaporation ponds are expensive, however, and may cause other environmental problems. Nevertheless, they are widely used throughout the Central Valley, and under certain conditions make economic sense.

A third alternative is to address the drainage problem by biological filtering. In this case, some of the drainage water is used to irrigate salt-tolerant crops with a high evaporation rate. Eucalyptus trees can be very useful for this purpose. Several thousand acres of eucalyptus have been planted in the Central Valley to accelerate the evaporation of drainage water. Another solution is to reuse water at a shallow aquifer below the root zone to slow the process of water logging. While this solution is feasible for a while, the shallow aquifers soon become excessively saline. Another solution may be to fallow some land.

The economics of all of these solutions is investigated in Dinar and Zilberman's *Economics of Water and Drainage*. However, the authors suggest that, though these solutions may slow the water-logging problem for a while, in the long run there may not be any other alternative but to build a major drainage canal from the valley to the bay or ocean. The forementioned solutions might not only delay the installation of such a canal, they might also reduce its size and dimensions and environmental effectiveness. The study of the drainage problem in the Central Valley will continue to be a major area of concern in years to come.

METHYL BROMIDE FUMIGATION

Public and worker health concerns are behind attempts to ban many agricultural chemicals. One such chemical is methyl bromide (Mbr), a commonly used soil and commodity fumigant. Methyl bromide is both highly volatile and extremely toxic to non-target organisms, including humans. When it was found to contribute to the continuing degradation of the ozone layer, procedures were initiated under the Montreal Protocol to lead to a complete national or worldwide ban on its use by the year 2000.

Mbr is particularly important in California for strawberries, nursery crops, and trees and vines. It is also used for post-harvest commodity fumigation, especially for walnuts and cherries, which accounts for just 5 percent of total agricultural use. While this application accounts for relatively little use overall, it is important to those crops relying on it for export shipments.

Mbr use for soil fumigation rose significantly from 1985 to 1990 as progressively fewer alternatives remained available. Crops affected by the cancellation of Mbr are strawberries ($431 million total farm value in 1990), tomatoes ($875 million), almonds ($592 million), grapes ($1.5 billion), peaches ($198 million), nectarines ($100 million), walnuts ($229 million), and nursery crops ($1.9 billion). Each of these crops has significant export value, which would be decreased by inability to fumigate as required by the importing country. Estimates of the cost of a contract for pre-plant soil fumigation with Mbr range from $225 per acre for strip fumigation of vegetable fields to $1,000 per acre for strawberries, with most orchards and vineyards falling in between.

The impact of removing Mbr is highly dependent on available alternatives. There is no single alternative capable of targeting the wide range of pests and diseases that Mbr is capable of controlling, but there are several alternatives available for specific crops and pests. One of the major problems facing the agricultural community is that the move from a broad spectrum to a narrow spectrum pesticide is likely to require greater expenditures on information gathering regarding available pest control strategies, on the monitoring of specific field conditions, and, most likely, on the pesticides themselves. The alternatives identified, which have varying efficiencies and efficacies compared to Mbr, are Metam-sodium, Telone, Nemacure, urea or other nitrogen fertilizers, crop rotation, fallowing, soil sterilization, and replanting without treatment. The latter strategy has yielded poor results and is not likely to be pursued by a commercial agricultural enterprise.

Economic analysis of the alternatives to Mbr shows that Vapam is the highest profit alternative for all annuals and a number of perennials. In some cases, crop rotation would be the highest profit alternative. These instances are typically characterized by relatively low per acre profits compared with Mbr, however.

Total lost profits in agricultural crops as measured by producer surplus are estimated to be $68.1 million annually, while lost consumer welfare is estimated to be $131.6 million annually. Consumer welfare change is significant only in the case of strawberries, due to California's high market share. Lost producer profits are also highest for strawberries, at $45.5 million annually. Distribution of these impacts varies significantly by region in California. They are highest in the central and southern coast areas, which have high strawberry production, and in the San Joaquin Valley, which has a high concentration of trees and vines. In addition, lost profits for the nursery industry are also estimated at $67.7 million annually, making it a severely impacted industry.

An interesting analysis is an evaluation of the net income effects of banning Mbr in terms of profits generated per pound of Mbr applied. This information is presented in Table 3. There is a wide variability in the profitability of Mbr fumigation, reflecting the wide range of environmental conditions in California agriculture. Mbr fumigation on almonds in the Sacramento Valley, for example, is barely profitable, as it generates incremental profits that just cover application costs. In high value crops such as nurseries and strawberries, however, Mbr fumigation generates large incremental benefits. In the case of cut flowers and nursery-grown fruit, nut, and vine seedlings, Mbr benefits exceed $40 per pound applied.

Table 3. Incremental Value for Methyl Bromide Fumigation, $ per lb.

Crop	Sacramento Valley	San Joaquin Valley	Northern Coast	Central Coast	Southern Coasts	Southern Valleys	Statewide
Almonds	1.7	1.8	---	---	---	---	1.8
Grapes	3.8	5.3	4.5	7	---	8.8	5.4
Nectarines	---	10.7	---	---	---	---	10.7
Peaches	4.7	7.1	---	---	2.5	---	6.4
Strawberries Fresh	---	11.1	---	26.4	30.5	19.4	27.5
Tomatoes	8.6	8.3	---	7.4	14.8	7.4	8.9
Walnuts	4.9	8.2	---	1.4	---	7.6	6.3
Rose Plants							28.7
Cut Flowers							40.5
Fruits, Vines, Nuts							41.7
Strawberry Plants							11.6

As demonstrated by Table 3, the variation in impacts by crop and region is significant. This variation is consistent with other analyses of environmental regulations of California agriculture. More than most states, California possesses a wide range of soil and climatic conditions, and the profitability of agriculture varies widely as a result. Thus, pesticide bans and other agricultural input regulations have variable impacts that depend on crop and region.

Post Harvest Treatment

Relatively few commodities are routinely fumigated with Mbr. It is phytotoxic to fresh fruits and vegetables, with effects ranging from reduced shelf life to burns that render the product unsaleable. For these products, Mbr is used only in quarantine situations for specific pests, such as the Mediterranean fruit fly, and often only for shipments sent to specific destinations. For less perishable commodities, such as dried fruits and nuts, fumigation is more common as a means of controlling pests that infest storage facilities. Alternatives to Mbr include phosphine, controlled atmosphere (carbon dioxide), temperature treatments (hot or cold), biological control, irradiation, and certified pest-free zones. The major advantage of Mbr is the short treatment period it requires; 3 to 24 hours as compared to 5 to 7 days for phosphine and as much as 40 days for cold storage or controlled atmosphere. Commodities currently being fumigated with Mbr include almonds, sweet cherries, peaches and nectarines, raisins, prunes, and walnuts.

Certified pest-free zones have been introduced by growers in Mexico, Texas, and Florida as a technique to allow export of fragile or perishable commodities without subjecting them to fumigation or other techniques. The concept is to have stringent pest control protocols observed by growers in an entire region, coupled with active trapping and monitoring programs to assure that pests are not present in the area. While this approach has allowed for increased exports from these areas, there is a concern about the increased use of pesticides required to maintain a pest-free status. In addition, the cost of monitoring and implementing eradication programs when pests are detected can be quite high (as in the case of the Medfly invasion into California), and is complicated if located in close proximity to urban areas or ports where control is more difficult.

Cherries exported to Japan and peaches and nectarines exported to Canada and Mexico are currently the only fresh fruits or vegetables routinely fumigated with Mbr. The relative fragility and perishability of these fruits make techniques that require longer treatment times unattractive. Further research may yield more plausible alternatives. Short-run impacts of a ban are estimated to be $15.8 million for these commodities. These impacts would be more severe if California had an exotic pest invasion or if regulators impose a ban on Mbr use that is not observed in competing parts of the world. For example, if a trade embargo were imposed and export markets were lost due to the fact that Mbr could not be used to satisfy an importing nation's requirement for fumigation, California grower revenues would fall by $55.8 million annually for table grapes and plums that are currently exported.

The commodity likely to be the most severely impacted in the dried fruit and nut category is walnuts, due to the industry's current reliance on Mbr and the strict time constraints of meeting holiday demand in the lucrative European market. It is estimated that California walnut producers would lose about $10 million annually through lost export sales if they lost the use of Mbr.

In addition to the impact on growers, the loss of Mbr would also affect the state's economy. The state gross domestic product would fall from about $288 million to $346 million annually, depending on the scope of quarantine restrictions. More significantly, between 8,200 and 9,900 jobs could be lost each year. Statewide impacts come mainly from soil fumigation, particularly on strawberries and nurseries. The trade disruption impacts of an Mbr ban might be small in relation to the soil fumigation impacts, but it is important to remember that only a small fraction of all Mbr used in California is for post-harvest fumigation. Thus the value of Mbr used for commodity fumigation is high per pound of Mbr applied.

ENDANGERED SPECIES REGULATION[2]

Federal and state legislation relating to endangered species has resulted in increased regulation and litigation affecting the business environment in California. The implementation of the federal Endangered Species Act (ESA) has had impacts that have included adverse effects on California agriculture and the state economy. In 1996, there were 105 animal species and 176 plant species that had been designated as endangered in California under both state and federal law. The animal species are

[2] For a more detailed study, see "Impact of Endangered Species on California Agriculture," A Report to the California Department of Food and Agriculture, September 19, 1996, Siebert et al.; Kit Fox Case study written by Joshua Zivin from same report.

classified into gastropods, crustaceans, insects, fishes, amphibians, reptiles, birds, and mammals.

An overall estimate of economic impact for California agriculture is highly difficult, because effects and recovery plans vary by species. (Any economic impact analysis must be based on published recovery plans.) Economic impacts take many forms, but usually they are based on the effects on costs of production and yields. These may come through restrictions on production inputs such as pesticides or on land use, cultural practices, and water. Another set of impacts arises because of inability to plant crops or use land for agricultural purposes, usually through the reduction of water allotments or restrictions on the conversion of land for agricultural purposes. A third set of impacts comes from a shift in agricultural production from a higher value use to a lower value use. Examples of this may be a shift from cropland to rangeland or a shift from irrigated to non-irrigated crops. These first three sets of economic impacts center on the generation of gross and net revenues. A fourth set centers on the value of an asset, usually land or the agricultural enterprise itself, when there is a restriction on its highest use. These economic impacts are not exclusive of each other and can occur in combination.

At least two policy issues are related to endangered species. The first is the issue of "takings," a thorny and complex question. Unlike other takings, where a private asset may be appropriated for public use (e.g., land condemnation for a public project), takings under the ESA are not as clear and have been treated as a private cost of doing business. Property owners contend that any restriction imposed by ESA is, in fact, a taking of private property by restricting its ability to generate its highest value or cash flow, and that compensation should be made. Legal interpretation of this claim is being developed, and legislative attempts have been made to deal with this issue.

The second issue is how the ESA is applied with respect to species. One approach is to administer recovery plans on a species-by-species basis, which can lead to duplication of efforts and resource use. An alternative is to manage on an ecosystem or habitat approach. This approach looks at the management of an ecosystem that will support many species, some of which will serve as natural predators to the species in question. Either approach will have economic consequences for the property owner in question; preference may depend on the relative costs of each approach.

Economic impacts of the ESA vary significantly by farmer, crop, and geographic location. Some farmers and sectors of agriculture might be totally unaffected, while others might experience significant consequences. The total impact on agriculture could be minimal compared to its gross value, but individual farmers and crops might be seriously affected.

Forest, rangeland, and abandoned farmland might be at greatest risk from endangered species legislation, since many species have habitat on these lands. Land under active cultivation might not be affected unless it is located in a buffer zone with certain practices excluded under the recovery plan. In the case of water reallocations, the method of reallocation will constitute the greatest factor in the size of the economic impact. In the case of pesticide restrictions, the impact will vary according to whether the regulations are selective or broad in their application. Hence, the selection of appropriate public policy alternatives is critical to mitigating economic impacts.

The Case of the Kit Fox

To demonstrate the expected economic impacts from the implementation of a recovery plan and the policy issues involved, we have selected the case of the kit fox. This case study centers on the protection of a vertebrate. One method of protection is restriction on the use of the pesticides chlorophacinone and diphacinone, which are two very effective anticoagulants used in California agriculture to control ground squirrels and jackrabbits that threaten crops. Currently, chlorophacinone and diphacinone are non-restricted materials that are purchased by growers from their County Agricultural Commissioner. These materials are formulated on grain (crimped oat groats) at 0.01 percent for broadcast baiting and at 0.005 percent for use in bait situations, with bait stations being the more prevalent method. These stations are generally placed around the crop at 150–200 foot intervals in areas frequented by ground squirrels and jackrabbits.

However, there are some externalities associated with this method of vertebrate control. Anticoagulants often kill the pest above ground, where other predators can feed on them. When predators feed on them, they too can be poisoned through biological magnification of the anticoagulants in the liver of the dead pest. One such predator is the endangered San Joaquin kit fox. The U.S. Fish and Wildlife Service (USFWS), in conjunction with the U.S. Environmental Protection Agency (USEPA), has responded to the problem with proposed restrictions on these vertebrate control agents. The proposal suggests the restriction of chlorophacinone and diphacinone use within the San Joaquin kit fox habitat as well as in buffer zones, which consist mostly of cropland, up to one mile from the habitat areas.

If this regulation is implemented, California growers will need to find alternative vertebrate control strategies and will have to weigh the different cost and yield effects associated with each. For the ground squirrel, there are several options. Selective fumigants can be effective; however, they should be used only during the late winter period or early spring, when there is sufficient soil moisture to hold lethal concentrations of gas in the burrows. Zinc-phosphide-treated grain is also registered for ground squirrel use, but in the past there have been some problems with bait acceptance. Additionally, both trapping and shooting can be used to control squirrel populations. For the jackrabbit, the choice is not so varied. There are currently no other registered control agents for jackrabbits. The only alternatives are trapping, shooting, and fencing.

This case study evaluated the economic impact of prohibiting the use of chlorophacinone and diphacinone as control agents for ground squirrels and jackrabbits in the relevant range. Farm profitability under the current pest control strategies, which include the anticoagulants, was compared with projected farm profitability when farmers use alternative strategies. The analysis was conducted using Kern County as a case study and was performed on each crop individually, because the degree of pest problem and the substitute control methods vary significantly by crop. The modeling approach allowed for an accounting of the different yield effects and cost characteristics across a multitude of crops.

The impact of chlorophacinone and diphacinone cancellation in the buffer zone was measured for each crop. These crops include: several varieties of grapes (sold in several markets), two varieties of cotton, alfalfa, apples for both the fresh and processed markets, almonds, pistachios, Valencia and navel oranges, lemons, and grapefruit. Anticoagulant use to combat the ground squirrel is widespread throughout these crops, with the exception of the row crops, cotton and alfalfa, where it is used to battle the jackrabbit.

There are significant differences in yields and farm gate prices for these crops. For example, pistachios and almonds have similar farm gate prices, but pistachio production per acre is more than double that of almonds, therefore it is more likely that pistachios will suffer greater losses per acre than almonds from a new regulation banning anticoagulant use. It is also crucial to note the differences in prices for the same product going to different markets. Failure to treat each market separately can lead to significant bias in estimation of regulation costs. Alternate pest control strategies for each crop included the expected costs and yield effects associated with a new pest management program. The alternative chemicals considered were zinc phosphide, a treated grain, and aluminum phosphide, a fumigant. [It should be noted that aluminum phosphide can only be sold to and used by a certified applicator.] The non-chemical controls considered were trapping, shooting, and fencing.

Only the short-term impacts of anticoagulant restrictions were examined, excluding any innovations in vertebrate control technology that might arise in the future. Research projects at universities, at the USDA, and in the private sector are currently underway to develop vertebrate control alternatives. However, any new chemical technology will have to undergo an extensive and costly registration procedure, which in itself can prove to be quite a hindrance. Because the results of this research are impossible to predict, this analysis was restricted to short-term impacts, given currently available technology.

Restricting chlorophacinone and diphacinone for vertebrate pest control would have a significant impact on Kern County growers. The short-term effects on revenues and costs were estimated to be annual losses in excess of $70 million dollars, with a large percentage of that being attributed to alfalfa and cotton. These losses do not include any multiplier effects on the nonagricultural economy.

The analysis indicated that the burden of this regulation would be unevenly distributed by crop type. A quick inspection of Table 4 reveals that if the proposed regulation were implemented, alfalfa farmers would suffer losses in revenues and increased costs of 3.54 percent of their total revenues; pistachio farmers would lose 3.44 percent; and acala cotton farmers' revenues would decrease 1.56 percent. However, all other farmers would lose less than 1 percent of their total profits. This large disparity is due to the fact that the primary pest for the row crops, unlike the other crops, is the jackrabbit. Currently the only registered chemical control agents for the jackrabbit are the anticoagulants, and without them, farmers are forced to use non-chemical methods that are drastically less effective and significantly more expensive. Additionally, while some crops would be particularly hard hit, it should be noted that total losses for all of the relevant crops in the buffer zone were estimated at only slightly over 1 percent of total profits for those crops.

The analysis evaluated the cost to growers of the proposed regulation but should be weighed with the benefits of protecting the San Joaquin kit fox. Additionally, there are also distributional issues to be considered. As demonstrated, proportionately more of the burden of regulation would be borne by row crop farmers than other farmers. An alternative solution that would spread the costs on a broader basis would involve either direct financial intervention by the government in the form of taxes or subsidies, or the promotion and registration of alternative jackrabbit control methods.

Table 4. Revenue Loss and Cost Increase Compared to Total Value of Crops in the Kit Fox Buffer Zone, Kern County.

Crop	Gross Farm Value	Net Change in Revenues & Costs	Percentage
Alfalfa	60,963,00	2,157,400	3.54
Almonds	190,630,000	1,822,660	0.96
Apples			
fresh	33,454,000	44,000	0.13
processing	2,736,000	2,460	0.09
Cotton			
acala	234,660,000	3,664,040	1.56
pima	26,795,000	492,000	1.84
Grapefruit	1,821,000	840	0.05
Grapes			
raisin variety			
fresh	100,907,000	99,020	0.10
raisin	37,562,000	19,320	0.05
processing	2,899,000	2,340	0.08
crushed	17,873,000	29,140	0.16
juice	442,000	180	0.04
table variety			
fresh	173,611,000	233,470	0.13
crushed	4,828,000	7,380	0.15
raisin	688,000	140	0.02
wine variety			
crushed	54,692,000	147,270	0.27
juice	2,892,000	22,490	0.78
Lemons	9,940,000	19,160	0.19
Oranges			
navel	115,419,000	1,100,020	0.95
Valencia	50,684,000	124,010	0.24
Pistachios	98,745,000	3,399,530	3.44
Total	1,222,241,000	13,386,870	1.10

Source: 1993 Kern County Agricultural Commissioner's Report.

The long-run impacts of the restrictions placed on chlorophacinone and diphacinone might differ substantially from the short-run impacts described above. These might include the invention of new vertebrate pest control schemes as well as the breeding of varieties with earlier harvest dates, so that crops could be harvested before the jackrabbits and ground squirrels begin their predations. The new regulations might also provide an incentive to relocate fields and orchards to internal pieces of property where anticoagulant use is still permitted, forcing rabbit- and squirrel-tolerant crops to the perimeter. However, since fruit and nut trees take five to ten years after planting to begin bearing economic yields, adjustments of this nature would take years to complete and would be very costly. Lastly, economic impacts on growers in the San Joaquin kit fox range might be exacerbated if other producers do not face similar regulation. Such a regulation could put growers in the kit fox areas at a competitive disadvantage, especially with respect to export markets.

EXOTIC PESTS: THE MEDFLY

The Mediterranean fruit fly, *Ceratitis capitata (Wied.)*, or the Medfly, is an imported pest, infestations of which have serious consequences for California agriculture. The 1980–81 infestation was ultimately eliminated at a great expense—reported at over $100 million—to the State of California and the federal government. A significant amount of public funds has been spent on eradication efforts for subsequent infestations. In 1989–90 there was another Medfly infestation (similar to the one in 1980–81), and findings of the Medfly have continued.

Because of aggressive eradication efforts, the impact on the California agricultural industry has been minimal compared to potential damage. However, the eradication efforts have not been without controversy. In addition, infestations to date have been in urban areas. The protocol for eradication involves a system of traps, aerial application of Malathion-treated bait, and the use of sterile male Medflies. The most controversial part of the protocol has been the aerial application of bait. This technique has raised fears and concerns among urban residents, and, coupled with diminished availability of public funds, has caused local officials, public interest groups, environmental groups, and health and safety groups to raise questions about the necessity of eradicating the Medfly.

The outbreak of the Medfly in 1993–94 raised the specter of a possible embargo of California products by Japan, and probably Korea, Taiwan, and Hong Kong (which usually follow Japan's lead). This concern increased with the discovery that the Medfly had spread eastward into Riverside County near commercial citrus orchards. Japan has indicated that if a fertile female Medfly is found in a commercial orchard, it will consider placing an embargo on shipments of fresh fruit and vegetables from California. (While the question could be raised regarding why the embargo should affect the entire state when only a small part of its production area is affected, it should be noted that the issue of trade sanctions is a political one, not necessarily based on science or economics.)

Cost of Controlling the Medfly

The list of crops that serve as hosts to the Medfly is quite extensive. In a 1991 production-cost study, 22 different commodities were included: apples, apricots, avocados, bell peppers, cherries, dates, figs, grapes, grapefruit, kiwis, limes, mandarin oranges, nectarines, olives, peaches, pears, persimmons, plums, prunes, and tomatoes (both processed and fresh). In 1992, these commodities represented nearly 1.6 million acres of irrigated cropland and over $4.2 billion in value of farm production. The farm value of exports amounted to $559 million, with a substantial amount shipped to Japan and other Asian countries.

The assumption made in the production-cost study was that through periodic and regular applications of Malathion-treated bait, a marketable product would be produced. Increased costs would come from the application of bait and, for those crops shipped from California in a fresh state, there would be a post-harvest treatment using methyl bromide or a cold treatment to meet U.S. Department of Agriculture quarantine restrictions. The annual increased costs were estimated to range from a low of $349.6 million to a high of $731.9 million. The reason for this range is that the effective application of pesticides is dependent on weather factors and the length of the season. The estimated cost for post-harvest quarantine treatments was $135.3 million, which includes the cost of the treatment and the loss of fruit due to treatment damage. An additional $8.1 million in transportation costs for movement to and from treatment facilities was also estimated. Hence, total annual costs of controlling the Medfly were estimated to range from a low of $493 million to a high of $875.3 million. Compared to the 1992 value of the total value of production for the crops affected, these costs are substantial.

Market Impacts from a Trade Embargo

The economic impacts from a trade embargo would include effects on fresh shipments of apples, apricots, avocados, bell peppers, sweet cherries, dates, figs, table grapes, grapefruit, kiwis, lemons, limes, tangerines, oranges, nectarines, peaches, pears, persimmons, plums, and tomatoes. These commodities do not necessarily match those of the production study, because an embargo would likely include all exported commodities to the countries in question. For example, in the production-cost study, lemons were excluded; however, in the embargo study, they are considered. Also, the embargo would likely take place even though the commodities could be treated for shipment.

The 1992 farm value of these products was $2.1 billion, and the farm value of total exports was $354.8 million. These crops were grown on 655,000 acres (8.5 percent of the total 1992 harvested acres in California). The 1992 total f.o.b. value of shipments of these products, including both domestic and export (excluding tomatoes for which there was no available data), was $2.9 billion. The total f.o.b. export value was $605.5 million, and the f.o.b. value of shipments to Japan, Korea, Taiwan, and Hong Kong was $376.3 million, amounting to 62.1 percent of total exports for this product.

Estimates of the changes in revenue from 1992 due to an export embargo vary by crop as to their significance. In most cases, the estimated change in price was small and not very significant as reflected in the lost revenue figure. However, for the citrus crops—grapefruit, lemons, navel oranges, and Valencia oranges—which were the most impacted, the estimated revenue loss was highly significant. For grapefruit, the loss in revenue is estimated to be 51 percent of the 1992 levels; for lemons, 38 percent; for navel oranges, 15 percent; and for Valencia oranges, 55 percent. The loss in revenue for all of the commodities considered was $564.2 million or 20 percent of the 1992 value of shipments.

This loss represents a decrease in income to growers, packers, and shippers of the commodities involved. At the levels indicated, it is highly unlikely that any profits would result to those commodities most heavily impacted. The costs of growing, packing, and shipping the commodities would still occur. The question that remains is how long the industries involved would continue to produce at the levels that existed before an embargo.

The total impact of a Medfly infestation on the industries involved should also take into account the costs of controlling the pest. When these costs are added to the embargo estimates, they indicate even higher losses to the industry. The total impact on the commodities would range from a low of $1.057 billion to a high of $1.44 billion. These figures represent losses to all segments of the industries involved—from pesticide applications to control the Medfly, to losses in revenues due to losses in export markets and price decreases in domestic markets.

In the short run, the domestic consumer would benefit from an embargo, particularly from citrus. Estimated price decreases range from no change in the case of apricots, to over 60 percent for grapefruit. How long the consumer would benefit from these price decreases would depend on how long it took for the industry to readjust its production or to find new markets. Price decreases of the magnitude estimated for the citrus industry would be expected to last no longer than two years before production adjustments would be made. In the long run, the consumer might be worse off. Producers would eventually decrease production in order to raise prices enough to regain lost revenues and adequately cover capital investments.

In addition to a loss in income to the commodities affected, the California state economy would also be impacted. It is estimated that there would be a $1.2 billion decrease in gross state product and a loss of 14,200 jobs. Hence policies to eliminate pest invasions have a significant impact on both the industries affected and the general economy.

CONCLUSIONS

This chapter has discussed several environmental issues associated with the production and marketing of agricultural products in California. The case studies presented are intended to bring out the many-faceted and complex issues associated with environmental externalities. While agriculture is not alone in its effects on resources, environmental quality, food safety and health, and worker safety, undesirable effects have led to the introduction of policies and regulations to deal with them. Clearly, the choice of policy instruments can have a significant impact on agriculture and its competitiveness. Economic analysis can assist in identifying those policy alternatives that achieve desired goals in eliminating or reducing the externality in question while minimizing the costs to agriculture. The use of market forces to assist in reducing problems is key. In addition, policies that encourage the rapid development of alternative technologies and management systems are essential.

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Chapter 9

AGRICULTURE AT THE URBAN FRINGE: A COMPETITION FOR SCARCE RESOURCES

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The state of California has been characterized by persistent population growth. Between statehood until the early 1970s, the state population doubled every twenty years. From the early 1970s through the present, growth has been relatively steady at about one percent per year. The state population today is roughly 32 million and is almost entirely urbanized. At the same time, California is home to a large and highly industrialized agricultural sector.

While both agricultural and urban production are integral parts of the state's economy, a tremendous imbalance exists between the populations involved in the two sectors. Nearly one-third of the state's land area is dedicated to commercial agriculture, yet less than one percent of Californians are ranchers or farmers (Coppock et al.). As the state population continues to grow, it is likely that both the total acreage dedicated to agriculture and the people who work this acreage will decrease.

As recently as 45 years ago, Los Angeles was the country's highest producing agricultural county (Berton). Today it is a vast area of suburban/urban subdivisions. The Santa Clara Valley, once a prime agricultural region, is now home to the high-tech computer industry and is known as Silicon Valley. The Central Valley, which runs from Redding to Bakersfield, is the state's top producing agricultural region. The Valley is really composed of three distinct regions: the north, which is the upper part of the Sacramento Valley and does not generally support intensive agriculture; the middle, which surrounds Sacramento and the San Francisco Bay Delta; and the south, which includes most of the San Joaquin Valley, traditionally an area of large-scale, intensive agricultural production.

California accounts for more than eleven percent of U.S. crop value, and almost two-thirds of that comes from the Central Valley. The Valley is comprised of parts of twenty-one counties, six of which are among the nation's top ten agricultural counties, including the number one Fresno County. The area produces 250 distinct crops, many of which are high-value, and generates a total farm gate market value in excess of $14 billion annually.

Because this large and distinctive agricultural industry must co-exist with an increasingly urban population, there will undoubtedly be heightened tensions between the two. As California continues to sustain the nation's highest population growth rate, urban-rural competition for scarce resources will persist as the key source of this tension. In the Central Valley this competition has already begun, for residential and commercial growth are currently consuming roughly 15,000 acres of farmland each year (American Farmland Trust). The competition is not limited to land but includes water, water quality, and air quality. As the pressure mounts, will the Central Valley succumb to urban sprawl? If it does, at what cost?

POPULATION GROWTH

Traditionally, population growth in the Central Valley has been slower than the state average. This is beginning to change, as Sacramento and Fresno are becoming major urban areas, while Stockton, Modesto, and Bakersfield lag behind. The Valley's current population is 4 million and is expected to nearly double by the year 2000 and to almost triple by the year 2040 (*California Almanac*). These figures represent a growth rate twice as fast as those predicted for the entire state (see Table 1).

Table 1. Projected Population Growth for Selected Central Valley Counties.

County	1995	2000	2040
Fresno	754,100	1,589,700	2,497,700
Kern	616,700	1,310,100	1,954,800
Kings	114,900	207,500	296,500
Madera	106,400	214,100	317,900
Merced	198,500	401,900	626,900
Sacramento	1,117,700	1,839,500	2,352,000
San Joaquin	524,600	956,500	1,356,500
Stanislaus	413,800	840,200	1,224,900
Sutter	73,800	168,600	271,500
Tulare	349,800	644,400	952,100
Yolo	150,800	285,900	386,100
TOTAL	4,421,100	8,458,400	12,236,900

Source: California Almanac and California Statistical Abstract.

Research by Blakely and Bradshaw indicates that new residents of the Central Valley consist of three separate groups: the traditional valley population which is primarily white and Latino, new immigrants who are mostly Asian immigrants and refugees, and commuters in search of cheaper housing. These different groups bring with them a wide range of skills and very distinct needs. To a large extent, these skills and needs will shape the pattern of future social, economic, and environmental growth in the Valley.

Migrant farmworkers, primarily from Mexico, make up a significant portion of the Valley's population. According to recent figures from the U.S. Department of Labor, 37 percent of all agricultural workers in California are temporary migrants. The impact of urban conversion on future migration is unclear for several reasons: (1) the extent of agriculture as a *pull* factor for migration is not clear; (2) to the extent that employment is a *pull*, it is unclear how agricultural labor-intensity and thus employment will change in response to urbanization; (3) urbanization may result in an increase in unskilled employment opportunities.

Traditional views (Gabbard) have suggested that agriculture provides a strong *pull*, encouraging Mexicans to migrate to California for agricultural jobs that are plentiful and a stepping stone to better jobs in the future. This view suggests that urban conversion of agricultural lands in the Central Valley will reduce migration. However, these views may not be an accurate portrayal of the migration situation today.

Many experts[1] agree that given Mexico's current economic situation, *push* factors are at least equally important in explaining migration patterns. Furthermore, recent figures reveal that only 12 percent of Mexican immigrants work in agriculture, and the importance of agriculture as a stepping stone for better jobs has diminished. Current research suggests that most new Mexican migration is occurring in urban centers, where new immigrants seek employment through relatives already living in these cities.

Regardless of the extent to which *push* versus *pull* factors dominate, the ultimate impact of urban conversion on migration patterns is unclear. Urban conversion may result in an increase in labor-intensity in agriculture, as high-value crops are substituted for less labor-intensive field crops. This would reduce employment losses in agriculture. In addition, urbanization changes employment opportunities in the city, which may result in more unskilled employment opportunities in the non-agricultural sector. To what extent these employment changes affect migration remains to be seen.

Composition of Employment in the Central Valley

According to figures from the California Employment Development Department, agricultural employment in the Central Valley accounts for about 11.5 percent of total Valley employment, compared to roughly three percent statewide. This figure is down from 13.5 percent in 1980, and is indicative of a trend that is expected to continue. As a result, the composition of Valley employment is changing. These changes are similar to nationwide trends, which include slow growth in agriculture and manufacturing and major growth in non-productive sectors such as retail, finance, insurance and real estate,

[1] Much of this information is based on conversations with George Goldman, U.C. Berkeley Cooperative Extension, Jeff Perloff, U.C. Berkeley Department of Agricultural and Resource Economics, and Ed Taylor, U.C. Davis Department of Agricultural Economics.

and services. Growth in the latter industries has been particularly strong in the Central Valley.

From 1983 to 1995, manufacturing employment grew by 27.3 percent, compared to –5.6 percent statewide. Employment in finance, insurance, and real estate (FIRE) grew by 39.4 percent, roughly 27 percentage points faster than statewide growth. The largest growth occurred in the services sector, where Valley growth was in excess of 69 percent, considerably faster than statewide figures. Lastly, growth in the retail sector registered at 35.9 percent, versus 29.1 percent statewide (see Table 2).

Table 2: Percentage Change in Employment, 1983-1995.

Sector	Central Valley	California
	------------percent------------	
Agriculture	12.8	7.9
Construction	23.2	31.4
Manufacturing	27.3	–5.6
Transportation & Utilities	21.9	20.1
Wholesale trade	17.2	27.4
Retail Trade	35.9	29.1
FIRE	39.4	12.4
Services	69.1	66.9
Government	23.7	22.5
TOTAL	33.2	27.8

Source: California Employment Development Department.

Kroll et al. examine location quotients (LQ) to determine the relative economic importance of activities in the Valley. The location quotient compares the share of employment by sector to the average share over the state or nation. Their results indicate that despite regional employment losses in agriculture, nine of the twenty-one counties in the Valley have (state-based) LQs in agriculture that are greater than five, indicating that they have five times more employment in agriculture than their size would suggest. Furthermore, in contrast to the strong growth in FIRE and manufacturing employment, these sectors showed fairly low LQs. In counties where agriculture was not dominant, mining and construction were the dominant source of employment.

Agriculture is still a vital contributor to the Central Valley economy. However, the Central Valley's present and future growth depends on an expanded economic base, which in turn will depend on the relative advantages for new firms to locate in the Valley. These include the availability of transportation and communication infrastructure, access to labor and output markets, and the competitiveness of factor prices. The Central Valley, especially in contrast to the rest of California, is highly competitive in all of these areas and is expected to sustain significant growth in the non-agricultural sector well into the future.

The Real Estate Market

As the state population continues to grow, so does the need for housing. While housing and land prices in the Central Valley are low, recent trends suggest they are not immune to the laws of supply and demand. According to the California Association of Realtors, the median home price for the Central Valley was $98,659 in August 1989, half the median home price for the state. Furthermore, while statewide home prices had risen by 46 percent between 1982 and 1988, increases in the Valley were about 19 percent. However, data on the last half of 1989 suggest that the median home prices rose by 8 percent in the Central Valley, a period when prices dropped by 4 percent in the San Francisco Bay area and 2 percent in the Los Angeles area.

The greatest price changes have occurred in areas within commuting distance of major metropolitan areas, such as San Francisco and Sacramento. These price changes reflect both the pressure from increased demand and a change in the types of housing being built. Newer homes tend to be larger and more expensive in response to a changing population base with different housing preferences.

Although most of the counties outside of the commuter belt have maintained relatively stable real estate prices, these commuter regions illustrate the susceptibility of the entire region to price increases as a result of rising growth.

Transportation

According to Jovanis et al., the population in the Central Valley relies on auto-oriented transportation systems. Economic and population growth will result in a greater demand for the transportation of goods and people. This increased demand will likely result in two major transportation issues: traffic congestion and rural road deterioration.

The issue of congestion is a fairly straightforward one. The current transportation system is of relatively fixed capacity, so that congestion is merely a function of economic activities and the population. At the present time, congestion is limited to a few areas on the fringe of larger metropolitan areas such as San Francisco and Sacramento. However, future congestion problems will not be limited to the metro fringe. The transportation network of the Central Valley was constructed on the basis of a low population density. As this density increases, even in non-urban areas, the demand for road space will exceed the supply, resulting in congestion.

The cost of maintaining a rural two-lane road is approximately $4,500 per mile per year. Much like congestion, road maintenance is a function of road use. As commuters begin to use roads constructed for farm-to-market transportation, maintenance costs will increase. In addition to people, roads carry freight; it has been estimated that 98 percent of California-produced commodities are moved by truck. Economic expansion in the Valley will lead to heightened truck use of the highway system and even greater maintenance costs than those caused by passenger automobile use.

NATURAL RESOURCE COMPETITION

The Central Valley is presently blessed with sufficient water supplies and reasonably high quality land and air. It is for these reasons that the population and economy are growing (and, ironically, creating pressures on these same natural resources). Continued population growth is likely to result in serious impacts on resources in terms of both quantity and quality. Competition for use will necessitate tradeoffs between users, particularly between the urban and agricultural sectors.

Water

In an average year, the state of California receives approximately 193 million acre-feet (AF) of water, of which 121 million is lost to evapotranspiration, leaving 72 million for streams and rivers. This 72 million AF is supplemented by 6 million AF from Oregon and the Colorado River, making a total of 78 million. Of this total, 30 percent is used by agriculture, 4 percent by the urban sector, and the remaining 66 percent for instream uses. State planners have suggested that there is not much more water available for further development, at most perhaps 5.5 million AF (Tanji).

The Central Valley accounts for a large portion of California water consumption. The Valley consumes 64 percent of the state's urban and agricultural uses, most of it in agriculture. Due to expected population growth, the Department of Water Resources (DWR) predicts that by 2010 the new citizens of the Central Valley will require 450,000 AF of water.

Research suggests that urban water use is equal to agricultural water use for an equal area of land (Tanji). Some of the needed supplies for urban areas will come from the conversion of agricultural land with surface water rights. When development occurs on lands without surface water entitlements, however, additional demand will be placed on already diminished groundwater supplies.

Groundwater accounts for roughly 39 percent of the state's applied water. A great deal of this water is replenished on a yearly basis, but in recent times withdrawals have exceeded recharge, causing an average annual overdraft of 2 million AF. At this rate, it is uncertain how long groundwater supplies will last; the life-span of supplies is likely to decrease as local populations and water demands continue to increase.

Problems of scarcity will be compounded by issues of quality. Both cities and farms rely on high-quality water to succeed, but there is mounting evidence that groundwater supplies in the Central Valley are contaminated with nitrates and pesticides. The sources of nitrates vary and are not limited to agricultural use. They include: agricultural drainage, fertilizer use, septic tanks, animal waste, and industrial waste. Furthermore, 54 different pesticides have been discovered in wells throughout the state, the most common being DBCP (1,2 Dibromo-3-Chloropropane). Although the use of DBCP was banned by the state of California in 1977, recent estimates suggest that nearly 30 million AF of groundwater, most of it in the Central Valley, are contaminated with this chemical. In the face of increasing demand for a finite resource, solid steps must be taken to ensure the quality of water and its usefulness to a growing population.

Air

Air pollutants, especially photochemical oxidants, have been reducing California crop yields for at least twenty years. As the Central Valley embarks on a period of continued economic and population growth, air pollutants will further threaten the productivity of agriculture. In 1980, the Valley had one operating power plant with a capacity of 200 MW. Today, counting all actual and permitted sources of energy, the Valley has a capacity of 2500 MW, and the California Energy Commission is discussing the potential for 150 additional cogeneration facilities. Thus elevated levels of photochemical air pollution, including the agriculturally damaging ozone, appear unavoidable.

In their study on the future of air quality in the Central Valley, Winer et al. assume that future ozone concentrations would be directly proportional to NOx emissions. Furthermore, they argue that if no additional control programs are adopted, ozone levels will increase by 18 percent by the year 2010, primarily due to growth in mobile and stationary pollution sources associated with increased populations in the Central Valley.

Ozone is the primary photochemical oxidant responsible for agricultural crop yield losses. Current losses to agriculture include: 20 percent for beans, melons, and grapes, and 9–15 percent for alfalfa, cotton, lemons, oranges, and potatoes. By the year 2010, yield losses are expected to climb by an additional 12 percent. This loss corresponds with an annual loss of roughly $277 million for Central Valley producers.

On the other hand, urban populations are not the only generators of air pollution, nor is agriculture the only sector to suffer from it. Through the daily rituals of modern agricultural production farmers too reduce the quality of air—from the use of pesticides that are subject to drift, the odors associated with livestock and food processing, and the stirring up of dust. The latter is particularly important, since several areas in the Central Valley have recently failed to meet national health standards for PM-10—particle matter 10 microns or less (Brookhart). As city boundaries spread closer to farm lands, these problems are expected to grow. Increased Valley population will intensify conflicts between urban and agricultural uses, further threatening air quality.

Land

The Central Valley is a geographical region that encompasses nearly 39,000 square miles, about a quarter of total land area in the state. While the quantity of land is finite, its uses are not. Johnston estimates that roughly 60 percent of the land in the Central Valley is farmland, 4 percent is "urban-rurban," with the remaining acreage public lands or other uses. "Rurban" refers to areas that are comprised of large lot subdivisions and ranchette developments. As local populations grow, so will the pressures to convert primarily agricultural land into non-agricultural uses. Because there are no additional valleys to the east or west capable of compensating for production losses of this nature, this conversion may be devastating to the agricultural economy of the state.

Furthermore, conversion in agricultural regions often occurs on the most productive soils due to the attractiveness of local resources and the infrastructure associated with pre-existing agricultural development. Changes to urban-rurban use are usually irreversible and represent a permanent loss of agricultural land. Thus, considerable foresight is crucial to planning future development in the Valley.

In October 1995, the American Farmland Trust (AFT) published a study on the future of urban growth in California's Central Valley. Their figures suggest that roughly 15,000 acres of farmland are converted to commercial and residential use each year in the Valley. The AFT analysis distinguishes between two different scenarios for urban growth: low-density urban sprawl, with three dwelling units per acre; and compact development, with six dwelling units per acre. It also distinguishes between two distinct urbanization effects on agriculture: farmland conversion, and reduced farm productivity on the fringe of residential development.

If urban sprawl continues, predictions for the year 2040 suggest a loss of 1 million acres of farmland and reduced productivity on 2.5 million acres near the urban fringe. On the other hand, if growth follows a more compact pattern, agricultural conversion could be limited to 500,000 acres. Land near the urban fringe could be decreased to 1.6 million acres (see Table 3). Given the apparent inevitability of farmland conversion, the key issue that arises is the wise allocation of land resources among competing uses.

Table 3: Agricultural Conversion and Conflicts in the Year 2040.

	Urban Sprawl	Compact Growth	Land Saved by Compact	As Percent of Sprawl
ACRES CONVERTED				
Prime & Important	613,669	265,937	347,732	57
Other Farmland	421,808	208,433	213,375	51
Total Converted	1,035,477	474,370	561,107	54
Urban Fringe	2,537,490	1,585,870	951,620	38
TOTAL ACREAGE AFFECTED	3,572,967	2,060,240	1,512,727	42

Source: American Farmland Trust, October 1995.

POLICY TOOLS

All the indicators suggest that "no growth" is not a realistic assumption for California or for the Central Valley. What is required to confront the projected problems of urban growth is the development of public policies to focus on the reduction of conflicts between the urban and agricultural sector. The pressures of population growth make it imperative that policy makers consider long-term plans to mitigate the consequences of the competition for natural resources, and set priorities for their use.

Transportation

Transportation congestion in the Central Valley can be reduced through various policies, which might include economic incentives, changes in infrastructure, and the promotion of changes in people's behavior and beliefs.

Road taxation is one possible solution to the problem of transportation congestion. While the implementation of general taxes often leads to unclear results, specific taxes tend to provide quite clear incentives. Road pricing is being used effectively in various parts of the world, including some parts of the U.S., to encourage less road use and the use of roads during non-peak hours. The practical implementation of such policies has been facilitated by technological advances. It is now possible, for example, to combine vehicle identification badges with optical scanners, which minimize bottlenecking at toll booths and drastically reduce the large labor costs traditionally associated with such activities. This system, if billed on a monthly basis, could provide further traffic reduction, as a monthly consumer bill could create the psychological illusion of higher road use expenses and thus a greater incentive to modify use. Nevertheless, there is a history of resistance to such measures in California; to some degree Californians still have a frontier mentality that partly consists of a belief in the right to free road use. If road pricing is to be seriously attempted in the future, this attitude on the part of the public will have to be overcome.

A more obvious policy alternative is the modification of transportation infrastructure. The easiest modification would be expansion of the existing highway system. While this policy might be quite effective at reducing congestion problems, it might very well create perverse incentives toward more road use, which in turn could lead to increased air pollution.

An alternative to road expansion would be the careful development of mass transit, in the form of rail systems and/or bus systems. A recent study by Jovanis et al. concluded that a new rail system would be unlikely to have much effect on traffic congestion in the Central Valley. The report points out that Sacramento's light rail system took four years to achieve the same total ridership that was previously carried by municipal buses. Given that Sacramento is one of the most densely populated areas in the Valley, conclusions like this are especially discouraging. Numerous other studies have shown that rail systems are economically feasible only when population densities are high enough to support the necessary patronage. Radial urban development and commuting patterns are also important to the development of a successful rail system. These conditions do not exist in the Central Valley, where housing and businesses develop in scattered patterns. As long as development continues in this manner, a rail system is not a feasible solution.

A bus system may be more effective under residential and employment patterns characterized by sprawl (Jovanis et al.). Although bus systems also require a minimum patronage to remain solvent, the minimum number is significantly smaller than that of a rail system. Furthermore, a bus system is far more flexible than a rail system in meeting time- and day-specific demands. Ultimately, however, the degree of a bus system's success will hinge on the logical development of businesses and residences and their accessibility to a fixed transportation system.

Local governments may try to alter transportation habits through financial incentives or through education. These may include the encouragement of ride sharing, flexible-hour work weeks, and the development of tele-commuting to allow people to work at home during regular business hours via electronic medium. A recent pilot study conducted by Kitamura et al. concluded that tele-commuting can be successful at reducing congestion effects associated with work commutes. As computing technology continues to improve, this option may become increasingly attractive.

Water Supply

The water supply can be effectively "increased" either through creating new sources or through more efficient use of existing water supplies. One way to stretch the water supply is to create urban and agricultural water conservation programs.

Currently, urban per capita water use in the Central Valley is quite high, mostly due to high landscape water requirements associated with the warm Valley climate. Programs that encourage the adoption of low-water-use landscaping along with the traditional focus on water-efficient plumbing fixtures can significantly reduce urban water use.

In the agricultural sector, there are several ways in which government can encourage more efficient water use. Agricultural production is a function of "effective water," where effective water is the quantity of water taken up by the plant and varies by crop type. Effective water is comprised of two parts: applied irrigation water (the quantity applied), and irrigation efficiency (the fraction of the water taken up by the crop). The policy makers interested in reducing agricultural water use can focus on either crop type or irrigation efficiency.

Agricultural economists often think of crop selection as a form of technology adoption by the farmer, where the technology is a biological one. Like other technology adoption decisions, crop selection is determined by land quality, input prices, and output prices. One way policy makers may try to discourage water use is by modifying the latter two factors so that low-water-use crops become more attractive. There could be outright restrictions on crop choices, taxes on water-intensive crops, subsidies for low-water-use crops, or taxation on water use.

Alternatively, or perhaps simultaneously, policy could focus on irrigation technology. In the Central Valley there are numerous irrigation technologies currently being used, which vary tremendously in their irrigation efficiencies. As was the case with biological technology adoption, irrigation technology adoption depends on land quality, input prices, and output prices. Strategies to induce the adoption of efficient technologies include taxation, subsidies, and direct control.

A last technology worth mentioning at this point is information. Many agricultural decisions are made based on weather uncertainty. Irrigation efficiency can certainly depend on daily or weekly changes in the weather. With current prices and crop biology, farmers tend to suffer greater losses from under-watering than from over-watering. Thus with weather uncertainties, it may at times appear to be in a farmer's best interest to use what amounts to excess water. Incentives to over-water could be reduced through the adoption of information technologies that reduce weather uncertainty. Policy makers might consider information technology subsidies, or provide public dissemination of precise and area-specific weather information (Parker et al.).

Another possibility is to encourage the re-use of drainage water for crop irrigation. Drainage re-use programs have had mixed results, mostly due to salinity problems. The use of drainage water on salt-tolerant crops could be fostered through planning incentives and drainage water taxes. Research and development of new salt-tolerant crops could bolster such use. Similarly, urban water users might be encouraged to use processed sewage water (gray water) for landscaping. Incentives could be provided through taxes and research on "gray water friendly" vegetation.

Many economists and policy makers are convinced that water marketing can successfully reduce water use. They argue that the market forces of supply and demand will create water prices that are higher than current water prices; that allocate water use to the most economically beneficial uses; and that will reduce overall demand. Research by Zilberman et al. suggests that a reduction of 0.8 MAF (to satisfy the Central Valley Project Improvement Act) would result in 2.5 times less revenue loss through the implementation of a water market than through a proportional allocation scheme. Opponents argue that while markets may be economically efficient, water is a social necessity, and the exclusion of poor consumers is not an acceptable policy alternative.

Lastly, the government could invest in the creation of water storage. As mentioned earlier, the California Department of Water Resources estimates that roughly 5.5 million AF of water is available for future development in the state. The actualization of this development, however, hinges on the availability of low-cost storage. One possibility currently under development in Kern County is the creation of a groundwater storage reservoir that can hold excess river flows from wet years and store them for dry years. The fate of this Kern Water Bank will provide vital information towards the development of others.

Water Quality

All of the previous discussion about water supply is moot if the quality is sufficiently low to render it useless to either urban or agricultural users. There are generally three sources of water contamination: livestock activities, urban industry, and agriculture. The first case is a fairly obvious one. When livestock are permitted near rivers, animal waste enters the water system and contaminates the supply. Two policies that could reduce this potential threat are a tax per head of stock, which should reduce the total herd size and ultimately the amount of waste entering the water, or the creation of buffer zones around streams and rivers, where livestock must be excluded. Unfortunately, this policy requires substantial capital costs in the form of fencing and forces ranchers to provide alternative water supplies for their herd. A more reasonable approach might be to designate certain bodies of water as livestock-friendly and others that are not.

Industrial pollution has been studied extensively both by academics and by policy makers. The usual array of policy tools apply here, including taxes, subsidies, pollution quotas, tradable pollution permits, and government-mandated abatement technologies. Given the extensive treatment this area of study has received (Anderson et al.; Baumol and Oates), we will make no attempt to present it here.

Agricultural runoff and drainage often contains pesticides, salts, and trace elements that are harmful to human health if consumed and reduce the effectiveness of irrigation. Policies directed towards maintaining water quality can focus on either reduction or treatment of drainage water. Specifically, the way to reduce agricultural runoff is to apply water more precisely to crops; policies could include encouragement of improved irrigation efficiency through conservation subsidies or through drainage taxes.

Drainage and runoff treatment in the past has followed the "solution-by-dilution" method. The solution was to run drainage pipes or deep trenches to whisk away the tainted water, preferably to a larger body of water that could sufficiently dilute contaminants. However, the diluting powers of these larger bodies of water were greatly overestimated and resulted in greater damage to water quality and risks to aquatic wildlife species. Fortunately, this failure has led to new innovations in the treatment of agricultural runoff and drainage. Schemes include the re-use of drainage water on salt-tolerant crops, the use of evaporation ponds to dispose of excess waters, and biological filtering. Biological filtering includes activities such as the planting of eucalyptus trees to remove salts and trace elements from drainage water.

Current research is being conducted on technologies designed to remove specific contaminants from drainage water. Some of the most promising processes are reverse osmosis and the use of various forms of bacteria, although at the present time these methods are expensive and unreliable. Policies to facilitate this research and test the results could go a long way towards reducing the problem.

Lichtenberg et al., in an analysis of policy options for reducing existing DBCP contamination in groundwater in Fresno County, concluded that regulatory solutions had to be situation-specific. In urban areas, the most cost-effective solution for DBCP reduction was to drill new wells to produce clean water. In rural areas, individual well filtration systems were more cost-effective. The costs estimated for each scenario were $300 and $750 per person, respectively, with wells having a typical life expectancy of ten years. It is important to note that these cost figures are based on post-treatment schemes for existing contamination and could have been substantially reduced through the use of strategies to prevent the contamination in the first place.

Urban water supplies are generally drawn from groundwater sources. If agriculture continues to contaminate these groundwater supplies, it may become feasible for urban users to switch to surface water supplies. Given the current allocation of water rights in the Valley, this switch could come only at the expense of someone else's surface water entitlements. Because some users will remain dependent on contaminated groundwater supplies, urban switching to surface water would be only a short-term remedy to maintain the safety of urban drinking water supplies.

Air

Better air quality in California might be achieved through a wide variety of activities, including transportation and land-use planning, as well as the regulation of industrial emissions and agricultural land-use practices. Transportation planning has already been discussed in this chapter. Due to the obvious relationship between road use, congestion, and auto emissions, all the policies aimed at reducing auto use will also work to reduce auto air pollution.

Land-use planning, or zoning, is probably the single most powerful tool policy makers have to mediate in the conflict between urban and agricultural sectors. Zoning laws allow local governments to specify allowable and non-allowable land uses by region, and further allow them to decide regional spatial distribution of societal activities. Prudent zoning can go a long way toward avoiding conflicts before they arise, and if combined with well-defined nuisance laws, can help to expediently resolve clashes that do arise.

The primary clashes between the growing urban sector and the agricultural sector in regards to air pollution are likely to be over the use of pesticides and the odors associated with livestock activities. Zoning provides the best opportunity to head off these conflicts. A wise policy might be to zone the urban fringe as an area for low-input agriculture, which requires the use of few chemicals, and to forbid livestock activities in that zone. Such policy strategies are likely to be effective only if the local government is simultaneously keeping urban sprawl in check and providing sufficient room for chemical-intensive agriculture and livestock activities.

In addition, conflicts are likely to arise from agriculture's production of dust and other particulates, which contribute to worsening PM-10 conditions in the Central Valley and are the target of recent Environmental Protection Agency (EPA) regulations. Research is being conducted on road uses, land preparation, agricultural burning, harvest activities, and agricultural equipment (Brookhart). Remedies for road-use dust may include paving, reducing speed limits on unpaved roads, and planting more vegetation along roadsides to stabilize the dust. Land preparation, such as disking, tilling, and subsoil mixing planing, may be restricted by geographical region, season, and crop. The most visible target for PM-10 reduction will probably be agricultural burning. Reduced burning can be achieved either through direct control or through taxes and subsidies that encourage the recycling or chipping of agricultural waste. Lastly, the use of harvest practices and agricultural equipment that reduce dust emissions can also be encouraged through command and control regulation or by economic incentives.

The flip side of the air pollution problem is that pollution generated by urban activities such as auto congestion and industry seriously reduce the productivity of some agricultural crops. A zoning system that encourages the production of pollution-tolerant crops on the urban fringe and confines urban emissions, whenever feasible, to urban sectors would significantly reduce the damages incurred by agriculture. Furthermore, policies directed towards the development of pollution-tolerant crops could also help alleviate the pains being felt by agriculture.

As in the case of water, policies to combat industrial air pollution have been studied extensively. Here too the mix of remedies consists of: taxes, subsidies, pollution quotas, tradable pollution permits, and government-mandated abatement technologies. The generation of pollution is generally linked to the use of electricity; therefore, policies that foster the use of alternative sources of energy also help to reduce pollution. These may include subsidies or preferential tax treatment for alternative energy users, where the degree of preference is linked to pollution per unit of energy.

Land

As Valley population expands, the finite nature of land becomes apparent as pressure mounts to convert agricultural land to non-agricultural uses. To protect the Valley's reputation as one of the world's most productive agricultural regions, policy makers may ultimately deem it necessary to take firmer steps toward protecting agricultural land from urban conversion, through such means as urban planning combined with zoning regulations and differential land tax assessment.

Urban planners have distinct opportunities to utilize zoning policies for the protection of agricultural land. First, they can define specific land-use patterns to outline in precise detail the allowable and non-allowable uses of specific land. They can simply limit the amount of land that can be used for non-agricultural uses, or they can restrict urban zones to land that is of low agricultural productivity. Limits on urban land may not be very practical in the face of projected Valley population growth; thus decisions based on "best use" policies may be preferred. "Best use" policies also provide the planner with the ability to adjust to uncertain land use demands in the future.

Another option is to mandate minimum requirements within a specified land use zone. For example, the planner may want to require minimum housing densities for urban sectors. A study by the American Farmland Trust examined such a policy, comparing urban growth and agricultural land conversion under two different scenarios: urban sprawl and compact growth. "Urban sprawl" was intended to reflect current growth patterns in the Central Valley, based on a gross residential density of three dwelling units per acre. "Compact growth" was defined by a gross density of six dwelling units per acre. AFT conclusions indicate that continuing urban sprawl will result in an eventual loss of over one million acres of farmland to urban uses, while compact growth would result in roughly one-half million acres converted. Thus compact growth strategies could save approximately one-half million acres of farmland from urban conversion.

Differential property tax assessment is another tool to limit agricultural land conversion. Differential tax programs usually fall into one of three categories (Isé). The first type provides preferential treatment by assessing agricultural land based on agricultural income; there are no future land restrictions, and there are no penalties for land use conversions. The second type involves preferential tax treatment combined with financial penalties based on the market value of the land when it is converted. The third type is a preferential tax agreement with a restriction that the land cannot be developed for a specified period of time. If this agreement is broken, penalties are levied.

The California Land Conservation Act, also known as the Williamson Act, is an example of the third type. One of the primary goals of the act was to preserve agricultural land, with a special focus on agricultural land on the urban fringe. Depending on the county, landowners contract with the county government not to develop their land for 10 or 20 years. Only land that meets certain land quality and farm income requirements are eligible for the program, and in exchange for the contract, enrolled land is taxed at a rate based on the capitalized agricultural income of the land rather than the market rate. Penalties for contract cancellation are 12.5 percent of the current market value of the land.

Isé and Sunding recently conducted a case study of Sacramento County and concluded that the Williamson Act was not very effective at protecting productive agricultural land near the urban fringe, probably because of the relatively small economic gain from preferential tax treatment in comparison to the profits realized from converting agricultural land to urban uses. If preferential tax programs are to be successful in the future, tax preferences and conversion penalties must be substantial enough to compete with the economic gains received from land conversion.

CONCLUSIONS

As population grows in the Central Valley, so will the competition between the agricultural and urban sectors for scarce resources. The consequences of this competition can be mitigated and in some cases eliminated by planning for the future today. Plans and decisions today, however, cannot simply be a reaction to current conditions, but demand foresight to identify the critical issues that will define the agricultural-urban interface in the future.

This chapter has discussed numerous public policy options but is in no way complete. Well-defined long-term plans for regional land, air, and water uses need to be developed. Future progress will hinge on the coordination and cooperation of both the scientific community and policy makers involved in the political and regulatory process. Scientists must provide research and technology aimed at monitoring, understanding, and eliminating the negative impacts of intense resource competition between sectors. Policy makers should incorporate this information into the planning process. Together they can provide a multi-faceted approach for the systematic reduction of conflicts between agricultural and urban sectors in California's Central Valley and beyond.

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Chapter 10

INTERNATIONAL TRADE AND PACIFIC RIM ISSUES

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The purpose of this chapter is to discuss the broad dimensions of California's agricultural trade and California's role in the changing world food economy. We identify trends in California's commodity and processed food trade[1] and discuss current trade issues, focusing on major trading partners in the Pacific Rim.

While domestic and international policy and market developments in the 1990s have created new opportunities for California agriculture, they have at the same time presented new challenges. For instance, the completion of the Uruguay Round (UR) of the General Agreement on Tariffs and Trade (GATT) in 1995 partially opened the Japanese and Korean rice markets, which are ideally suited for California Japonica rice. However, at the same time, U.S. domestic environmental pressures and reductions in U.S. government rice subsidies under the UR could lead to a reduction in California rice acreage and an inability to supply these growing foreign markets.[2] Thus the effects of freer trade on California agriculture could be mixed.

In addition to the UR multilateral free trade agreement, the 1989 Canadian/U.S. Free Trade Agreement (CUSTA) and the subsequent regional North American Free Trade Agreement (NAFTA) implemented in January 1994 have had a significant impact on California agriculture.

Under NAFTA, Mexico, the United States, and Canada agreed to eliminate tariffs on most agricultural products imported from within the region over a ten-year period, with remaining tariffs and non-tariff barriers phased out over 15 years. From California's perspective, perhaps one of the most important results of NAFTA was the

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[1] Any data analysis in this chapter is constrained by the fact that state level trade data are limited. For example, there are no reliable data on California's agricultural imports. Almost all trade data is collected at the national level rather than the state level. In addition to this obstacle, the California Department of Food and Agriculture (CDFA) changed the method of calculating export values in 1992, and this makes any long-term analysis of export trends problematic. Furthermore, export statistics published by the CDFA are not very reliable because it is difficult to measure exports originating in the state. Even for those U.S. commodities produced mainly in California (e.g., almonds and walnuts), the CDFA data are not trustworthy.

[2] The net impact of Japan and Korea's rice imports as a result of the Uruguay Round are yet to be determined. So far, Japan's net imports are not as large as expected because Japan's Ministry of Agriculture, Forestry and Fisheries (MAFF) started exporting rice as food aid for developing countries in order to reduce burdensome rice stocks. Meanwhile, Korea has tendered for the world's cheapest imported rice to fulfill its UR quota, and this process has effectively excluded U.S. supplies of high-quality medium grain rice.

liberalization of foreign investment laws in Canada and Mexico.[3] For the UR it was probably the tariffication of quotas and non-tariff barriers in East Asian markets.

California is well positioned to take advantage of ongoing changes in the global food trading environment. Given its abundant resources and dependable climate, the state is a very reliable exporter of agricultural products. The future of California agriculture will be shaped by market access in key Asian markets and further progress on the integration of global food markets. It is already the case that rapid income growth in Asian economies and freer trade on the North American continent have both stimulated demand for California's agricultural exports. In particular, the strong economies in southeast Asia have led to increased purchasing power, and agricultural imports into this region have grown dramatically in the 1990s.

OVERVIEW OF CALIFORNIA'S TRADE IN AGRICULTURAL PRODUCTS

International trade exerts an important influence over the make-up of California agriculture, because one-quarter[4] of the agricultural commodities produced in California are exported abroad. Trends in export markets determine the profitability of most of California agriculture; to some extent trade is the "tail that wags the dog." For instance, six of California's top ten commodities, in terms of value of production, also rank in the state's top ten exports. These commodities are dairy, grapes, beef, cotton, lettuce, and almonds.

For the purposes of this chapter it is important to recognize that California is not only the leading state in U.S. agricultural production, but it is also the United States' largest exporter of agricultural products. California's agricultural exports represent about 20 percent of total U.S. agricultural exports. The other leading states measured in terms of export value are Iowa, Texas, Illinois, Nebraska, and Kansas. Interestingly, the state of California exports more agricultural products than most countries do, including such countries as Australia and Canada. The make-up of California's exports reflect the highly diversified nature of the state's agriculture, and they include bulk commodities as well as consumer-ready foods.

The relative importance of California's top five export products (beef, cotton, grapes, almonds, and fish) is displayed in Figure 1. According to the California Department of Food and Agriculture (CDFA) statistics, beef exports comprise 8 percent of the state's agricultural exports,[5] followed by cotton (7 percent), grapes (6 percent),

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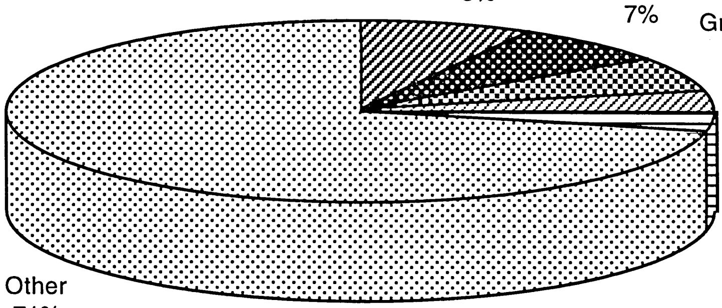
[3] According to the U.S. Department of Agriculture, U.S. investment in Canada's food industry increased from $2 billion in 1989 to $3.6 billion in 1993. Canadian investment in the U.S. food industry increased much faster, from $900 million in 1989 to $5.6 billion in 1994. U.S. investment in Mexico's food industry increased from $618 million in 1989 to $2.3 billion in 1993. However, Mexico's investment in the U.S. food industry is very small, at around $79 million in 1994. See Bolling, Handy, and Neff for further details.

[4] This figure (of one-quarter) is based on the farm gate value of commodities exported relative to the farm gate value of all commodities produced. From 1992, the California Department of Food and Agriculture (CDFA) reports a different export statistic from this. The new way of reporting exports includes value added between the farm gate and the port. Including the value added roughly doubles the value of exports and according to this new method of recording exports, California agricultural exports totaled $11.72 billion in 1995.

[5] The value of agricultural exports reported by CDFA shows beef as ranking number one. This is somewhat misleading. Beef would not be the top export if the state's trade were measured on a net (exports minus imports) basis instead. The state of California is far from being self-sufficient in beef as it may depend on imports to supply

almonds (4 percent), and fish (4 percent). Agricultural exports from California in 1995 totaled about $11.7 billion,[6] which was around 12 percent of the state's total exports in that year.

Figure 1. California Agricultural Exports By Commodity, 1995.



Source: *California Agricultural Resource Directory*, CDFA, 1995.

It is evident from Figure 1 that the top five products taken together account for less than one-third of California's agricultural exports. This lack of product concentration underscores the fact that California agriculture is different from that of the other large agricultural states in the United States. The top U.S. agricultural states, ranked by farm cash receipts, are California, Texas, Iowa, Nebraska, and Illinois. The agricultural sector in Iowa and Illinois is concentrated on just three commodities—corn, soybeans, and hogs, accounting for 70–80 percent of the state's farm cash receipts. Nebraska's production of corn and cattle generates over 70 percent of that state's farm receipts. Of course Texas depends on the cattle sector, which produces 50 percent of its farm cash receipts. In contrast, California's top five farm products (dairy, grapes, nursery, beef, and cotton) account for less than 40 percent of total statewide farm cash receipts.

California's leading agricultural exports comprise varying shares of total U.S. production, and many do not dominate U.S. production. For example, California produces about 4 percent of the nation's beef, 15 percent of the cotton, 20 percent of the rice, and 25 percent of the orange crop (*California Statistical Abstract*, 1996). However, some of California's top export commodities are specialty crops, and

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about fifty percent of consumption. The CDFA data record exports as originating from California if the official exporter on the bill of lading has a California address. For a considerable amount of beef, the exports are likely trans-shipped through California ports from other states.

[6] See footnote 4.

California's production does dominate most of the U.S. production in these crops (e.g., almonds, grapes, walnuts, and wine).

California tends to specialize in high-valued commodities that are generally sold to high-income countries. The top six destinations are Japan, Canada, European Union (EU), South Korea, Hong Kong,[7] and Mexico (see Figure 2). With the exception of Mexico and South Korea, these are high-income countries. South Korea ($8,260 per capita income) and Mexico ($4,180 per capita income) are rated as upper middle-income countries (World Bank, 1996).

Table 1 reports the value of exports for the state's historically important export commodities, along with the total agricultural exports. Annualized growth rates are reported for two different time periods (1985–1991 and 1992–1995). The periodization was dictated by the 1992 change in the way the state's export statistics are reported. From 1985 to 1991, total exports grew rapidly at an average rate of 8.3 percent per year. With the exception of oranges, trade in all products grew over this period. Trade in table grapes (17.8 percent) and dairy (12.2 percent) expanded most abruptly. Of the commodities listed in Table 1, the largest export growth in the 1992–95 time period was also experienced by dairy (16.8 percent), almonds (9.6 percent), and table grapes (9 percent).

In 1995, beef exports from California were primarily destined for Japan (44 percent), Canada (19 percent), and Korea (16 percent). CDFA statistics indicate that these exports were mostly in the form of chilled or frozen boxed beef. Japan is also the major market for California cotton, followed by Indonesia, China, and Korea. The European Union (EU), Japan, and Canada imported 80 percent of California's almond exports in 1995, with the EU buying 60 percent alone. Canada is the largest international market for California table grapes (43 percent), followed by Hong Kong (18 percent) and the Philippines (5 percent). Most of the wine and raisin exports are sold into either the EU, Canada, or Japan. The largest markets for California dairy exports are Algeria (30 percent), Japan (21 percent), Mexico (14 percent), and Hong Kong (7 percent). The make-up of dairy products exported include powdered milk, concentrated milk and cream, whey, and cheese.

[7] If accurate statistics on re-exports from Hong Kong to mainland China were available, then China might well replace Hong Kong as one of the top six markets, from California's perspective. Unofficial trade sources indicate that anywhere from 10 to 60 percent of the agricultural exports to Hong Kong are re-exported to China, some of these illegally.

Table 1. California's Main Agricultural Exports.

	Beef	Cotton	Almonds	Grapes	Oranges	Dairy	Total
				million dollars			
1995 export value	$993	$799	$780	$674	$335	$236	$11,720
				percent			
1985-91 annual growth rate	7.8	2.4	6.2	17.8	−4.1	12.2	8.3
1992-95 annual growth rate	0.4	7.3	9.6	9.0	−0.9	16.8	1.3

Source: *California Agricultural Resource Directory*, CDFA, 1995. Data for Almonds was obtained from the USDA's FATUS.

California is also a significant importer of food and agricultural products although data on state level imports are not readily available. For instance, California's livestock industry (including poultry) is highly dependent on feed grain imports, some of which originate in Canada. The state's total feed grain imports are estimated to be approximately 5 million metric tons per annum (see Carter, 1993), most of which comes from the Midwest, but nonetheless a large enough tonnage that would make California a significant grain importer if the state were a separate country.

California's dependence on global markets means that foreign market shocks are quickly reflected in commodity prices received by the state's farmers. In addition, the regional concentration of production of some of California's key crops (e.g., almonds) means that commodity prices in California can be highly variable over time. Some information bearing on this point is provided in Table 2. Along with representative California commodities, the variability of wheat, cotton, and beef prices are shown to serve as a reference point for commodities produced over a wider geographic area in the U.S. The coefficients of variation (i.e., ratio of standard deviation to the mean) across the commodities in Table 2 indicate higher variability in the prices of almonds, oranges, lemons, grapes, and lettuce, compared to the price of wheat, cotton, and beef. According to the summary statistics in Table 2, there seems to be some support for the claim that commodity prices faced by California producers are more variable compared to other parts of U.S. agriculture.

Table 2. **Estimated Commodity Price Variability, 1972-95.**

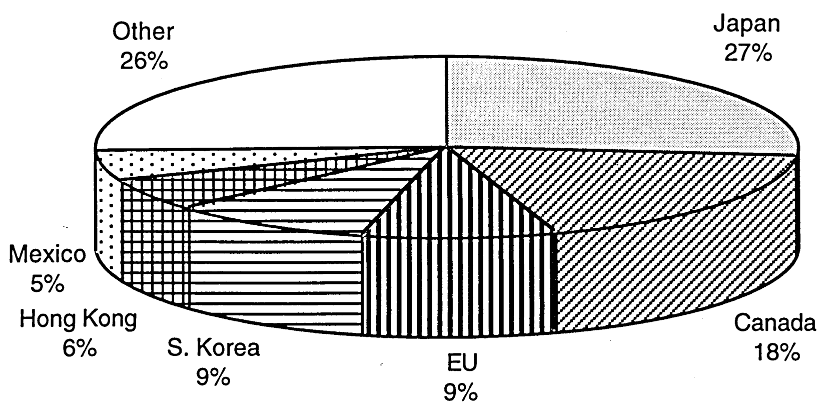
	Beef	Cotton	Almonds	Grapes	Oranges	Rice	Wheat	Lettuce	Lemons
coefficient of variation	0.29	0.17	0.53	0.35	0.38	0.22	0.19	0.35	0.36

Source: Price data obtained from the *California Statistical Abstract*, Department of Finance, Sacramento. Calculations are based on annual average prices from 1972 to 1995.

MAJOR EXPORT MARKETS

Figure 2 lists the top six export markets. The leading export commodities for each market for 1995 are reported in Table 3. In order of importance, the top six markets are Japan, Canada, European Union (EU), South Korea, Hong Kong, and Mexico. In order to highlight some of the trade issues that California faces in the Pacific region, market developments in Japan, Canada, Hong Kong, China, and Mexico are briefly discussed below.

Figure 2. Distribution of California's Agricultural Exports By Destination, 1995.



Source: *California Agricultural Resource Directory*, CDFA, 1995.

Table 3. Major Export Markets and Commodities, 1995.

Japan	Canada	EU	S. Korea	Hong Kong	Mexico
		million dollars			
Beef $436	Beef $188	Almonds $289	Beef $162	Oranges $76	Beef $80
Cotton $188	Lettuce $131	Wine $110	Oils $120	Oils $47	Poultry $35
Fish $140	Grape $105	Raisins $95	Cotton $100	Grapes $44	Pork $38
Pork $129	Fish $100	Walnuts $76	Hides $98	Pistachios $31	Dairy $32
Oranges $98	Oranges $99	Prunes $73	Fish $36	Apples $29	Fats/Oils $28

Source: California Department of Food and Agriculture.

Japan

Despite the fact that Japan has one of the most highly protected markets in the world, it is also the largest net importer of agricultural products. The United States accounts for roughly one-third of Japan's agricultural imports. In 1995, Japan's agricultural, fish, and seafood imports from the U.S. reached $16.2 billion. About 20 percent of these exports to Japan originated in California. Japan is California's largest export market for agricultural products, with beef, cotton, fish, pork, and oranges ranking as the top commodities (see Table 3).

Unlike the bulk commodities such as grains and oilseeds, which are experiencing stagnant demand growth in Japan, demand is growing for California's exports into this market. In the 1990s the most significant import growth in Japan has been in the area of fruits and vegetables and beef.[8] However, Japan continues to restrict imports of horticultural products, livestock products, and processed foods, all of which are important exports from California.

Until recently, Japan's system of food imports used mainly non-tariff barriers such as quotas and licenses, instead of tariffs. Sazanami et al. found that Japan's tariffs on food imports averaged only 8 percent, but the (tariff equivalent) quantitative import barriers averaged 272 percent, with the rice tariff equivalent barrier at an astonishing 737 percent. Today, with tariffication, most of Japan's agricultural imports remain highly protected (e.g., beef tariffs of 46 percent). In addition, Japan continues to use

[8] USDA/FAS AGR No. JA6047 *Agricultural Situation Annual Report*, Washington, D.C., October 1996.

health and safety regulations to serve as barriers to trade. However, there are exceptions that are important to California. For example, raw cotton imports enter Japan duty free.

In the case of fresh oranges and lemons, the U.S. (primarily California and Arizona) is the largest supplier to Japan, accounting for over 90 percent of Japan's imports. Other exporters of oranges and lemons of lessor importance in Japan are Australia and South Africa. The Japanese Government continues to impose a high import tariff on fresh oranges. The tariff rate is 37.3 percent for imports during the December–May period (the marketing season for domestically-produced citrus) and 18.7 percent during June–November. These tariffs will eventually drop to 32 and 16 percent in accordance with the GATT Uruguay Round Agreement (USDA/FAS *Japanese Attaché Report, Citrus Annual Report*, 1996).

Rice policy is the focus of Japanese agricultural policy. The stated goals of Japan's food policy are to enhance food security and raise farm incomes. Following the recent Uruguay Round GATT trade agreement, Japan's rice market since 1995 has been partially opened to imports. Japan agreed to import 4–8 percent of domestic rice consumption over the next six years. In addition, important products for which tariffs will be lowered include beef, oranges, grapefruit, corn grits, sugar confectionery, certain dairy products, canned frozen peaches and sweet corn, wine, and vegetable oils. A U.S./Japan beef market access agreement was signed in 1988, whereby beef import quotas were initially increased and then replaced by tariffs in 1991. In 1992, import quotas on oranges and orange juice were also converted to tariffs.

To adjust to market opening, Japanese policy makers are calling for changes in agricultural policy, especially with regard to rice. A new Food Law was passed in December 1994. Under the new law some market-oriented principles will be introduced into the rice market, and the role of the government will be slightly reduced. However, rice and wheat imports will continue to be strictly controlled.

The key issue is how long the Japanese government is willing and able to support the current high level of domestic agricultural subsidies. In October 1994, the Japanese government agreed to spend $61 billion in an agricultural "package" to assist farmers in adjusting to the Uruguay Round GATT agreement. This suggests that Japanese farmers remain politically powerful and that the market will not open up in the foreseeable future.

Canada

The formation of the Canada/U.S. Free Trade Agreement (CUSTA) in 1989, and then NAFTA in 1994, has led to expanded agricultural trade between Canada and the United States. Since 1989, U.S. agricultural exports to Canada have expanded by 60 percent while imports of agricultural products from Canada have risen by 90 percent. In 1995, U.S. agricultural exports to Canada totaled $5.74 billion, up from $3.6 billion in 1989. U.S. imports from Canada were valued at $5.56 billion in 1995, compared to $2.9 billion in 1989 ("NAFTA: Year Three," USDA/ERS, 1996). Fruits and vegetables account for more than one-third of Canada's agricultural imports from the U.S., and thus California plays an important role in this north-south trade.

Trade disputes have become a byproduct of lower trade barriers on the North American continent. A recent and contentious disagreement was over increased

Canadian exports of wheat to the United States, some of which made its way into California. The Canadians attributed the increased flow of wheat to the effects of U.S. export subsidies under the Export Enhancement Program (EEP). However, in the United States this expanded trade has been seen in a different light. It has been interpreted as the consequence of "unfair" trade practices pursued by Canada, such as transportation subsidies on grain export shipments[9] and the secretive pricing policies of Canada's state trader, the Canadian Wheat Board (CWB). The United States government has taken steps to have the export activities of state trading enterprises, such as the CWB, addressed by the World Trade Organization (WTO). In addition, the Canadian-U.S. binational Joint Commission on Grains recommended that Canada should place the CWB at risk of profit or loss in the marketplace to remove its discretionary pricing practices.

Canada's implementation of its UR commitment to convert import quotas/licenses to tariffs has resulted in some extremely high agricultural tariffs. This is viewed in the U.S. as being in conflict with Canada's NAFTA commitment to lower tariffs. The matter remains an important issue between the United States and Canada. The U.S. government argues that the NAFTA agreement to eliminate existing tariffs and prohibit any new tariffs should apply to the high Canadian tariffs for dairy and poultry resulting from the UR tariffication. Canada argues that it does not have to reduce its new tariffs by more than the 15 percent agreed to in the Uruguay Round.

In 1995, the United States filed a complaint with a NAFTA trade panel complaining about Canada's high import tariffs on supply-managed dairy, poultry, and egg products. The U.S. argued that these tariffs conflict with Canada's NAFTA commitments. Under the UR Round, Canada has replaced import quotas on supply-managed commodities with tariff rate quotas (TRQs). Under the TRQs, small amounts of imports can enter at low rates of duty, but imports above those limits are subject to prohibitively high duties ranging from 100 to 350 percent. In 1996, Canada's over-quota tariffs were 343 percent for butter, 275 percent for cheese, and 270 percent for milk and cream. A panel under NAFTA Chapter 20 (dispute settlement procedures) held hearings in 1996 on the matter, and all five panelists supported Canada's view that it could apply high tariff rates under the WTO tariff rate schedule. The panel ruled that Canada's new tariffs do conform with its NAFTA obligations.

From the U.S. perspective, Canada continues to use non-tariff barriers, such as licenses, which restrict trade in bulk produce (e.g., potatoes). Fresh fruits and vegetables are also affected by these hidden barriers. For instance, Canadian regulations on fresh fruit and vegetable imports prohibit consignment sales of fresh fruit and vegetables without a prearranged buyer.

Hong Kong

Hong Kong is physically small, very densely populated, and relatively affluent. Hong Kong's population is 6.3 million, compared with China's 1.2 billion (one-half of one percent). However, Hong Kong's GDP is equivalent to 21 percent of China's, and Hong Kong's per capita income is higher than that of most Western countries, at nearly

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9 The Canadian transportation subsidy on grain was eliminated in August 1995. In all likelihood, removal of the transport subsidy will lead to additional exports of Canadian grain to the United States because the subsidy encouraged east-west shipments in Canada.

$24,000 annually. Hong Kong is highly dependent on the rest of the world for food, and the California farmer plays an important role in supplying this high-valued market. For instance, fruit and vegetable exports are air freighted across the Pacific in order to reach Hong Kong consumers within days of harvest.

The largest supplier of agricultural products to Hong Kong is the People's Republic of China with 35 percent of the market, down from about 40 percent ten years ago. The United States is second, with about 16 percent of the market, up from about 13 percent ten years ago. The PRC and California compete head-on in this market exporting similar products such as fruits, vegetables, nuts and rice.

Hong Kong is an increasingly important and rapidly growing market for California's agricultural commodities. The free market economy of Hong Kong is considered to be the most open agricultural market in the world. There are no import tariffs on food, and non-tariff barriers, such as phytosanitary or plant quarantine regulations, are almost nonexistent.

Even though Hong Kong is an important market for California, it must be recognized that Hong Kong re-exports a considerable amount of fruits and vegetables brought in from California, primarily to mainland China. It has been estimated that from 50 to 60 percent of Hong Kong's fruit imports are re-exported (USDA/FAS AGR No. HK6113, 1996), with table grapes, oranges, and apples the main products involved. Most of Hong Kong's re-exports of agricultural products to China are undocumented. This traffic occurs because of China's high tariff and restrictive phytosanitary requirements on imports.

In 1995, total U.S. agricultural exports to Hong Kong were $1.23 billion, with California supplying about 60 percent of these sales. Hong Kong currently ranks as the seventh largest export market for U.S. agricultural products and the fifth largest for California. U.S. exports to Hong Kong registered an impressive 75 percent increase over the five-year period 1989 to 1994.

Of the California agricultural exports to Hong Kong, oranges, essential oils, grapes, pistachios, apples, and dairy products are the leading items. California is the number one supplier of fresh fruit to Hong Kong, and the territory is among the top six California export markets for oranges, grapes, wine, tomatoes, dairy, raisins, and lettuce.

On July 1, 1997, China regained sovereignty over Hong Kong. Under the terms of the Sino-British agreement, Hong Kong will become a Special Administrative Region (SAR) of China. The agreement to shift the colony back to China will have important implications for the world trading environment, including agricultural trade. Under the agreement, Hong Kong is supposed to retain its status as a free port, and Hong Kong's free trade structure will remain in effect.

With further economic integration between Hong Kong and the PRC, farmers in China will be given incentives to improve the quality of their fruits and vegetables in order to compete more effectively with California. The PRC does have the potential to export high-quality food to Hong Kong; agronomically, this does not pose a problem. Hurdles in the PRC are lack of proper incentives and inadequate infrastructure. After 1997 it may actually be Hong Kong entrepreneurs who produce higher quality food products in China for sale in Hong Kong. This development could well affect California's competitiveness in the Hong Kong market.

China

The People's Republic of China officially bans the importation of most fruits for consumption in China. However, fruit imports are permitted if the products are subsequently re-exported in a higher-valued form after further processing. Japan has the same rules in place for some of its imported products that are tightly controlled.

These types of import permits are open to abuse. For instance, processors with access to import permits can switch imports with locally produced goods and use the local produce for food processing, while selling the imports for direct consumption. However, this may not be necessary in China, where smuggling is thought to be uncontrolled.

China was an original member of GATT after World War II, but withdrew in 1949 (Theiler and Tuan; West). It has been trying to rejoin ever since 1986, as part of the government's decision to open up the economy to foreign trade. At present, there are many potential barriers to increased agricultural trade with China, including sanitary and phytosanitary restrictions on fruit imports. Joining the WTO will restrict China's ability to use such non-tariff barriers. Despite the dire (and implausible) predictions of Lester Brown (1995) that China will starve the world, it must be recognized that China has the potential to become a serious export competitor with the U.S. in third markets for rice and horticultural products. As China's agricultural sector moves away from its historical focus on grains and concentrates more on labor-intensive cash crops, markets in other parts of Asia will be subject to increased competition from China. After joining the WTO, export opportunities will greatly improve for China for such products as rice, fruits, and vegetables (Theiler and Tuan). It is also the case that entry into the WTO will mean that China's consumers will have more open access to world food markets, and this could lead to increased imports.

Since the 1979 reforms, China has been both a significant exporter and importer of rice. Under freer trade, it is plausible that both exports and imports may increase. For example, China might export Japonica rice to Japan (competing with California) and, at the same time, import Indica varieties from Thailand and Vietnam. As consumers' preferences have changed with higher incomes, Japonica varieties have replaced high-yielding hybrid Indica varieties, putting further pressure on overall grain production in China.

Southern China is suitable for growing Indica varieties of rice, and consumers in this region are used to consuming Indica. The current grain deficit position and the likely further decline in grain production in this fast-developing southern region may lead to a larger demand for imported Indica varieties of rice from abroad. On the other hand, as Japan has partly opened its rice market, the Northern provinces of China may be in a position to export Japonica varieties of rice to Japan.

Mexico

NAFTA was designed to integrate economic activity among three nations: Canada, the United States, and Mexico. It was a free trade agreement rather than a customs union or common market. Measured in terms of GDP, the North American economy is about the same size as all of Western Europe. NAFTA was a logical extension of the Canadian-U.S. free trade agreement (CUSTA). The objectives of NAFTA are set out in Article 102:

(a) eliminate barriers to trade in, and facilitate the cross border movement of, goods and services between the territories of the Parties;
(b) promote conditions of fair competition in the free trade area;
(c) substantially increase investment opportunities in three countries;
(d) provide adequate and effective protection and enforcement of intellectual property rights in each country;
(e) create effective procedures for the implementation and application of the agreement, for its joint administration, and for the resolution of disputes; and
(f) establish a framework for further trilateral, regional, and multilateral cooperation to expand and enhance the agreements benefits.

The agricultural provisions of NAFTA address import barriers, domestic support, export subsidies, and grading and marketing standards that affect trade.

Mexican agricultural trade is highly dependent on its two partners in NAFTA. Under NAFTA, agricultural tariff and non-tariff barriers are to be phased out over varying time periods up to 15 years. Mexico agreed to convert import licenses into either tariffs or tariff rate quotas. Beginning with the devaluation of the peso in December of 1994 and early 1995, the Mexican economy experienced a two-year financial and economic crisis that halted the expansion of trade and economic growth that was expected to result from the implementation of NAFTA in January 1994. The peso went from 3.4 per dollar in 1994 to 7.9 per dollar in 1996. Inflation in Mexico went from single digits in the early 1990s to over 50 percent in 1995 and 30 percent in 1996. This crisis had a large impact on Mexico's trade in agricultural products. Imports dropped dramatically due to the declining real incomes in Mexico associated with the high inflation. At the same time, Mexican exports of agricultural products benefited from the peso devaluation. Mexico's key agricultural exports are tomatoes, orange juice, coffee, fruits, cattle, beer, and grapes.

NAFTA has brought considerable trade tensions between the U.S. and Mexico. However, despite continued protectionism on both sides of the border, there has been progress made towards freer trade. For instance, in 1996 the U.S. opened its market to Mexican avocados for the first time in 82 years. Prior to this ruling, phytosanitary rules banned unprocessed Mexican avocado imports and provided considerable protection to California growers. The U.S. decision to import avocados will extend beyond that single market and will probably help in alleviating U.S./Mexican trade tensions in peaches, nectarines, and cherries.

Agricultural provisions were indeed an important component of the NAFTA agreement (Orden). Within U.S. agriculture some groups supported the agreement while others opposed it. The main opposition came from producers of wheat, sugar, peanuts, citrus, and winter fruits and vegetables (Orden).

A large percentage of California's agricultural production is labor-intensive because it uses a relatively high proportion of labor relative to other inputs such as land and capital. This includes the production of fruits and vegetables, nuts and various horticultural crops, where labor costs range from 20 to 50 percent of total production costs (Martin and Perloff). Prior to NAFTA these crops were protected by import tariffs (ranging from 5 to 30 percent) and other non-tariff barriers such as marketing orders. Much of this labor is unskilled and most of the workers are immigrants from Mexico.

Some agricultural interests in California were opposed to NAFTA because of the fear of competition from low-wage Mexican agriculture in the production of labor intensive crops. Others argued that NAFTA would drive down agricultural wage rates in California and this would enhance the competitiveness of California's agriculture. Factor price equalization was at the root of this debate over the effects of liberalized trade on the competitiveness of California agriculture. However, the linkage between wages and agricultural trade flows was over emphasized in this debate.

THE ENVIRONMENT AND CALIFORNIA'S AGRICULTURAL TRADE

The environmental effects of trade policies did not receive much attention until the early 1990s. Attention to this matter heightened during the UR and NAFTA negotiations, and environmental protection was a significant component of both the NAFTA and GATT agreement. This matter is particularly important for California agriculture, where the nexus between agriculture and the environment is very acute, given the high population density of the state and the environmental externalities (i.e., pollution of the soil, air, and water) generated by agriculture. Under NAFTA, some groups argued that Mexico had lax environmental standards compared to the United States and that freer trade would lead to a higher level of continental pollution.

Many environmentalists are skeptical of trade liberalization because they feel that economic growth leads to more pollution, and this is to be avoided at any cost. Others argue that freer trade leads to higher incomes, which in turn mean less pollution, because rich people are more willing to pay for clean air and water. There is still tremendous uncertainty surrounding this issue. The empirical evidence has not convincingly shown that economic growth has led to environmental degradation in the developing world.

Depending on the value consumers place on pollution, environmental benefits and economic benefits may appear to be in conflict. Krissoff et al. have studied the linkages between trade and the environment and have come up with some interesting conclusions. First, they find that any effects of domestic environmental regulations on agricultural production, trade, and competitiveness tend to be small. Second, they do not find that agricultural production tends to shift from those countries with tight environmental regulations to countries with loose regulations. Krissoff et al. report that some environmental policies may in fact stimulate technological change and enhance competitiveness.

TRADE IN PROCESSED FOOD PRODUCTS

Global trade data show that annual trade in processed foods is larger than trade in raw agricultural commodities. Bredahl, Abbott and Reed (1995) observed that the

United States has traditionally exported its agricultural products in bulk form rather than in processed form, which has more value added. Other competing agricultural countries, and especially the European Union, export relatively more processed food. Bredahl, Abbott and Reed also observed that United States food processors have invested in foreign countries rather than in the United States and consequently have exported less from the United States. However, California does not fit this mold, because it has a large food processing industry that is successfully exporting.

Over the past few decades, the food processing industry has increasingly contributed to the globalization of industrial economies. Moreover, foreign affiliate sales appear to be significantly more important than processed food exports. For this reason, *foreign direct investment* (FDI) has become a topic of major interest. Trade agreements such as NAFTA have encouraged foreign investment through liberalization of investment laws.

State level data on trade in processed food and FDI are not available. However, the United States is the home of several food processing firms that invest abroad. Six of the ten largest and 21 of the 50 largest food processing firms in the world are located in the United States (Henderson et al.).

U.S. trade of processed foods is particularly important within NAFTA, given the proximity of Canada and Mexico to the United States. Canada is the second largest market for U.S. processed foods, after Japan. The top industries supplying the U.S. processed food exports to Canada include meat packing, canned fruits and vegetables, and prepared fresh or frozen fish. These three industries supply about 35 percent of total U.S. processed food exports to Canada. The leading food-exporting industries to Mexico are meat packing, poultry slaughtering, and animal and marine fats and oils (Bolling, Handy, and Neff, 1996).

On the import side, U.S. processed food imports from Canada are led by meat packing and prepared fish and seafood. The leading import industries from Mexico include prepared fish and seafood and beer (SIC 2082).

Canada's import tariffs in the food manufacturing sector average 7.3 percent. The notable exceptions are milk and cream, wheat gluten, pork and beef, poultry, ready to eat stews, sugar, molasses, and mayonnaise (Canada: Trade Policy Review, GATT, 1995). The highest tariffs are in the dairy sector. Because of the tariff rate quota enacted in NAFTA, effective tariffs on dairy and poultry products range from 180 to 400 percent. The tariffs are 326 percent for ice cream and 280 percent for yogurt. Wines also carry heavy tariffs and taxes.

In his survey of FDI determinants in food and tobacco manufacturing industries, Connor (1983) categorized the factors affecting the FDI decision into three groups, namely, firm-specific, industry-specific and location-specific determinants. He noted that expenditures on advertising, research, and development are the most significant explanatory variables causing FDI. Handy and MacDonald (1989) also found that research and development investment has a positive impact on FDI.

Another interesting observation was made by Pagoulatos (1983). He pointed out that the primary concern of most of the foreign investors in the United States is access to the U.S. market rather than foreign trade. Pagoulatos argued that foreign investors prefer to enter the U.S. market via mergers and acquisitions of existing firms rather than establishing new firms, in order to gain quick access to technological and marketing skills.

In summary, the theory of intra-industry trade predicts that:

- intra-industry trade will be more important for highly processed (differentiated) agricultural commodities than for raw (homogeneous) agricultural products;
- intra-industry trade will be more important among developed countries and less important for developing countries;
- intra-industry trade will be more important among countries located near one another; and
- intra-industry trade will be more important among countries that are members of a trading bloc or customs union (Carter and Yilmaz, 1996).

EXPORT SUBSIDIES AND PROMOTION PROGRAMS

The U.S. federal government has been involved in an ongoing effort to boost agricultural exports through explicit export subsidies and non-price trade promotion subsidies. The federal export promotion program most important for California agriculture is now called the Market Access Program (MAP).[10] Under MAP and its predecessors, the federal government has spent anywhere from $150 to $225 million a year promoting U.S. products abroad. The MAP covers a wide range of commodities, and the contributions flow to commodity organizations, cooperatives, and private firms under a matching fund arrangement. In a typical year, California has received about 40 percent of the MAP/MPP/TEAP expenditures. Table 4 lists the main commodities in California that were funded under MAP in 1996.

Halliburton and Henneberry studied the effectiveness of the MPP promotion of almonds in the Pacific Rim. Their results were quite mixed and did not provide strong evidence that the promotion program was effective. This is not a big surprise, because there is little or no economic justification for these kinds of export promotion programs. This is not to say that the benefit/cost ratio of export promotion may not justify expenditure on advertising, technical training, store promotions, etc. However, if the benefit/cost ratio is favorable, then its seems logical that private firms and cooperatives benefiting from such promotion should be willing to invest their own money on such ventures. The MMP is a classic example of a wasteful government program captured by organized rent-seeking firms and organizations, at the expense of taxpayers.

[10] The MAP was formerly called the Market Promotion Program (MPP), and before that the Targeted Export Assistance Program (TEAP). The TEAP was established in 1985 and operated from 1986 to 1990. The MPP program was funded from 1991 to 1995.

Table 4. USDA Market Access Program Allocations Relevant to California, 1996.

Trade Organization	Allocation
	--dollars--
Blue Diamond Growers (cooperative)	1,410,000
California Agricultural Export Council	275,000
California Cling Peach Advisory Board	630,000
California Kiwifruit Commission	155,000
California Pistachio Commission	335,000
California Prune Board	2,020,000
California Strawberry Commission	455,000
California Table Grape Commission	1,970,000
California Tomato Board	410,000
California Tree Fruit Agreement	450,000
California Walnut Commission	2,230,000
Cotton Council International*	8,207,000
Raisin Administrative Committee	1,405,000
Sunkist Growers, Inc. (cooperative)	2,020,000
U.S. Dairy Export Council*	1,680,000
U.S.A. Rice Federation*	3,080,000
Wine Institute	2,980,000

*Funds allocated for cotton, dairy and rice are for the entire U.S. production, not just California.
Note: These allocations represent about one-third of total MAP 1996 allocations.

Source: USDA/FAS, Fact Sheet, June 1996.

The program has been particularly controversial because it allocated considerable funds for the export promotion of brand-name products such as Sunsweet prunes, Sun-Maid raisins, Blue Diamond almonds, Gallo wines, and Dole fruits. From 1986 to 1993, about 40 percent of program expenditures (totaling $1.25 billion) funded brand-name promotions (Mendelowitz, 1993). The U.S. General Accounting Office (GAO) studied the MPP and was critical of the program's impact and overall value to the U.S. taxpayer (see Mendelowitz, 1993).

The GAO found the export promotion program:

- may have simply replaced promotional funds that would have been spent anyway by firms or industry associations;
- lacked meaningful criteria for eligibility and participation of commercial firms; and
- was never exposed to a credible evaluation as to its effectiveness.

SUMMARY

In the foreseeable future, growth in trade of agricultural products is expected to be most vigorous in the Pacific Rim. As a major food exporter, California is well situated to participate in this growing market. Unlike most of U.S. agriculture, California does not specialize in the production and exportation of bulk agricultural goods. Instead, it is highly diversified and produces a range of high-valued food products destined for sale in relatively high-income countries. California is not only the leading state in U.S. agricultural production, it is also the United States' largest exporter of agricultural products.

This chapter discussed the importance of regional and multilateral trade agreements for California agriculture. It identified two critical developments from these agreements, namely tariffication of border distortions in East Asia and liberalization of foreign investment laws in Canada and Mexico.

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GOVERNMENT POLICY AND CALIFORNIA AGRICULTURE

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Government influences agriculture everywhere. California is no exception. U.S. federal farm programs and other policies also apply in California. In addition, the State of California applies some policies of its own. This chapter reviews some of the most significant governmental programs that influence California agriculture and highlights similarities with and differences from agricultural policy elsewhere.

The key legislative basis for federal farm programs is now the Federal Agricultural Improvement and Reform (FAIR) Act of 1996 (PL 104-127). Also at the federal level, we discuss the implications of implementation of the Uruguay Round Agreement for Agriculture (URA), which became effective in 1995. Federal budget outlays that support California agriculture are also covered. The most important of the California state policies that we cover is the state milk marketing order. However, we also discuss other state marketing orders and state outlays for agricultural support.

Other chapters in this book have dealt with environmental and resource policies that affect agriculture, and labor and immigration policies that are particularly important in California. Here we focus the discussion mainly on farm commodity programs, but other governmental policies that provide support to agriculture are also included in the review.

As noted throughout this book, one of the most striking aspects of California agriculture is the breadth of commodities produced. This breadth makes it nearly impossible to deal with each of the policies or programs that may be important for individual commodities. Our approach here is to consider the overall degree of government support for agriculture and to summarize the major policy tools used. We also highlight major programs that affect the most important handful of the more than 250 commodities grown commercially in the state.

Government's overall effect on agriculture includes the impacts of a variety of policies that affect business in general. These policies include taxes on sales, income, excise, and real estate property, as well as the provision of infrastructure, education, and other government services. In addition, regulation of certain other businesses may affect agriculture indirectly. While these general policies pertaining to business may be important, they will be dealt with here only to the extent that agriculture is treated differently from other industries.

A discussion of agricultural policy can be organized in a variety of ways. In this chapter we examine both major policy tools and major commodity-specific programs to summarize the influence of government. In order to provide a summary measure and a framework for the discussion, we have developed Producer Subsidy Equivalents by policy and by commodity for California agriculture.

USE AND LIMITATIONS OF THE PRODUCER SUBSIDY EQUIVALENT

The Producer Subsidy Equivalent (PSE) can be used as an approximate indicator of some policy effect. The PSE is a widely applied summary measure of agricultural policy that attempts to measure the money value of explicit or implicit income transfers to agriculture. When calculated as a ratio of total transfer to total industry revenue, the percentage PSE is a rough guide that may be compared across commodities, time, and national or other geographic boundaries. When these comparisons are interpreted with care, they provide useful summary indicators. The PSE may also be decomposed by policy type to indicate the relative importance of different policies.

The *producer subsidy equivalent* is not a measure of *production* subsidy. It measures all transfers to an industry, including those that may do little to stimulate output. The PSE is not a substitute for a measure of import protection or export stimulant. Nor is the PSE a measure of producer benefit from government programs. Program outlays or other measures that enter the PSE may do little for net revenue or producer surplus. The PSE does not offer a substitute for a full analysis of the market and non-market effects of government programs. It is simply a convenient summary measure of a variety of agricultural programs that does not require a full analysis of each industry. Changes in the PSE do not necessarily reflect changes in government programs. In particular, for a PSE that contains aspects of trade policy, price support, or even deficiency payments, the movement of market prices may dominate movements in the PSE over time. Therefore, change in the PSE is itself not an indicator of policy change. This means also that a PSE for a single year may not reflect accurately the degree of government support for a commodity in other years.

Even with these limitations, we believe that it is useful to summarize government policies affecting California agriculture by using a variety of decompositions of the PSE for recent years. The following sections discuss the PSE by program or policy category and by commodity, using recent data.

THE PATTERN OF GOVERNMENT TRANSFERS AND SUPPORT FOR AGRICULTURE

Column 1 of Table 1 reports total receipts for a set of commodity or commodity groups for California in 1995. Column 2 reports the dollar value of the Producer Subsidy Equivalent, using methods and data similar to that used by the U.S. Department of

Agriculture (Nelson, Simone and Valdez, 1995) and by the OECD (OECD, 1995). Column 3 of Table 1 presents the percentage PSE. In Figure 1, we summarize the percentage PSE for major commodities and commodity aggregates.

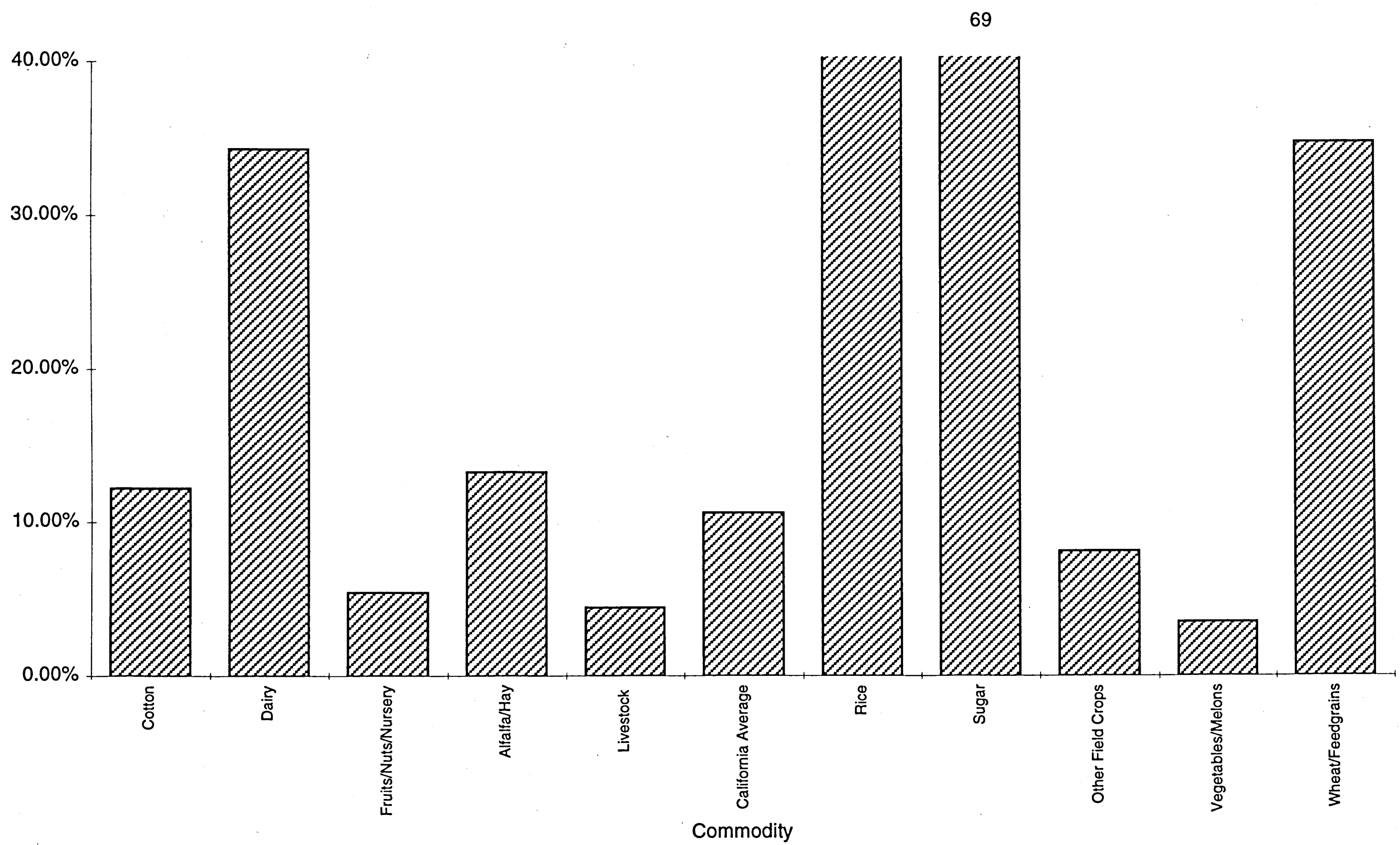
Table 1. Producer Subsidy Equivalent (PSE) by Commodity, 1994-96.

Commodity	Cash Receipts (1995)	Support	PSE
	-----*thousand dollars*-----		*percent*
Dairy	3,078,480	1,055,305	34.28
Grapes	1,638,418	89,411	5.46
Nursery & Flowers	2,171,904	75,654	3.48
Cattle & Calves	1,289,765	67,671	5.25
Cotton	1,392,899	169,928	12.20
Tomatoes	865,360	36,218	4.19
Almonds	888,000	48,848	5.50
Alfalfa & Other Hay	673,459	89,350	13.27
Citrus & Olives	729,158	62,495	8.57
Deciduous Tree Fruit	866,522	56,298	6.50
Strawberries	634,133	26,726	4.21
Poultry[a]	855,097	30,972	3.50
Lettuce	1,385,397	46,018	3.32
Broccoli	317,604	11,165	3.52
Melons	407,238	14,079	3.46
Rice	279,042	116,794	41.86
Avocados	232,440	16,409	7.06
Walnuts & Pistachios	373,722	24,566	6.57
Wheat	136,347	57,954	42.50
Sugar Beets	107,870	74,114	68.73
Feed Grains[b]	105,783	26,235	24.80
Other Fruits & Nuts[c]	167,186	7,383	4.42
Other Vegetables	2,585,111	81,570	3.16
Other Field Crops[d]	583,311	47,112	8.08
Other Livestock[e]	295,185	10,102	3.42
Total/Average	22,089,431	2,342,408	10.6
Livestock Total/Average	5,548,527	1,164,050	20.98
Crop Total/Average	16,540,904	1,178,358	7.12

Notes: Total Cash Receipts for 1995 are $22,895,100 from CDFA data. About 3.52% of total receipts is derived from farm related income that is not attributed to commodity marketing. Support was calculated by authors using USDA formulas.

[a] Poultry includes broilers, eggs and turkeys.
[b] Feed grains includes corn, barley and oats.
[c] Other Fruits & Nuts includes figs, dates, bushberries and other fruits & nuts.
[d] Other Field Crops includes dry beans, oil crops, potatoes, sweet potatoes and others.
[e] Other Livestock includes aquaculture, hogs, honey, sheep and lambs, wool and others.

Figure 1 : Producer Subsidy Equivalent by Commodity or Commodity Group



The dollar value of the PSE is designed to reflect the government support provided to a commodity industry from a variety of policies and programs. We have used a large number of sources for information on budget outlays, internal and external prices, quantities, and other data that enter into the calculations of the PSE. In some cases we measure a portion of the government support as an average for recent years. For example, for disaster payments we use 1988–1993 averages. For broad-based input subsidies, we use national data and allocate a share of the national total to California based on California's share of national receipts. We then allocate the California total to commodities within California by their share of California agricultural receipts. In other categories of support, we use California budget data for 1994 or 1995 as available. For direct commodity support payments from the federal government, we updated the payment rates to reflect the FAIR Act of 1996. We use national payments by commodity and allocate those payments to California based on the California share of national payments for an average of 1993 and 1994. Other specific measurement or data issues are dealt with below when we discuss individual programs and policies. The appendix contains a detailed description of our data and calculations.

The PSE calculations and the percentage PSE results would differ somewhat if we chose different base years or calculation methods, but, under any reasonable procedure, the pattern across commodities and policy instruments would differ little from the results presented here. The state average PSE would also change slightly if we used different base years. However, we do not believe that the current estimate represents any systematic bias, except that the PSE has likely been declining gradually over time as the share of relatively less subsidized products has expanded and as subsidy rates for some crops have declined. More recent data would tend to show a smaller PSE in most cases.

As noted in Table 1, the state PSE is about $2.34 billion or 10.6 percent. This tells us that, looking across all commodities, the total support for California agriculture is about 10 percent of total commodity receipts. (See also Figure 1.) The OECD calculates and reports PSEs for member countries for five major crop categories and seven livestock products. Fruits, vegetables, and other horticultural crops are not included in the OECD figures. For 1994, the OECD reports an aggregate PSE range from about 3 percent for New Zealand to over 80 percent for Switzerland. Norway, Japan, and Iceland all have PSEs over 70 percent. The OECD reports an aggregate PSE of 21 percent for the United States. For the twelve commodities used by the OECD, the average PSE in California is roughly equal to that of the U.S. as a whole. Support levels tend to be lower for fruits, vegetables, and other horticultural commodities in the U.S. and many other countries. The less subsidized crops and livestock commodities are particularly important in California and therefore the average PSE we report is well below the figure for the United States reported by OECD.

Figure 1 illustrates substantial variation across commodities in the percent PSE. At the high end, sugar has a PSE of more than 65 percent. Rice and wheat are next at about 40 percent. Dairy has a PSE of about 34 percent and feed grains have a PSE of about 25 percent. Cotton and alfalfa and other hay also have above-average PSEs, whereas other field crops have a PSE slightly below the state average. Among the horticultural crops, citrus and olives, avocados, walnuts and pistachios, and deciduous tree fruits all have PSEs in the 6.5 to 9 percent range. Other livestock and poultry and the remaining crop categories have PSEs between 3.4 and 6 percent. This low PSE group includes such important California crops as nursery and flowers, grapes, lettuce, tomatoes, almonds, and strawberries.

As background to further discussion, Figure 2 shows the distribution of total agricultural receipts in California by commodity category. The two broad categories of horticultural crops (including all tree crops, vegetables, melons, berries, and nursery crops) comprise well over half of all agricultural receipts in California. Dairy is the most important single commodity, with about 14 percent of receipts. Of the field crops, cotton is most important, followed by alfalfa and other hay.

Figure 2 is presented to provide a basis for comparison with Figure 3, which shows a companion distribution of total support by commodity. Now the dairy industry is dominant in terms of share of total support. Dairy is an important commodity in California and also has a relatively high degree of government support. More than 45 percent of all subsidy equivalent in California agriculture is provided to the dairy industry. Notice that, because they are so important in total receipts, even the less subsidized categories of horticultural crops receive a combined total of 25 percent of all the PSE for the state. Also, the heavily subsidized but relatively minor crops, such as sugar and grains, show up significantly in Figure 3.

Table 2 provides an alternative categorization of the aggregate PSE. Rather than providing a distribution across commodities, Table 2 distributes the PSE by policy area and more specific policy tools. Import barriers account for the largest share of support, followed by input assistance. By far the most important policy tool in terms of the aggregate PSE is the dairy import barrier, valued at more than $500 million per year. Water subsidies, which apply to most crops, are next, with a value of almost $240 million per year. Direct payments under the FAIR Act apply to cotton, rice, wheat, and feed grains and are worth about $200 million per year, almost half going to rice.

Figure 4 provides an illustration of some of the data in Table 2. This figure emphasizes visually how widely the aggregate PSE is spread across instruments. It also reveals that, despite their national prominence in the policy debate, direct government payments play a relatively minor role in California.

The rest of this chapter is devoted to discussing individual policies in more detail. While the discussion is limited to a very broad overview, it provides both additional background on the policies underlying the PSE and more analysis of their effects. Because of its complexity and importance in California, we begin with a discussion of dairy policy. We then turn to a brief review of various policy instruments, beginning with trade policy.

Figure 2. Commodity Share of Total Receipts.

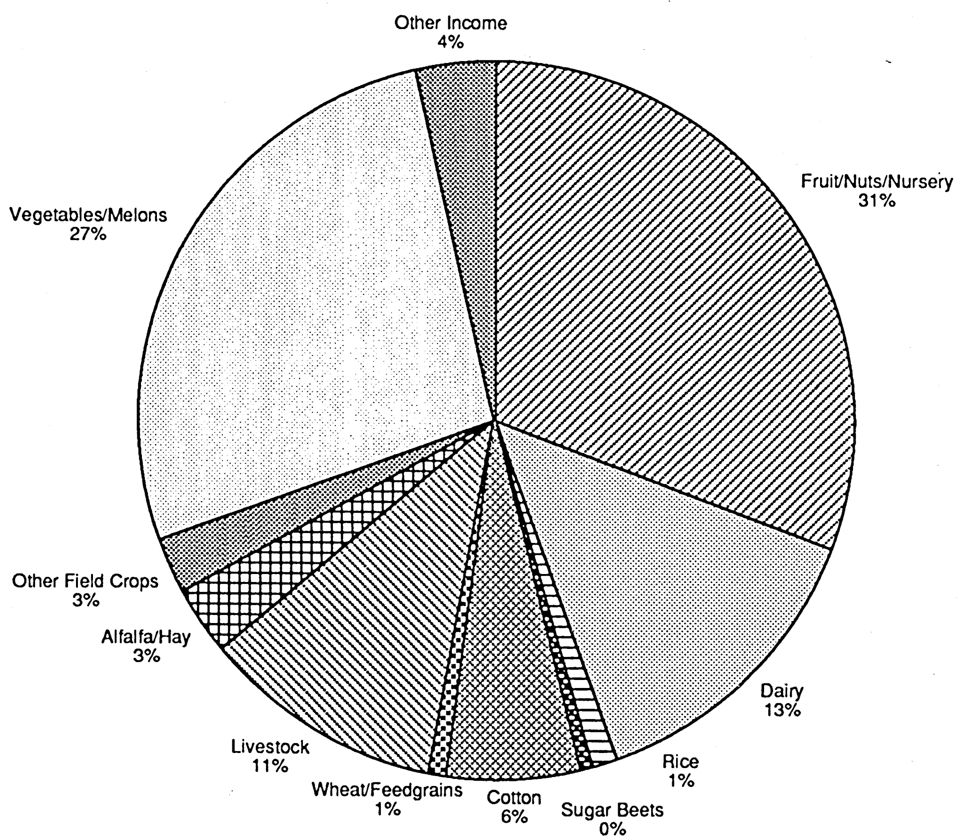


Figure 3. Share of Total Support by Commodity.

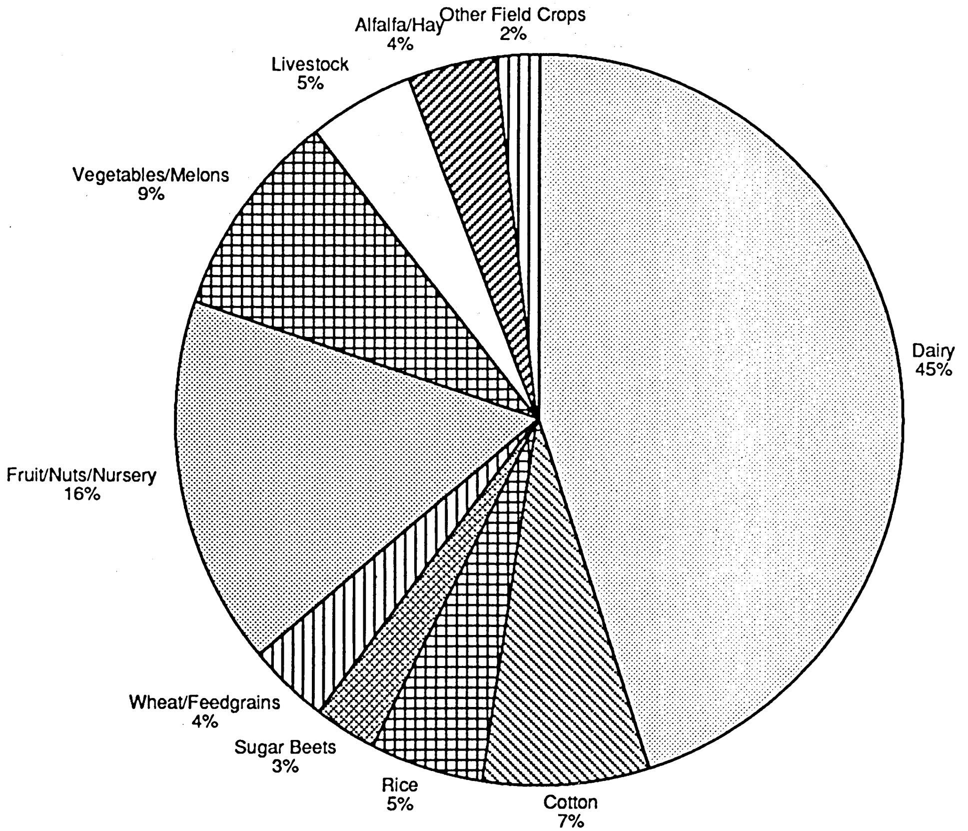
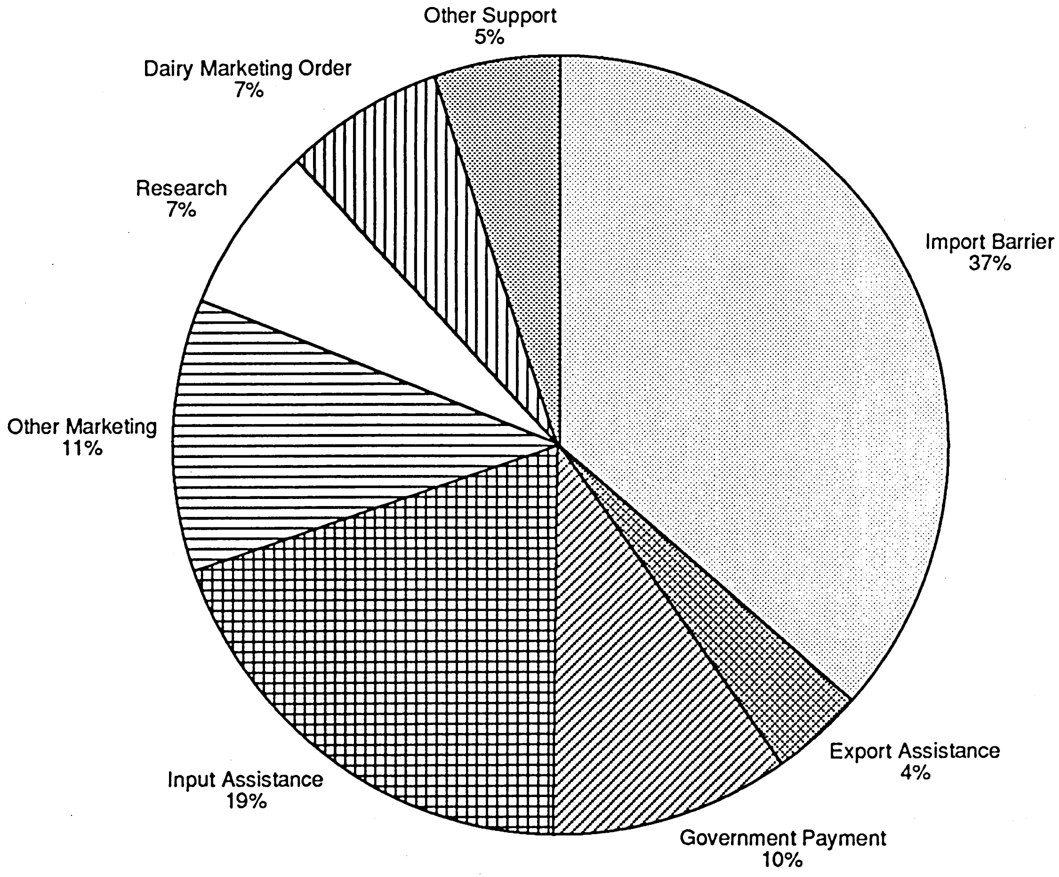


Table 2. California Producer Subsidy Equivalent Contributed by Each Policy Tool.

Policy Tool	Value	Percent
	thousand dollars	
Import Barriers	857,092	37
Dairy	780,791	33
Sugar Beets	56,092	3
Cattle & Calves[a]	20,208	1
Export Assistance	87,597	4
Export Subsidy	46,986	2
FMD/MPP[b]	40,611	2
Government Payment	236,779	10
FAIR Act Direct Payment	205,333	9
Disaster Payment	31,446	1
Input Assistance	455,609	19
Water	236,232	10
Farm Credit	155,755	7
Crop Insurance	33,227	1
Fuel Excise Tax	870	0
Pest and Disease Control	22,937	1
Grazing Fees	2,018	0
Emergency Feed	4,570	0
Other Marketing	264,698	11
Advisory	24,198	1
Inspection	120,500	5
Processing and Marketing	120,000	5
Research	160,764	7
Dairy Marketing Order	154,309	7
Infrastructure/Land Improvements	33,986	1
Economy-wide Policies	91,533	4
Taxation	72,582	3
Transportation	18,951	1
Total	2,253,694	100

[a] Includes beef purchases of $1,681,000.
[b] In the Fair Act of 1996 MPP was renamed MAP (Market Access Program).

Figure 4. Share of Total Subsidy by Policy Area.



DAIRY POLICY

Dairy policy in California is important and unique. It is important in that the dairy industry is the largest agricultural industry in the state as measured by gross receipts. Policy governing the industry is highly developed and associated with a substantial share of industry revenue. It is unique in the sense that some policy instruments are unlike those used in other agricultural industries—and, whereas much of California dairy policy is the same as applies in other parts of the U.S., some of its instruments are unlike those used elsewhere. The California dairy industry participates in the U.S. federal price support program, and the industry benefits from U.S. import barriers and export subsidies, but California operates its own marketing order system, which has some features that differ from the federal system.

The federal price support program for milk in the United States is implemented with a government purchase program for manufactured dairy products. The USDA purchases butter, non-fat dry milk (NDM), and American cheese from processors at prices calculated to ensure that the farm price of milk used for the manufacture of those products will generally remain above the legislated support price. From 1990 to 1995, the price support program included a small assessment on milk production to help offset the budget cost of the price support. The assessment varied from year to year and was implemented in a complex way, but was essentially a tax on milk output of approximately $0.11 per hundredweight (about one percent of milk revenue). The FAIR Act of 1996 changes the price support policy fundamentally over the next four years. The dairy price support program will be phased down 15 cents per hundredweight per year, from $10.35/cwt, and completely eliminated by the year 2000 (at which time it is to be replaced by a recourse loan program). Given the strength of dairy product markets, the impacts of phasing out federal price supports will likely be minimal. The assessment on dairy production was eliminated immediately, and this affected producers immediately (Cox and Sumner, 1997).

Trade barriers are the most significant feature of U.S. dairy policy, yet no serious trade policy reform was even contemplated in the policy discussions leading to the FAIR Act. In general, imports of dairy products in the United States have been limited to about 2 percent of U.S. consumption. The import barriers allow the domestic price of milk and milk products to remain well above the price for traded products in world markets, making price discrimination policies feasible. As part of the Uruguay Round trade agreement that took effect in 1995, the system of absolute quotas gave way to a system of tariff-rate quotas (TRQs). However, the second-tier tariffs that limit over-quota imports remain prohibitively high; therefore, the effects of the TRQs remain the same as the absolute quotas that were replaced. The Uruguay Round GATT agreement also provides for a gradual increase in the quantity of dairy product imports into the United States under the TRQs. This provision will allow for a gradual increase in import access into the U.S. dairy market over the next five years. The North American Free Trade Agreement (NAFTA), which took effect in 1994, had no significant quantifiable effects on dairy import barriers.

California shares in the impacts of the import barriers. As noted in Table 2, by raising the domestic price of milk above the world price, the import barriers alone contribute more than $780 million to the dairy PSE in California.[1]

Subsidized exports, along with donations to domestic food programs and international food aid, have long been used to dispose of stocks of dairy products acquired under the federal price support program. Subsidized exports have been considered a market for U.S. dairy products that does not disrupt domestic commercial sales. In addition to the disposal of government stocks, the Dairy Export Incentive Program (DEIP) has provided explicit price subsidies for commercial dairy product exports since 1989. The DEIP will be scaled back over the 1995–2000 period as part of the Uruguay Round GATT agreement. Even in 1995, the dairy export subsidy had only a small impact on the dairy industry, estimated at about $20 million.

The FAIR Act extends and fully funds the Dairy Export Incentive Program through 2002. In addition, the Act authorizes USDA to assist in forming export trading companies and allows the National Dairy Board to use funds for export market development. These later provisions have no direct implications that are readily quantifiable.

Federal milk marketing orders in the United States are regional in their implementation. California is the only significant dairy state that is not a part of the federal system of milk marketing orders. Both the California and federal milk marketing orders establish specific minimum prices that must be paid for milk according to the class of its end use (classified pricing). The California milk marketing order operates with five classes of milk designated by end use. These classes provide separate prices for milk sold for fluid use and for manufactured products such as yogurt, ice cream, cheese, butter, or NDM. Marketing orders also establish pool pricing for farms such that individual farmers receive weighted average prices of milk sold in the marketing order. Federal milk marketing orders calculate a single, separate pool price for all milk under each of the regional orders (Neff and Plato, 1995). The California marketing order now provides for two producer "pool" prices. Individual farmers in California receive a weighted average of the two prices, with these weights determined by individual ownership of milk quota (Sumner and Wolf, 1996).

Each federal marketing order regulates milk within a geographically limited market. The relationship of prices among orders is determined, in part, by the formula used to set minimum prices in the orders themselves. The price of unregulated Grade B milk (milk ineligible for fluid use) produced in the Minnesota-Wisconsin region is the basis for the minimum price for Class III (or IIIa) milk in all federal orders. This price was previously known as the M-W price; however, this price has been reformulated and is now the Basic Formula Price (BFP). With different minimum prices in each region, regulations are needed to prevent milk from being transported across regions. Milk transported freely across marketing order borders would undermine the maintenance of separate fluid milk markets in different orders. These regulations ensure that there is generally little economic advantage to arbitrage across prices in different orders.

The FAIR Act of 1996 left the federal milk marketing orders in place with relatively minor adjustments. The Act requires the USDA to consolidate current federal orders from about 33 to between 10 and 14 within three years. There is no implication

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[1] USDA, FAS (1995) provides the world price data that we use in this calculation.

that this policy change will affect milk pricing in any fundamental way. The Act also authorizes the USDA to consider multiple basing points and fluid milk utilization rates for setting minimum Class I prices, and to consider uniform multiple component pricing in designing a new Basic Formula Price. The process of making minor adjustments to the federal system is expected to last until 1999.

Several dairy provisions of the FAIR Act were directed explicitly or implicitly at California. The legislation provides that if California producers petition and receive approval, a federal order for California may become one of the 10–14 federal orders. This prospect is being debated actively in California, because joining the federal system would allow some control over milk shipments into California from out of state. The marketing order provisions in the FAIR Act do not require or even suggest that fundamental reform is likely, nor do they provide any directly quantifiable impacts on milk markets.

The California milk marketing order provides for price discrimination, with different minimum prices set by the State for milk designated for different end uses. A high price is required for milk that is used for fluid products with relatively inelastic demands. Until a regulatory change in 1994, the California milk quota program provided that owners of milk quota received benefits from this program by receiving a bonus for quota milk equal to the difference between the average of the high price uses and the average of the low price uses. This difference averaged approximately $1.70 per hundredweight (Ekboir and Sumner, 1995). The total annual flow return to quota ownership has been about $154 million per year. This figure is taken as an estimate of the value of the marketing order in the PSE calculations. The underlying assumption is that the flow to quota owners has represented the approximate flow to the dairy industry from price discrimination that nets out the transfer from those who own less quota to those who own more than the average allocation of quota.

OTHER TRADE BARRIERS

Import barriers are also used for sugar and beef. Under the URA, quotas and voluntary restriction agreements of the Meat Import Law were converted to TRQs. In general, over-quota tariffs remain prohibitively high. But the subsidy value of the trade barrier is represented as the difference between the internal U.S. price and the appropriate world price. Based on OECD data this difference is low. The import barrier constitutes a small percentage PSE and 27 percent of the support for the beef industry.

The trade restrictions for sugar have resulted in a U.S. domestic sugar price twice that of sugar traded on world markets. The proliferation of high fructose corn syrup as a sweetener is a by-product of the relatively high price of sugar in the U.S. The sugar import barrier provides California sugar beet producers with almost three quarters of their substantial amount of total support.

Other trade barriers for California commodities have relatively insignificant effects. A potential exception relates to selected phytosanitary or food safety and sanitary regulations. Most countries restrict imports of commodities that may transmit diseases, pests, or parasites, in order to keep the infection from developing domestically. For example, beef products from countries that have herds with endemic Foot and Mouth Disease infections are generally banned from import into countries free of the disease. These kinds of regulations can be considered protectionist trade barriers when they are not based upon sound scientific principles. The United States has challenged a number of barriers of other countries, and a few U.S. barriers have likewise been challenged on these grounds. For example, the phytosanitary regulations blocking avocado imports from Mexico to the U.S. were challenged, and the barrier was relaxed slightly. Following the practice of OECD and the USDA, we have not attempted to judge which technical restrictions are protectionist. Therefore, trade restrictions based on technical considerations have not been included in calculating the Producer Subsidy Equivalents.

EXPORT SUBSIDIES

Explicit export subsidy programs have been particularly important for selected grains and oilseed products. For wheat and a few other commodities, the United States has operated the Export Enhancement Program (EEP) since 1985. The Uruguay Round Agreement (URA) implied no significant commitments for domestic subsidies in the United States, but it did impose limits on direct export price subsidies (Sumner, 1995b). Limits were placed on subsidy outlays and quantities subsidized by commodity. The EEP was continued in the FAIR Act, but because of relatively high grain prices, the EEP has not been used since 1995. Based on historical averages, EEP export subsidy outlays represent over 25 percent of the PSE for wheat in California, and substantially smaller shares of the PSE for rice, poultry, and beef.

Although FAIR continued authorization for export subsidies, it does set a policy environment that may provide an opportunity for more progress in reducing these programs in the next multilateral trade negotiations. The United States no longer maintains high support prices and no longer requires farmers to idle cropland to get government support. Therefore, U.S. exports may be better able to compete on world markets without direct export subsidies. Further, the higher domestic price caused by subsidizing exports no longer reduces outlays on deficiency payments and therefore no longer has a budget offset in USDA accounts. (However, contrary to the conclusion that the EEP would now have less political support is the claim that the wheat lobby now sees the EEP as its primary policy tool and will demand that it be used fully.)

In the URA only direct price subsidies were counted in the export subsidy category. In particular, export credit guarantees and export promotion programs were not included among the programs facing restrictions. Here we have included foreign market development and credit programs as part of export assistance. The Market Promotion Program (MPP), renamed the Market Access Program (MAP) in the FAIR Act, and the Foreign Market Development (FMD) programs are market development programs that provide funds for advertising and product promotion in overseas markets. Under these programs, money is used by nonprofit trade organizations, state and regional trade groups, private companies and agricultural cooperatives to develop markets mostly for high-value and processed products. The FMD focuses on bulk products, such as grains and oilseeds. During the FAIR Act creation, there was a drive to limit (or eliminate) these export promotion programs, but little has changed with MAP funded at $90 million annually. The MAP and prior programs are the most visible federal subsidy programs for many horticultural commodities, and these industries defend the programs vigorously. While some of the MAPs have a substantial impact on some California commodities (almonds and grapes, for example), the overall benefit from export promotion is quantitatively small, only about 3 percent of the total support for many commodities.

COMMODITY PAYMENTS, CONSERVATION, AND DISASTER PAYMENTS AND CROP INSURANCE

Commodity Payments

Until the FAIR Act of 1996, the deficiency payment program was the key government price and income support program for wheat and feed grains. The deficiency program was voluntary, but participation required compliance with planting restrictions and other rules. Three features characterized the deficiency payment program: (1) Payment rates were lower when market prices were higher; (2) Participants were required to idle some share of their historical crop base; (3) Participants were required to plant within a minimum and maximum share of base acreage (Sumner, 1995a).

The FAIR Act is best understood as another step in the decade-long process that made direct payment commodity programs more market-oriented and allowed production to become responsive to market signals. Key provisions of the FAIR Act in this regard included the following: (1) Deficiency payment programs were eliminated, including the 0–85 and 50–85 programs; (2) Authority for acreage reduction programs was eliminated; (3) The price support and marketing loan programs were retained; (4) New "production flexibility contract payments" were established; these new payments are based on the same acreage and yields as used under the deficiency payment program; (5) Base land may be used for almost any agricultural activity, including fallow, except fruit or vegetable production (Young and Shields, 1996; Nelson and Schertz, 1996).

Under the FAIR Act, participants receive a fixed payment each year for seven years, based on a percentage of past deficiency payments. These payments are independent of market prices or the "agricultural" use of the land. Annual idling requirements (ARPs) and most other planting restrictions are eliminated. There is no commitment to continue or eliminate these payments after the initial seven-year period. FAIR payments were designed to start out approximately equal to the average annual payments from 1990–95, and then to decline by about one third over seven years (Young and Shields, 1996; Smith and Glauber, 1996). Current grain price projections indicate that deficiency payments are likely to be very small over the next seven years. With these price projections, it is likely that FAIR will cost taxpayers about $20 billion more than FACT would have (Young and Westcott, 1996; Paarlberg and Orden, 1996).

Price supports and marketing loans remain in FAIR, but for the past several years, and in most projections for the future, this price safety net is at such low levels that the government is very unlikely to acquire any stocks, and the market effect of the support remains minimal. For several years, price supports for grains have been set low enough that they did not interfere with U.S. exports and did not raise costs to processors or the livestock industry.

The FAIR Act provisions reduce the total payments to the commodity industry compared to what had been received in the 1990 to 1995 period (although not compared to what would have been received under the 1990 FACT Act under market conditions expected for 1996–2002). More important for supply effects, the FAIR Act allows producers significantly more opportunity to adjust their land use patterns without affecting their government payment. In particular, under the old program in order to participate in the rice program, a farmer was required to plant rice to at least 50 percent of the farm's maximum payment acres. In order to receive a full payment the farmer was required to plant the full maximum payment acres. On the upper end, a farmer was not allowed to plant more than the farm's base acres less any acreage reduction percentage. (An exception was that a program crop could be planted on the "flex" acres of other program crops.)

The FAIR Act is likely to affect acreage in several ways. First, it eliminated the minimum planting requirement in the 50–85 programs that applied to rice and cotton. Second, it eliminated the program-payment incentive to plant program crops rather than other crops. Both of these factors will allow acreage of program crops to fall in areas with high cost of production or profitable alternative crops. Third, the FAIR Act eliminated the restrictions on planting in excess of base acreage and will allow expansion, with no loss of payments, if market conditions warrant. Fourth, by eliminating any provision for acreage reduction, program crop acreage will not be limited through mandatory government restrictions.

Conservation Reserve

The Conservation Reserve Program (CRP), and related long-term land idling schemes that focus on water quality and wetlands, cost the U.S. taxpayers about $2 billion per year and idle about 37 million acres in total. Land idled by the CRP has significant effects on grain supply and price. In the spring of 1997, the U.S. Secretary of Agriculture accepted bids for land to enter a smaller reformed CRP for the next 10 years. Of the national total, fewer than 200,000 acres are in California. Due to the relatively small use of CRP in California, the CRP contracts were not included in our PSE calculations.

Disaster Payments and Crops Insurance

Crop insurance and disaster policy was modified with the Federal Crop Insurance Reform Act of 1994 in an attempt to reduce total outlays, reduce the variability of outlays over time, and reduce some of the subsidy variation across farms. Reform of these programs was important because outlays averaged several billion dollars per year. In addition, there has been a large production subsidy implicit in both the ad hoc disaster assistance and the crop insurance programs. The disaster program simply provided payments when yields were unusually low. This encouraged production of selected crops (especially wheat and soybeans) in areas with marginal profitability and variable production. Further, many crop insurance premiums were far below actuarially fair rates, especially in regions where particular crops were marginal on economic grounds (Goodwin and Smith, 1995).

The 1994 Act attempted to reduce the likelihood of ad hoc disaster payments by changing congressional budget rules so that budget saving offsets would be required if ad hoc payments were made. In addition, the 1994 Act encouraged some reform of premium rates and required program crop producers to purchase a minimal crop insurance policy. The 1994 Act left the basic crop insurance subsidy in place. FAIR modified the program slightly, but did not reduce the size of the subsidy. In California, fruit, vegetable, and field crops received the largest share of disaster payments, with total payments around $30 million. Field crops also (especially sugar beets and oilseeds) benefited from crop insurance. Empirical research would almost surely confirm that there remains a significant supply subsidy in the U.S. crop insurance and disaster programs.

IRRIGATION WATER SUBSIDY

As shown in detail in a previous chapter, irrigation is a key element of the current pattern of agriculture in California. Water subsidy to California agriculture derives from access to surface irrigation water at prices below cost and below likely market prices for irrigation water if a market were allowed.

Much of the reservoir and distribution system that serves agriculture was developed by the federal and state governments. The federal Central Valley Project (CVP) and the California State Water Project (SWP) system of dams and canals are important providers of water storage and delivery to growers. In these projects, water is accumulated and stored in large reservoirs in the northern part of the state and released into Sacramento River canals for delivery. Almost half of the water available for use in the San Joaquin Valley comes from CVP and SWP sources. In addition, the All-American Canal diverts water from the Colorado River for use in the Imperial Valley in the far south of California. Imperial Valley dependence on canal water is acute; over 90 percent of valley water comes from federal or state projects.

For PSE calculations we assembled data on irrigation water usage by crop and then developed estimates of the subsidy implicit in the state and federal water projects. For quantities of water we use the product of the share of water from CVP and SWP by region, and the applied water by commodity per region. Data on water usage is compiled by the California Department of Water Resources (DWR Bulletin 160-93, 1993). We use total water supplies based on 1990 average supplies. For commodities without individual data in DWR data, the share is determined by value of production (commodity share of total value for commodities in that line item).

There is no reliable data on subsidy rates. The water projects have multiple uses and historical costs are not relevant to current decisions. We created two subsidy rates, one for the north and another for the south. For the Sacramento River and Central Coast regions, we use a subsidy rate of $15 per acre foot of water. In these regions distribution costs are small, and there were substantial irrigation water supplies even before development of the major subsidized projects. For the San Joaquin, Tulare Lake, South Coast, Colorado River, and South Lahontan regions, we use a subsidy rate of $30 per acre foot of water. In these regions distribution costs are substantial.[2] The water subsidy for California agriculture is estimated to total almost $240 million.

OTHER INPUT ASSISTANCE

In addition to crop insurance and water subsidies, input assistance programs include farm credit, the fuel excise tax, and pest and disease control. The farm credit system provides loans to farmers at favorable (and slightly subsidized) interest rates. Agricultural uses of fuel are exempted from federal gasoline taxes, and these exemptions are reflected in the PSE. Pest and disease control refers to outlays for the Animal and Plant Health Inspection Service. The emergency feed program provides feed for cattle. The grazing fees paid to the federal Bureau of Land Management do not reflect the full cost of the grazing and thus provide a small amount of input assistance to cattle farmers in California.

MARKETING ASSISTANCE

Marketing assistance encompasses many programs and departments that provide resident assistance to the agriculture industry. Cooperative Extension and the Agricultural Cooperative Service provide advisory assistance. Inspection services are provided by the Federal Grain Inspection Service, the Food Safety Inspection Service, and the Packers and Stockyards Administration. The state government also provides approximately $40 million for inspection services. Outlays for the Foreign Agriculture Service, Agricultural Marketing Service, and Office of Transportation comprise the federal portion of processing and marketing assistance. State outlays for California Department of Food and Agriculture marketing assistance total around $85 million. For those commodities with relatively small amounts of total support, marketing assistance (along with input assistance) provides the bulk of the support. Assessments are subtracted from outlays to determine contribution to the PSE.

Both federal and state marketing orders promote California commodities or provide funds for research. Usually these orders use commodity assessments to fund their activities and these assessments are subtracted from outlays into PSE calculations. Federal programs tend to focus primarily on promotion and market development, while state programs often have a considerable amount of research spending. Federal promotion market orders for milk and cotton are important in California. The state avocado marketing order has one of the largest budgets ($11.2

[2] The subsidy rates are based on conversations with Professor Richard Howitt, University of California, Davis and are based on estimates related to how a water market would operate if water transfers within agriculture and movement toward urban uses were to develop more fully. (See also Sumner, 1995a).

million in 1992), with most of that money provided for market development (Lee et al., 1996). In our PSE calculations, marketing order expenditures on promotion were included in the marketing assistance category.

RESEARCH

Research support for California agriculture is derived from a combination of federal and state funding. On the federal level, the state commodity shares of the budgets of federal research agencies provide the measure of the support to California commodities. On the state level, around $95 million is provided annually for agricultural research (Alston, Pardey and Carter, 1994). In addition to federal and state funds, a handful of commodities have state marketing orders that fund commodity-specific research. Rice, citrus, and strawberries have the largest state marketing order research budgets.

INFRASTRUCTURE AND ECONOMY-WIDE POLICIES

Infrastructure support includes federal soil conservation programs, which provide assistance in reducing soil erosion and degradation of resources. While the contribution of these programs to overall support of California agriculture is small, they are included as a separate category for consistency with the PSE calculation.

Economy-wide policies include taxes and federal transportation spending. There are various tax benefits for agriculture and foreign sales corporations that indirectly support the agricultural industry. Nelson, Simone and Valdes (1995) have compiled the total value of federal tax benefits to agribusiness and have also calculated the value of inland waterway construction and railroad interest rate subsidies. In general, the value of transportation subsidies is relatively small, usually around 2 percent of total support for each commodity. This is likely an over-estimate, however, because the California share in these benefits is likely smaller than the California share of agricultural output (which was the basis for our estimates). Tax breaks were a larger share of the support, but were not substantial by themselves.

We did not include in our PSE calculations the value of state and local real estate tax benefits to agriculture. California, like many other states in the U.S., provides for a special taxation rate on agricultural real estate. The state's Williamson Act, introduced in 1965, provides a preferential assessment program for agricultural land. Williamson Act acreage currently represents almost half of California agricultural land. Under the Williamson Act, landowners sign a contract with the appropriate local government agency (usually city or county government) restricting urban use of that land for ten years. In return, property under Williamson Act protection is assessed for tax purposes according to its capitalized agricultural income. Capitalized income assessments are usually about half of the market value-based assessments for Williamson Act land; thus landowners receive approximately $120 million in tax benefits. Contracts may be terminated through nonrenewal or cancellation. Nonrenewal gradually phases in the market value-based assessment over nine years; at the end of the ten-year contract, the land is appraised (and taxed) at full market value. Cancellation of Williamson Act contracts must be approved by the local governing board after conducting public hearings. If the contract cancellation is approved, the landowner pays a penalty of 12.5 percent of the current market value of the land (see Carter et al., 1989; Sokolow, 1990).

A REVIEW OF COMMODITY SUPPORT

Table 3. Percent PSE for Each Commodity[a] Distributed by Policy Area.[b]

Commodity	Import Barrier	Export Assistance	Government Payment	Input Assistance	Misc.[c] Support
Dairy[d]	73.99	2.29		2.37	21.35
Grapes		8.80	1.36	34.38	55.46
Nursery & Flowers		2.44	0.75	32.30	64.51
Cattle & Calves	27.38	2.61		22.74	47.27
Cotton		2.32	44.15	32.96	20.57
Tomatoes		3.23	1.79	41.04	53.94
Almonds		14.07	4.61	30.66	50.66
Alfalfa & Other Hay			1.06	83.59	15.35
Citrus & Olives		6.95	12.91	41.10	39.04
Deciduous Treefruit		7.22	7.13	32.74	52.91
Strawberries		13.95		28.92	57.13
Poultry		8.28		27.32	64.40
Lettuce		1.76	0.28	29.10	68.86
Broccoli		3.50	0.73	32.25	63.52
Melons		2.56	1.65	30.22	65.57
Rice		2.43	85.22	6.44	5.91
Avocados		8.99	4.57	38.20	48.24
Walnuts & Pistachios		7.53	0.68	20.82	70.97
Wheat		26.60	46.23	21.79	5.38
Sugar Beets	75.65		0.54	20.56	3.25
Feedgrains		1.72	52.30	36.98	9.00
Other Fruits & Nuts				47.76	52.24
Other Vegetables		0.48	1.37	27.01	71.14
Other Livestock		12.69		27.86	59.45
Other Field Crops			2.37	69.51	28.12

[a] See Table 1 for definitions of commodity categories.
[b] See Table 2 for detailed list of Policies.
[c] Includes research, infrastructure and land improvements, economy-wide policies and the California dairy marketing order classified pricing.
[d] Under miscellaneous support for Dairy we include the 20% of the total dairy support associated with the California dairy marketing order classified pricing system.

Dairy

Dairy policy is discussed in detail above. Here we note only that, in addition to trade protection and internal price policies, the dairy industry receives support from several smaller programs as well. In addition, the industry receives indirect support in the form of subsidies to the grain industry and, especially the alfalfa hay industry. Hay is important in dairy production, accounting for about 20 percent of total costs. The major subsidy for alfalfa is irrigation water; some have argued that the water subsidy to alfalfa is a major contributor to lower dairy production costs in California. Let's examine this proposition. Total alfalfa support is about $90 million. Most of this, about $70 million, is attributable to the irrigation water subsidy. Some of the alfalfa and other hay grown in the state is consumed by other livestock; approximately $50 million of the water subsidy to hay is ultimately of direct benefit to the dairy industry. That $50 million added to a subsidy of about $1 billion raises the overall dairy subsidy from 34.3 percent to 35.8 percent. Another way to consider the issue is to note that the water subsidy lowers the cost of alfalfa by about 10 percent, resulting in a reduction in dairy costs of about 2 percent—not far from our PSE effect of 1.5 percent.

Fruits, Nuts, Vegetables, Melons, Nursery and Flowers

Commodities in this category have little government intervention in their markets. The PSEs range from about 3 to 8.5 percent of the revenue. There are no significant trade barriers or direct payments for these commodities. The main portion of support comes from input assistance, marketing assistance, broad government infrastructure, and economy-wide policies. While these commodities have no explicit export subsidies, they do benefit from foreign market development (MAP and FMD) funding to some degree, especially almonds (16 percent of support) and strawberries (14 percent of support). Crop insurance benefits and disaster payments are also a source of a small amount of support for this group (only strawberries did not receive some income support from crop insurance or disaster payments). In the citrus industry, crop insurance and disaster payments comprise almost 30 percent of the support; large payments were made following a 1990 freeze that took a heavy toll on the California citrus industry.

All commodities in this group have some sort of marketing order, either federal, state, or both. The marketing order share of total support ranges from 3 percent (tomatoes) to around 25 percent (avocados, broccoli, and walnuts and pistachios). The share of support from research is relatively high for these commodities, around 25 percent.

Cotton and Grains

The federal programs for these commodities were discussed in detail above. Direct government payments provide the lion's share of support: 83 percent for rice, 72 percent for cotton and feed grains, and 38 percent for wheat. Cotton, wheat, and rice have active marketing orders but compared to the value of the direct income support, the marketing order budgets are relatively small. The magnitude of the direct payments and the export subsidies also make the value of the input assistance, marketing assistance, infrastructure, and economy-wide policies a small percentage of total support.

Alfalfa

As noted above, the most important feature of support for alfalfa and other hay is the water input subsidy. Alfalfa production in California uses approximately 2.3 million acre-feet of CVP or SWP water per year. Like fruits, nuts, and vegetables, alfalfa production does not benefit from trade barriers or direct payments. Research accounts for about 15 percent of alfalfa support, while the input assistance (excluding water), marketing assistance, infrastructure, and economy-wide policies provide about 35 percent. Excluding water, the alfalfa industry would have a PSE of 3 percent.

Meat and Poultry

Cattle and calves and poultry have similar policies and a similar overall level of support; both have a PSE around 4 percent. Research accounts for about 25 percent of the support in both industries. Both commodities benefit from the various government programs and agencies that are included in market assistance, infrastructure, and economy-wide policies. Also, both commodities have federal and state marketing orders to facilitate market promotion and research. Both commodities benefit in a small way from export subsidies. About 27 percent of support for the cattle and calves industry comes from beef import restrictions. Despite the trade-distorting export subsidies and import barriers, support for the cattle and poultry industries remains a small percentage of revenue.

CONCLUSIONS

California agriculture is diverse. The policies that support and regulate the industry are equally diverse. This chapter has not attempted a full economic analysis of these policies, but has taken on the more modest task of describing key policies and providing a set of summary measures of producer support. It is useful to reemphasize here that the PSE does not measure welfare gains to producers or welfare losses to consumers or taxpayers. Some of the policies described above may have little net benefit to agriculture. Some policies primarily benefit rural landowners, who may or may not be active agricultural producers. Other policies may provide substantial benefits to consumers, and some may even provide net benefits to California as a whole. A small subset of policies may even contribute to net world welfare gains as conventionally measured. However, this paper does not claim to have provided the analysis necessary to substantiate any claims about welfare effects. Some of the literature we cite does provide such analysis, and the reader is encouraged to consult those sources.

Given its commodity mix, California agriculture has an aggregate PSE below the comparable figure for the U.S. as a whole. The major crop industries in the state compete effectively with relatively little direct subsidy and almost no commodity-specific support. These commodities tend to welcome policy reform of the sort, for example, that is being pursued in the World Trade Organization. Other California commodities, such as dairy and sugar, continue to maintain relatively high import barriers and have traditionally resisted market opening and other policy reforms. Nevertheless, even many of these segments of California agriculture expect to prosper as markets are opened and subsidies reduced.

APPENDIX

Producer Subsidy Calculations

Direct Payment. 1996 FAIR payment (total) X commodity share of transfer payment X the California historical share of commodity payments. (The California historical share of commodity payments is the simple average of 1993 and 1994 payments to California by commodity divided by total U.S. payments by commodity.) 1996 FAIR payment total is from the *USDA Farm Bill Commodity Fact Sheet* (1996). The historical share of payment data is from Farm *Business Economics Report*. (USDA, ERS, 1995).

Crop Insurance. If loss ratio is greater than 1; premium X (loss ratio – 1). Insurance performance is examined by Lee and Chalfant (1994) from 1988–1992. If loss ratio is less than 1, then no benefit accrued from crop insurance.

Disaster Payment. Total disaster payment by commodity (total from years 1988–1993) divided by 6 (Lee, Harwood and Somwaru, 1995).

Trade Barrier, Dairy. (California price – world price) X California production. 1995 California production is used for cheddar cheese, butter and Non-Fat Dry Milk and early 1995 prices are used (*California Dairy Industry Statistics*, 1995). The world price is a simple average of the EU export price and the Oceania export price (*Dairy World Markets and Trade*, USDA, FAS, 1995).

Trade Barrier, Sugar. 1995 California receipts X the ratio of 1994 world price to 1994 domestic price. (Using the California production X price differential yielded an inaccurate estimate, presumably due to differences in data sources. Instead, we calculated the price ratio to be .48 (the U.S. price is 48 percent of the world price), and one could extrapolate from this ratio that the value of the import barrier is approximately 48 percent of the receipts.) U.S. and world prices come from Lord (1995). Cash receipts come from the *1996 California Agricultural Resource Directory* (1996).

Beef Tariff; Grazing Fees; Beef Purchases. Average U.S. expenditures (1982–1992) X California share of U.S. cattle & calf industry. Nelson, Simone and Valdes (1995) calculated the value (to the U.S. beef industry) of the import restriction at $.02/lb X carcass weight of production. California market share is from the *1992 Census of Agriculture* (U.S. Census Bureau, 1992).

California Dairy Marketing Order. $1.70/cwt price differential X 790 million lbs SNF (amount of quota) divided by 8.7 lbs SNF/cwt. Amount of quota is determined in Sumner and Wolf (1996) and the price differential for quota is derived by Ekboir and Sumner (1995).

Export Subsidy. EEP (or DEIP) expenditures X California commodity share of national receipts. EEP (DEIP) expenditures are from Ackerman, Smith and Suarez (1995). The California market share of rice is from Schnepf and Just (1995). For dairy, wheat and feed grains, California market share is calculated from information in the *1992 Census of Agriculture* (1992). DEIP benefit determined from Uruguay Round Agreement maximum DEIP levels (Sumner, 1995).

FMD/TEA/MAP. 1989–1993 average expenditures by commodity X California share of U.S. value. Vegetable, fruit and nut expenditures divided by share of commodity value in those categories. Expenditures are found in Ackerman, Smith and Suarez (1995). The California share of U.S. value is from the *1992 Census of Agriculture* (1992). Lettuce, tomatoes, broccoli and melons are Vegetables. Grapes, citrus, avocados, strawberries, almonds, walnuts and pistachios and tree fruit are Fruits, Nuts and Berries.

Water. Share of water from CVP and SWP (by region) X applied water by commodity (per region) X regional subsidy level. Share of water from CVP and SWP (calculated by the CVP and SWP percentage of water supply by region) and applied water figures are taken from the *DWR Bulletin 160-93* (1993). Water supplies are from the 1990 average supplies. Commodities without an individual line item were grouped into a specific line item. (Melons, lettuce, broccoli, strawberries, nursery & flowers were grouped into Other Truck. Tree fruit and avocados were grouped into Other Deciduous. Walnuts, almonds and pistachios were grouped into Almonds & Pistachios). The commodity share of line item of applied water was determined by value of production (commodity share of total value for commodities in that line item). The North Lahontan region received no water from the CVP or SWP. The Sacramento River and Central Coast Regions were given a subsidy value of $15/acre foot of water. The San Joaquin, Tulare Lake, South Coast, Colorado River and South Lahontan regions were given a $30/acre foot subsidy. (Subsidy levels are author's estimates based on conversations with Richard Howitt, University of California, Davis.)

Emergency Feed. Average U.S. expenditures (1982–1992) X California cattle/poultry/other livestock share of U.S. production X commodity share of cattle/poultry/other livestock value. Expenditure data is from Nelson, Simone and Valdez (1995). Cattle/Calves and Poultry products share of U.S. production is found in the *1992 Census for Agriculture* (1992). Cattle/Calf, Poultry/Eggs and other livestock share is determined by the percentage value from each of the three commodities (individual commodity value divided by the sum of the three commodities value). The values are from the *1996 California Agricultural Resource Directory* (1996).

Advisory. [Average U.S. expenditures (1982–1992) X California share of U.S. value + CDFA export program] X commodity share of California value. CDFA expenditures are 1995–96 expenditures from the *Governor's Budget* 1996–97 (1996). The U.S. expenditure data is taken from Nelson, Simone and Valdez (1995).

Inspection. [Average U.S. expenditures (1982–1992) X California share of U.S. value + CDFA agriculture, plant, pest and animal disease prevention expenditures] X commodity share of California value. CDFA expenditures are 1995–96 expenditures from the *Governor's Budget* 1996–97 (1996). The U.S. expenditure data is from Nelson, Simone and Valdez (1995).

Processing and Marketing. [Average U.S. expenditures (1982–1992) X California share of U.S. value + CDFA marketing commodities and agriculture services] X commodity share of California value + federal marketing order promotion expenditures – assessments + state marketing order promotion budget * 0.3. The 30 percent factor represents the authors' estimate of the benefit from state marketing orders to producers. CDFA expenditures are 1995–96 expenditures from the *Governor's Budget* 1996–97 (1996). Federal marketing order data is found in Neff and Plato (1995). State marketing order data is from Lee, Alston, Carman and Sutton (1996).

Research. (California share of average U.S. expenditures (1982–1992) + 1992 State research appropriations) X (commodity share of California value) + (state marketing order research budget) X (0.3). The California share of U.S. expenditures is calculated by multiplying the market share found in the *1992 Census of Agriculture* (1992) (10.5 percent of U.S.) by the research expenditures reported in Nelson, Simone and Valdez (1995). State research appropriations are taken from Alston, Pardey and Carter (1994). Marketing order data is from Lee, Alston, Carman and Sutton (1996). Commodity shares are found in the *1996 California Agricultural Resource Directory* (1996) data. The 30 percent factor represents the authors' estimate of the benefit from state marketing orders to producers.

Farm Credit; Fuel Excise Tax; Pest and Disease Control; Land Improvements; Taxation; Transport. These are calculated as the product of (average U.S. expenditures (1982–1992)) X (California share of U.S. agriculture value) X (commodity share of California value). Expenditures are from Nelson, Simone and Valdes (1995). The California share of U.S. value is found in the *1992 Census of Agriculture* (1992). Commodity shares are from the *1996 California Agricultural Resource Directory* (1996).

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